CLIMAAX
climate ready regions

# Deliverable Phase 1 – Climate risk assessment

## Name of the project:

## Climate Risk Assessment and Adaptation Strategies for Kula Norinska Municipality in Neretva Delta, Croatia (C-RAKUN)

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

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# Document Information

| | |
|---|---|
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| Brief Description | This deliverable is the first phase of the CLIMAAX project that deals with climate change issues based on a single methodological approach. It is a climate risk assessment of climate hazards in a peripheral rural Municipality of Kula Norinska in southern Croatia. This report identifies relevant hazards, stakeholders, systems and areas affected just as wider social and economic context of implementation of climate change adaptation policy. It also tends to provide us with deeper understanding of issues concerning climate change adaptation and mitigation policies on local level. |
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## Abbreviations and acronyms

| Abbreviation / acronym | Description |
|---|---|
| CLIMAAX | CLIMAte risk and vulnerability Assessment framework and toolboX |
| CRA | Climate Risk Assessment |
| CRM | Climate Risk Management |
| EU | European Union |
| NGO | Non-governmental organization |
| SSP | Shared Socioeconomic Pathway |
| ToR | Terms of Reference |
| UV | Ultraviolet |

# Executive summary

This deliverable was developed through CLIMAAX project that aims to design a framework and a toolbox for climate risk assessment both at local and regional levels. The very goal is to prepare Europe for climate hazards and to develop adaptation strategies that would help European regions and municipalities to deal with climate change. This document is a climate risk assessment that address climate hazards in the territory of a small rural municipality of Kula Norinska, situated in the Neretva River Delta, in southern part of Croatia. Although small, it is an area of diverse nature resources at the contact of waterless karstic hills, rivers and Mediterranean wetlands. The reader will learn from this deliverable about relevant climate hazards, their geographic dimension and time projection till the end of the century. It also provides us with the knowledge of the main stakeholders involved in the process of climate adaptation on local level.
During this initial phase of the project research has been focused on defining the main climate hazards and areas where their impact is the strongest. Another important action was stakeholder analysis that was made to define social groups that may be affected by climate adaptation policies.

The main results achieved during this stage of the project are:

- recognition and definition of main climate hazards in the municipality: droughts and wildfires analysed on the level of settlements, the basic unit that form the municipality
- definition of areas of the municipality that are the most endangered by two climate hazards
- definition and analysis of local stakeholders involved in the climate adaptation process showed that although the municipality of Kula Norinska occupies a small area, there are many stakeholders involved in the process: municipal authorities, Hrvatske vode (national public agency in charge of water management), local farmers, tourism operators, fishermen and hunters, NGOs and environmental groups, neighbouring municipalities, scientists
- definition of relevant climate hazards based on CLIMAAX methodology
- climate risk analysis forecast till the end of the 21$^{st}$ century

The CRA constists of five operational steps – Scoping, Risk Exploration, Risk Analysis, Key Risk Assessment and Monitoring & Evaluation – in accordance with CLIMAAX Framework.

These results are crucial for next phases of the project because they set the scene for further research and development of the climate change adaptation and mitigation strategies and policies. They also serve to direct the course of the project work in phases yet to come.
Climate risk assessment provided researchers with key findings and understanding of the climate hazards related issues in a small rural municipality. It also showed that even such geographically limited territories with extremely small populations may be characterized by very subtle social interrelations that may burden implementation of climate adaptation policies that conflict with concerns of certain stakeholders. The research showed interconnection between droughts and fires, two key hazards in the municipality although they are a result of different mechanisms. While droughts are a result of exclusive climate change mechanism, the first one, fires are a result of combined impact of nature and humans who live in the areas and use local nature resources. The two hazards are also mutually connected since the prolongated droughts make fires more dangerous for local ecosystems and human dwellings and activities.

# 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 20$^{th}$ 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 20$^{th}$ and 21$^{st}$ 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 projects** can be defined in form of four questions that the authors of this deliverable find to be the most informative and concise.

1) Which aspects of climate change do the local Municipality face? We are aware that besides scientific research the local population has its own perception of climate change that does not rely on data analyses. As part of this project researchers aim to define the aspects of their everyday life that are influenced by climate change.
2) What kind of climate adaptation action is possible in a small peripheral rural area? Although contemporary digital civilization includes both the inhabitants of urban and rural areas, the population of small rural peripheral areas still differs significantly regarding their traditional values, life concepts, beliefs and other cultural elements. From that point of view, we want to undesratnd which kind of climate adaptation action the local stakeholders find easier to adopt.
3) How to achieve behaviour change toward climate change? It it probably the most difficult task because behavioural change does not happen easily and it involves the temporal dimension that makes it hard to be seen in a short time span. Nevertheless, it is an additional reason for facing such an important issue.
4) 4) How to involve the relevant stakeholders in climate adaptation programme? The authors of this deliverable will try to single out and find ways of involving the local stakeholders in climate adaptation policy without putting them out of their „comfort zone“ and alienating them from the issue.

**The significance of the projects** to a small rural Municipality, situated in the peripheral area of the country, may be seen from different points of view: scientific, environmental, political, economic and transformative.

Scientific point of view is focused on analysis of climate elements and scientific understanding of climate change. It is done by scientists and uses scientific language, concepts and models. The CLIMAAX project is the first one of such a type that is going to be conducted in a small peripheral Municipality like Kula Norinska and it would be a blueprint for other scientific analyses.
Environmental point of view incorporates all the elements of the local ecosystem with the man-made system that are influenced by the climate change. Environmental change that currently happens due to climate change puts under pressure local biodiversity tighter with human activities that depend on nature resources (such as farming, fishing and tourism).
Political dimension combines all the parts of human life, natural resources and decision making. The CLIMAAX project is opening a gate to a new level of interaction between the local population and their decision makers to define the means of adapting to climate change.
Economic point of view is centered around introducing the local population to alternative ways of practicing traditional economic activities such as farming. **Intensive summer droughts, high solar irradiance during the summer, combined with salinization of freshwater are changing the face of traditional farming and are demanding applying of adaptive ways of farming.**
Transformative dimensions are significant since they cover the most important aspect of adaptation to climate change: behavioural change in the local population. Since the whole climate adaptation policy depends on its application among human population, the behavioural change is crucial

element. This CLIMAAX project puts the local stakeholders in the Municipality of Kula Norinska at the forefront of implementation of the climate adaptation strategy.
The most important **expected benefit of applying the CLIMAAX Handbook** is the designation of climate risk assessment of the Municipality 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 participate 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 documents according to the CLIMAAX deliverable generic guideline and consists of the following sections:

**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.

**Climate risk assessment – phase 1** is a section focused on detailed climate risk analysis that relies on CLIMAAX Methodology Framework: Scoping, Risk Identification, Risk Analysis, Key Risk Assessment, Monitoring and Evaluation. The first section begins with three subsections: scoping (definition of objectives, context and stakeholders involved in the process), risk identification and risk analysis. The second part consists of two subsections about preliminary key risk assessment findings and preliminary monitoring and evaluation. The section ends with a brief description of the work plan for the remaining phases of the project.

**Conclusion – phase 1** concerns the conclusion regarding the climate risk assessments.

**Progress evaluation and contribution to future phases** 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 1

This assessment of climate risks in the Municipality of Kula Norinska is based on research and existing historical data of relevant climate risks applying the CLIMAAX methodology and their impact on biodiversity, economic activities and everyday life of the local population. The initial phase consists of three steps (scoping, risk exploration, risk analysis), just like the final phase (definition of preliminary key risk assessment findings, preliminary monitoring and evaluation and designation of work plan).

## 2.1 Scoping

Scoping, as the initial phase of the climate risk assessment, relies on definition of objectives, context and definition of the relevant stakeholders involved in the whole process.

### 2.1.1 Objectives

**The objective of this CRA** is to define and research climate risks in the small rural Municipality of Kula Norinska in Croatian County of Dubrovnik – Neretva, just as the attitude of the relevant stakeholders toward the climate risks and climate change in general. The purpose of this CRA is designating a general overview of the local climate risks to designate adequate climate change and risks adaptation plan. The expected outcome of this CRA primarily is raising consciousness of the risks initiated by climate change and laying foundations for designation of general climate change adaptation plan and strategy. On the other hand, **the CRA is designed as a document that should provide the decision makers with better knowledge and understanding of the climate risks in their Municipality**. It is a deliverable that aims to be at the same time informative just as useful from the point of view of policy making and current or upcoming local climate change/adaptation plans, strategies and policies.

There are some **boundaries of this CRA** that should be clarified at the very introduction to this document. The first one is the availability of the climate data since there is no weather station in the administrative unit of Kula Norinska. Therefore, we must use the data for air temperature and precipitation form the geographically nearest weather station in Metković, located just several kilometers to the east. Since the Metković weather station does not dispose with a sunshine recorder (heliograph), the data for sunshine is taken from the weather station of Ploče, that is located 15 km to the west, at the coast of the Adriatic Sea. The second boundary is the involvement of stakeholders, an issue that always is, at least, demanding for every researcher. This is something challenging in a peripheral rural area, like Kula Norinska, especially when we are dealing with some behavioural patterns that are destructive for local nature resources.

### 2.1.2 Context

**Climate hazards, impacts and risks** have not been assessed adequately by now in the region where the Municipality of Kula Norinska is located. Although the legislative documents on national, regional and local levels about climate change, the fact is that nothing has been specifically done to address the issue. The climate change policy is generally understood, both by the local population and the decision-makers, as a formal concept that demands currently unavailable financial, technological

and human resources. The actual weather disaster policy still relies on the concept devised more than half a century ago, where, in case of financial losses, the national and regional governments compensate a part of losses.

**The project is primarily trying to address** the conceptual problem of understanding the climate hazards, impacts and risks issues in the context of wider regional and national systems. Namely, the perception of climate change consequences in the region, just as on the national level, is not based on active but reactive concept. Such a reactive concept does prescribe steps necessary to face the climate change issues but functions in reverse trying to minimize the consequences. We are trying to introduce the active concept that would define the most relevant climate risks and anticipate sets of actions that would minimize their impact in advance.

**The governance context** of Kula Norinska's climate risk assessment is subordinated to the wider regional and national legislative frame that proscribes passing regulations in accordance with national laws. It is a bureaucratic system that turns many regulations into formal rather than living documents and demands subordinate rather than creative approach toward various problems. On the other hand, the bright side of the current governance approach is the possibility of creating plans and strategies that address various issues, including climate change, and freedom of cooperation with relevant institutions, including the EU agencies, in such activities.

In a small peripheral Municipality with limited nature resources, such as Kula Norinska, there is no wide possibilities of economic development. This fact makes it even more vulnerable to climate change. There are three **relevant sectors** that might be sincerely affected:

1) agriculture,
2) tourism
3) biodiversity

Although agriculture is the principal source of income to very small portion of the local population it is a traditional activity that is still widely practiced. In addition, agriculture, primarily farming, is an additional source of income to many households and an important element of social life in the Municipality. Extensive period of summer droughts, combined with high solar irradiance, have a negative impact on crops.
Tourism in the Municipality of Kula Norinska relies on ecotourism in summer months, the same time when prolongated heatwaves, high air temperatures and high UV index make outdoor living unbearable. Summer droughts have a negative impact on water levels in the wetlands and because of that vast areas of wetlands are unreachable to tourist boats.
Biodiversity, especially in local wetlands, is threatened by periodical fires and long periods of summer droughts. Negative changes in biodiversity are the least visible to humans, but they have far-reaching consequences for natural resources and human life and economic activities in the Municipality.

Only one climate risk has been **addressed by the outside initiative**: the fires in the wetlands. Although the fires can be started spontaneously in accordance with natural mechanisms, during the summer months of prolonged heat and high air temperature, majority of fires in the wetlands happen out of summer. They are started by irresponsible individuals whose motives for such activity with extremely devastating consequences stretches from poaching to "wetlands spread controlling". Regional nature protection authorities, under whose jurisdiction are protected wetlands in the Municipality, in cooperation fire brigade and police forces, have initiated a more active approach

toward the issue. Although the problem has not been solved yet, there are some positive results and full implementation of such a policy can have a positive influence on the problem in the future.

There are some **possible adaptations** that can help meet objectives. The first one is establishing communication with local populations to raise awareness about biodiversity and the importance of local wetlands for their everyday life. The second adaptation intervention is the introduction of multi-stakeholder participative system of nature resource management that would involve different stakeholders in wetlands protection and conservation. One more adaptation measure is education of local farmers in non-traditional ways of farming that would help them leave some activities that may have devastating results on nature (such as burning weeds that may turn into wildfire).

### 2.1.3 Participation and risk ownership

After research and defining all the relevant stakeholders, an initial step of setting up the **stakeholder involvement process** is establishing communication with them by applying the inclusive policy of climate risks adaptation. 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).

**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 it 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.

**Relevant representatives of vulnerable groups** should be defined in the process by the very members of those groups. The project team, in cooperation with representatives of the local

authorities, would encourage all the stakeholder groups involved in the process to choose the representatives that would correspond to their interests.

**The risk ownership** is regulated in accordance with assessing specific risks to each stakeholder group within the Municipality. The project team would ensure that all the stakeholders are accountable for proactive involvement in the process and that risks are assigned according to their responsibilities.

The consensus regarding **the level of risk acceptable to the Municipality** of Kula Norinska has not been reached yet. Our project team insists that such a level should be aimed at being as low as possible. This point of view demands of all the stakeholder's maximal engagement since we believe that climate risks will be higher through time. Therefore, the "second chance" policy should not be a possibility because the damaged would probably be irreversible.

We would like to **communicate the results 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.

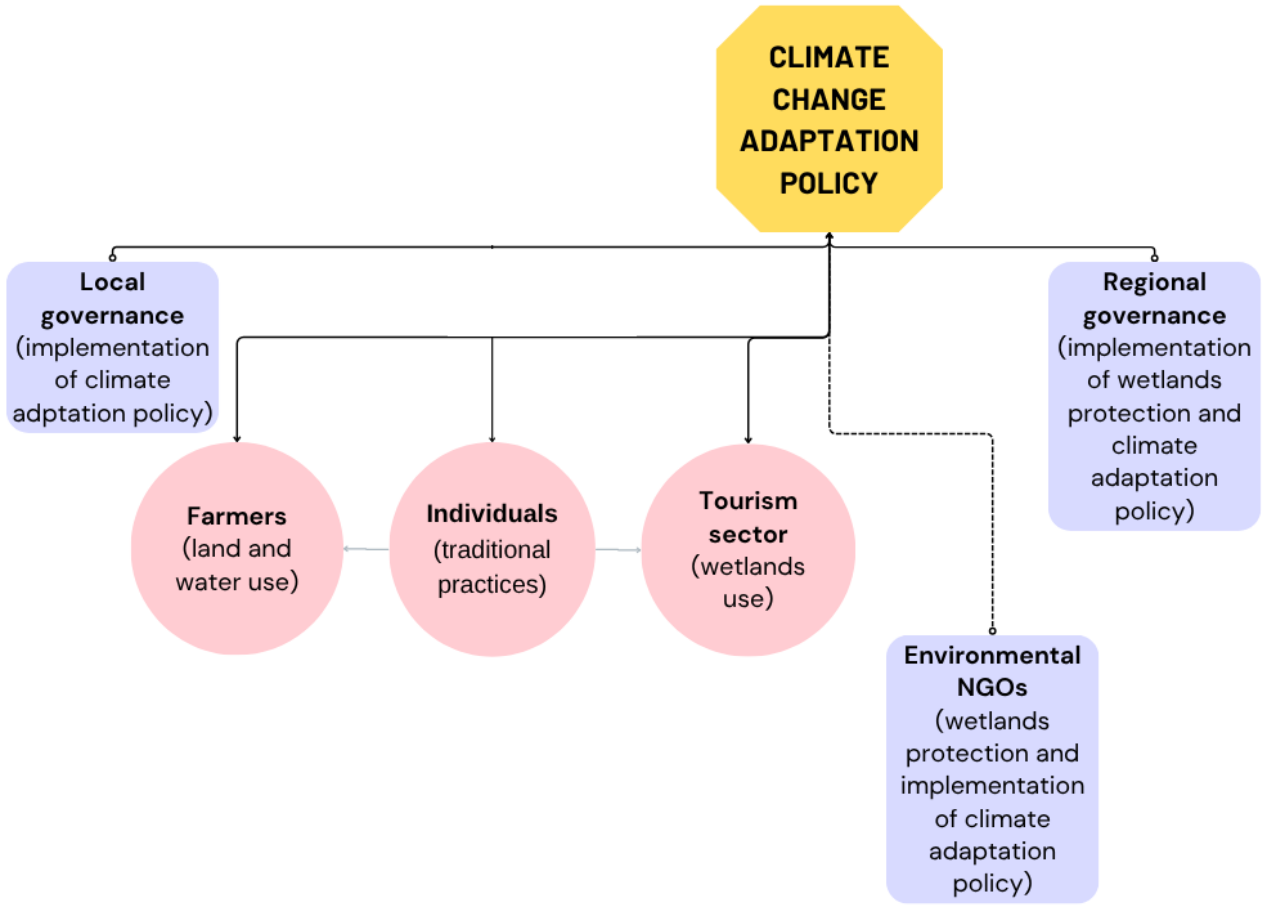


Fig 2-1 Current model of interrelation among stakeholders in the process of implementation of climate adaptation policy in the Municipality of Kula Norinska

During the research we have established contact with members of the local stakeholders. We have engaged with them to validate the data collected and the preliminary findings, as planned for Phase 1 of the project.

One of the results of the field work was definition of the relevant stakeholders. At the beginning it was easy to recognize two local stakeholders: the municipal authorities and the *Hrvatske vode* company (national public agency for water management). The *Hrvatske vode* agency is not involved directly into the policy of climate change mitigation and adaptation in the municipality but ii does have to ensure the water use by human in environmentally sustainable way. Since a part of our research is connected to the wetlands conservation as part of reducing the greenhouse gas emission from the wetlands our interaction with the company representatives was limited to establishing an initial contact and presenting the scope and goal of our research. On the other hand, interaction with the municipal authorities was more complex and intensive. It helped us to understand the wider frame of political and institutional interconnections when dealing with climate change and the wetlands conservation policies. Since the municipality of Kula Norinska consists of fine small rural areas on a small area the municipal authorities helped us to establish a contact with other stakeholders: farmers, tourism operators, fishermen and hunters, NGOs and environmental groups. Such an approach helped us to facilitate initial contacts and communication with members of this small peripheral rural community that is socially closely knit with many interdependent relations. In accordance with the Individual Follow Up Plan we have discussed with stakeholders about the initial findings of our research during the field work and during the first workshop where we involved the neighbouring municipality of Metković which shares the wetlands with Kula Norinska.
Establishing the contact, opening the communication lines, discussing preliminary findings and encouraging the stakeholders' involvement in the process were basic goals of Phase 1 of the research.

## 2.2 Risk Exploration

The existing insights from experts and local stakeholders allow us **to define the sectors and geographic areas at risk**. Regarding the sectors, human activities, such as farming and tourism, are especially influenced by climate change. Affected entities are groups of the local population that are involved in farming and tourism as a main or an additional source of income. Possible dissatisfaction of these groups, because of climate change negative impact on their activities would result in putting up pressure on local and regional decision makers. On the other hand, the area of wetlands is the most vulnerable to climate hazards and their devastation would activate various NGOs dedicated to preservation and conservation of the environment.

### 2.2.1 Screen risks (selection of main hazards)

Thanks to the recommended participatory approach, based on consultations with relevant local stakeholders and decision makers we were able to define and research the groups, sectors and areas affected by climate change. The stakeholder's engagement during focus group discussions and workshop was crucial for identifying risk severity, urgency, resilience capacity and risk priorities (Figure 2-2). The analysis showed that there are two risk workflows with very high-risk priority: drought and fire. Two risk workflows are of moderate risk priority: river flooding and heatwaves. The

situation of a part of the municipality at the contact of karstic hills and alluvial plain in the Neretva river delta determines possibility of periodical river flooding. In the 21st century there was only one big river flooding in the Lower Neretva Delta, in Januray of 2010, that did not have substantial impact in the Municipality of Kula Norinska. All the municipalities in the delta have high substantial resilience capacity since the system of flood defense, in charge of the public agency *Hrvatske* vode, is at a high level. On the other hand, heatwaves occur in the summer months, from June to August, and demand more action to be taken in the future. Remaining four risk workflows (coastal flooding, heavy rainfall, snow, wind) have low risk ranking.

| Risk workflow | Severity | | Urgency | Capacity | Risk priority |
|---|---|---|---|---|---|
| | C | F | | Resilience/ CRM | |
| River flooding | | | | | Moderate |
| Coastal flooding | | | | | Low |
| Heavy rainfall | | | | | Low |
| Heatwaves | | | | | Moderate |
| Drought | | | | | Very high |
| Fire | | | | | Very high |
| Snow | | | | | Low |
| Wind | | | | | Low |

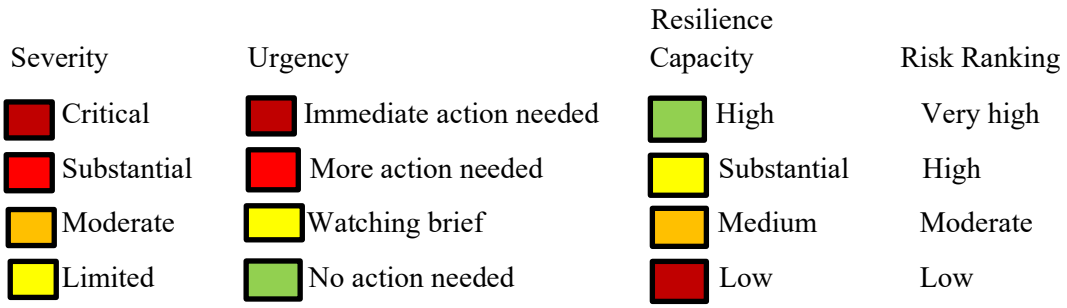


Fig 2-2 Key Risk Assessment of each risk workflow in the Municipality of Kula Norinska

Our research showed that the two climate-related hazards and potential risks are relevant for the Municipality of Kula Norinska: **wildfires (ignited by natural causes or human activities) and droughts**. The two hazards also act in correlation since wildfires are also a result of prolonged summer droughts.

The analysis helped us to single out two most important workflows in the municipality: wildfires and droughts (Figure 2-3). Wildfires are recognized to have critical current and future severity with

immediate action needed. Since the firemen service in the municipality, and in Croatia in general, is organized on very high level with significant experience of the trained personnel, the resilience capacity is not low. However, medium resilience capacity is determined by insufficient efficacy when dealing wild devastating wildfires in the wetlands that are mostly human-inflicted.

Droughts are the second workflow with substantial severity which is expected to turn into critical in the future. Draughts got more severe since 2020 with dry season expansion to a longer period than just two summer months (July and August). The municipality has medium resilience capacity due to availability of fresh water for agricultural purposes and with stable provision of drinking water for local households but damage to the wetland's ecosystem would be irreparable.

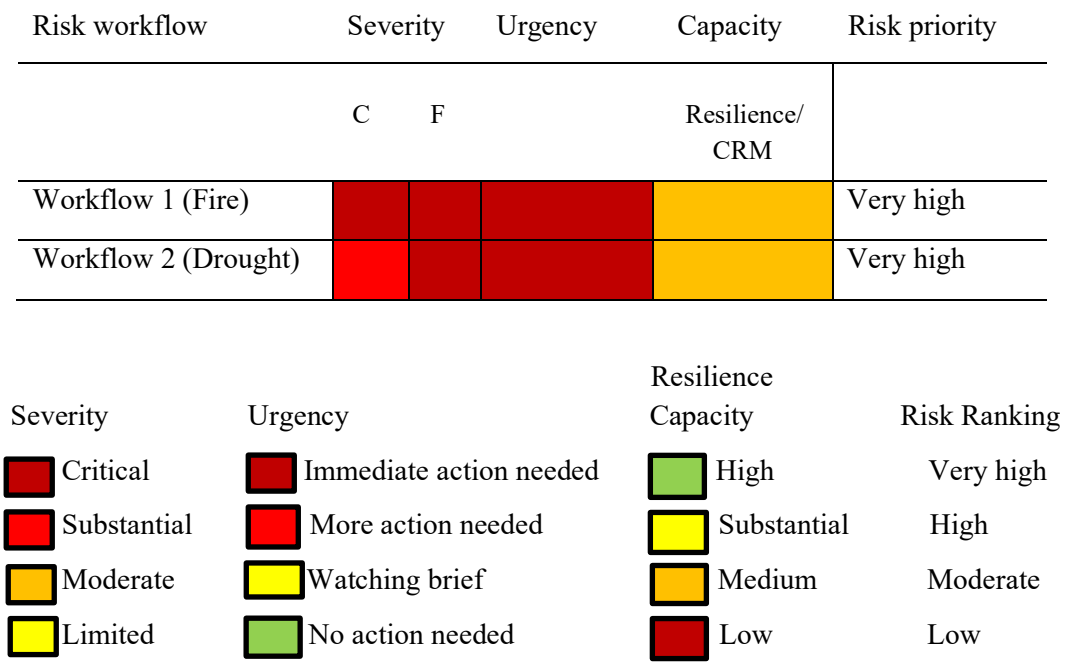


Fig 2-3 Risk prioritization of two most important risk workflows in the Municipality of Kula Norinska: (wild)fires and droughts

Currently, wildfires are **the most important hazard** in the Municipality of Kula Norinska. They occur in the wetlands during the whole year. Nevertheless, the distinction between wildfires started by natural causes should be separated from wildfire that are deliberately or not started by humans. The natural mechanism of wildfires takes place during the extensive and prolongated summer heat and droughts when reeds in the wetlands self-ignite and start the fires that spread in different ways, depending on the prevalent wind direction. On the other hand, the man-inflicted fires may occur in every part of the year. Fires that do not deliberate regularly happen in spring and partially in the summer months. They are started by negligent farmers that burn weed on their parcels and sometimes these types of open fire spread and transform into extensive wildfires. However, there is another face of man-inflicted wildfires that occur periodically, mostly in the winter and early spring and that are caused deliberately by irresponsible individuals. Such an activity has a devastating impact on local wetlands and cannot be explained rationally nowadays. Such fires were part of the traditional mindset because in the past they were started by local bird hunters who wanted to keep

vast areas of wetlands (especially those important for bird nesting) available to them to ease bird hunting. Although the bird hunting today is totally marginal activity in the Municipality of Kula Norinska, a part of local population still practices the reed torching as part of their "cultural identity" justifying them by various irrational and unscientific arguments. Though such acts are illegal since the local wetlands are under legal protection, the fact that perpetrators usually remain unknown additionally encourage such actions. Fires in the wetlands have an extremely destructive impact on local biodiversity and environment in general. Further on, they sometimes affect the local population and their activities (farming, tourism) because, when combined with strong winds, the fires in the reeds spread on fire agricultural parcels, stop tourism visits and even threaten the dwellings of the locals.

**The second hazard** is that the droughts that occur during the summer months are a result of climate change in general. Droughts extends to the whole Municipality of Kula Norinska and wide regions of southern Croatia and neighbouring southwestern Bosnia and Herzegovina. Although the impact of droughts is obvious in the areas of karstic hills with no watercourses or lakes, the wetlands are especially vulnerable to extremely dry seasons. Firstly, droughts are interconnected with wildfires, as previously explained. Furthermore, low level of water in wetlands and periodical drying of certain areas results in emission of methane that is storage in the mud. 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.

Current hazards that are expected for the Municipality of Kula Norinska are: droughts and fire. The findings from other sources, such as **Copernicus Atlas**, show rise of mean daily air temperature, rise of numbers of extreme hot days and tropical nights and higher potential evapotranspiration. These indicators are directly connected with global climate change and global warming as the main element of climate change in general.

In this risk assessment **we will cover two hazards**: ***fire and droughts***. We decided to focus on those two hazards because our research in the area, especially findings based on the knowledge and perception of the stakeholders, showed their impact to be the most relevant.

**The knowledge that we have on these two hazards** is based on the stakeholders' interviews and analysis of historical data from the nearby weather stations of Metković and Ploče. We used additional data from these two weather stations on three climate elements for present and further analyses: air temperature, precipitation and solar irradiance.

### 2.2.2 Workflow selection

After the hazard selection, the next step of this deliverable is identification of the risk workflows by defining the relevant vulnerable groups and exposed areas for every risk.

#### 2.2.2.1 Workflow #1: Wildfire risk management

**Wildfire risk** should be understood in interconnection between the local inhabitants and their activities on one side and natural resources (vegetation, fauna, landscape) on the other. There is also a specific problem when dealing with wildfires in the Municipality of Kula Norinska: causes of wildfires are not only natural but also, and very often, anthropologic.

Vulnerable groups are formed of individuals that belong to various social elements of the Municipality: ***smallholder farmers, tourism sector, dwellers, firemen***. Since wildfires are very

destructive sometimes, a vast palette of the local population is threatened by its uncontrolled spread. Although the fire service is organized on a very high level, the unpredictability of the wildfires makes them an important issue in the Municipality.

Local wetlands are primarily exposed to the wildfires where they are regularly started but it is important to point out that sometimes wildfires spread to forests on local karstic hills and endanger the houses on the hillslopes.

#### 2.2.2.2 Workflow #2: Drought risk

**Drought risk** in the Municipality of Kula Norinska is a result of prolonged dry periods and heat during the summer months, late spring and early autumn. The type of drought typical for Kula Norinska is a meteorological drought that is caused by short-term precipitation deficiency during the warm part of the year.

The most vulnerable group to drought is local farmers who have been dealing with droughts by themselves using irrigation machines of limited capacity and reach. Nevertheless, the problem of droughts persists because of the salinization of the Neretva River and spread of the salt seas water into the adjacent watercourses.

The local wetlands are the area predominantly exposed to droughts. That exposure is devastating for the wetland's ecosystem from the point of view of biodiversity. Lowering the water level in the wetlands during the summer months is extremely negative for the plants and animals and presents a major threat to biodiversity. It also contributes to the greenhouse gas (methane) emission of the mud that is exposed to the atmospheric air.

### 2.2.3 Choose Scenario

**Workflow #1: Wildfires risk**

These fire risk maps provide a spatial overview of current wildfire vulnerability across the Kula Norinska region, with clearly defined risk zones based on environmental factors, historical data, and topographical features.

Interpretation and Use: The map allows for localized analysis of high-risk zones, particularly in proximity to populated areas and ecologically sensitive zones. It aids in:

· Strategic deployment of firefighting resources

· Emergency evacuation route planning

· Prioritization of forest and vegetation management

· Risk communication with local communities

Given the increasing frequency of drought periods and shifting vegetation patterns in the Adriatic hinterland, this map forms a crucial element of regional fire preparedness and climate resilience strategies.

This projected map offers a detailed visualization of evolving fire risk patterns across the Kula Norinska region over the mid-21st century, integrating regional climate models, land-use trends, and anticipated ecological shifts.

Key features of the forecasted landscape include:

· Expansion of high-risk zones inland, particularly around semi-rural and forested areas, driven by longer drought spells and increasingly volatile summer temperatures.

· Urban interfaces, such as the outskirts of Metković and Ploče, face heightened vulnerability due to both climate stress and the encroachment of vegetation near built environments.

· Wetland dynamics may shift, potentially reducing their natural role as fire buffers and complicating fire spread behavior depending on seasonal moisture levels.

· Fire risk distribution suggests greater spatial fragmentation, with new moderate- and high-risk patches emerging in previously stable zones.

This map serves as a strategic planning tool for local governance and emergency response agencies, prompting proactive interventions in vegetation management, land-use zoning, and Municipality resilience efforts. The increasing unpredictability of climate extremes positions wildfire adaptation as a critical pillar of regional sustainability moving into the second half of the century.

This future-oriented map captures a climate-altered landscape in the Kula Norinska region during the final four decades of the 21st century, illustrating intensified fire risk patterns shaped by escalating environmental stresses.

Projected landscape features and implications include:

· Substantial increase in high and very high-risk zones, particularly in previously moderate areas, driven by more extreme heat anomalies, soil desiccation, and vegetation flammability.

· Disruption of hydrological cycles may significantly alter the extent and function of local wetlands, reducing their role as buffers and amplifying fire susceptibility in adjacent terrain.

· Urban-periurban zones, including Metković and Ploče, may become increasingly exposed due to expanding development pressure and diminishing vegetation belts.

· Wildfire behavior becomes more erratic and intense, with shorter ignition-to-spread timelines and higher potential for prolonged fire seasons.

· Remote and elevated areas might face new ignition risks due to lightning-induced fires and shifting wind regimes, which alter suppression dynamics.

This 2050–2095 risk visualization serves as a critical planning and resilience tool, emphasizing the need for:

· Adaptive land management and fire-resistant urban design

· Integration of real-time monitoring systems and early AI-driven warning platforms

· Cross-sector cooperation on ecosystem restoration to enhance landscape fire resilience

· Municipality-centered risk education focused on long-term climate realities

As the century advances toward its close, the map underscores the strategic importance of transforming firefighting policies from reactive frameworks to proactive, climate-responsive systems.

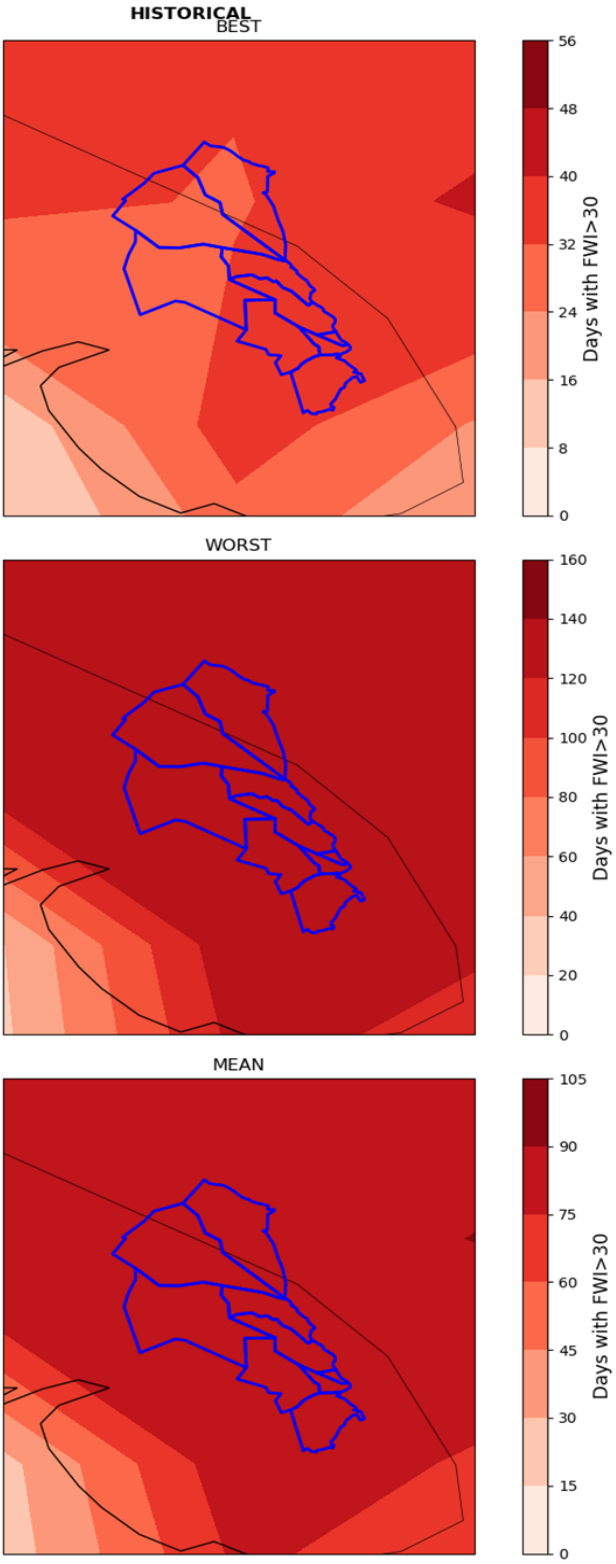


Fig 2-4 Geographic distribution of Days with FWI≥30 in Municipality of Kula Norinska by settlement: historical situation (best-up; worst – middle; mean-down)

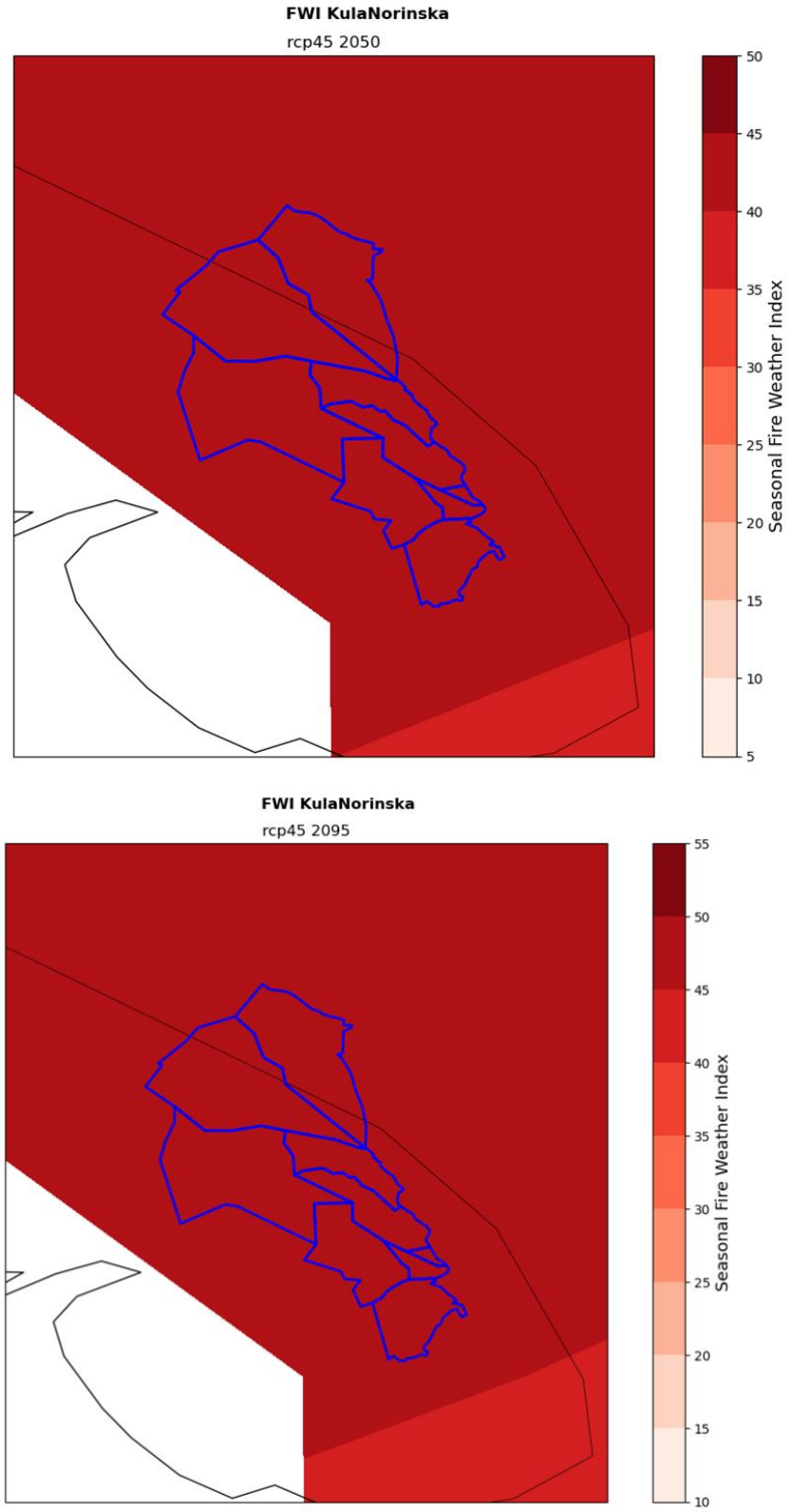


Fig 2-5 Distribution of fire risk in Municipality of Kula Norinska by settlement: projection for FWI (scenario RCP 4.5) until 2050 and FWI (scenario RCP 4.5) until 2095

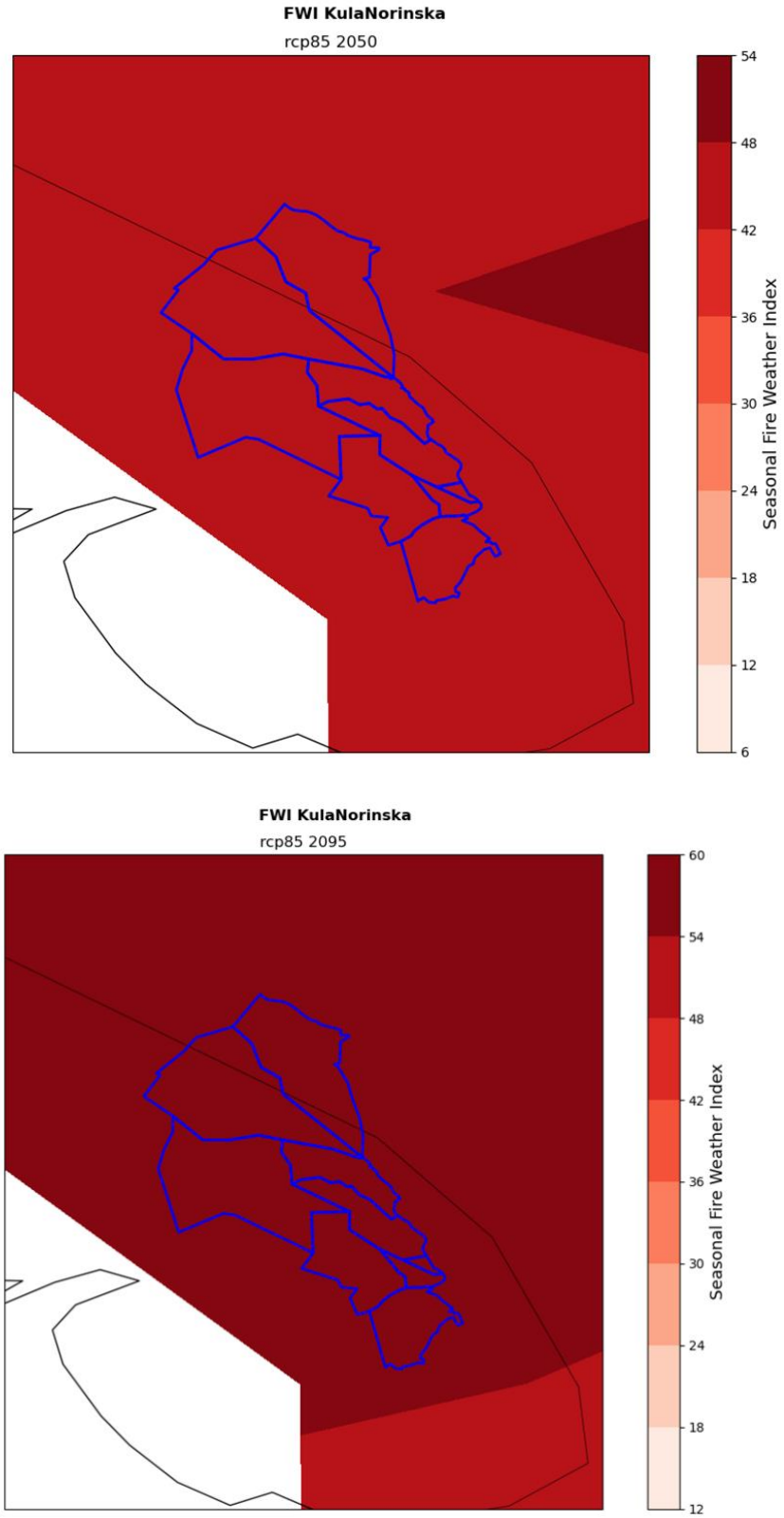


Fig 2-6 Distribution of fire risk in Municipality of Kula Norinska by settlement: projection for FWI (scenario RCP 8.5) until 2050 and FWI (scenario RCP 8.5) until 2095

**Workflow #2: Drought risk**

This droughts risk map provides a spatial overview of current droughts vulnerability across the Kula Norinska region, with clearly defined risk zones based on environmental factors, historical data, and topographical features.

Current Climate Profile – Municipality of Kula Norinska

- Climate classification: Marine west coast climate with warm summers (Cfb according to Köppen classification)
- Average annual temperature: 16.9°C – approximately 3.4% higher than the national average
- Warmest month: August, with an average high of 32.8°C
- Coldest month: January, with an average low of 2.5°C
- Annual precipitation: 181 mm – with pronounced seasonal variation
- Wettest month: November (305 mm)
- Driest month: August (52 mm)
- Number of days with precipitation: Approximately 152 days per year (41.8% of the time)
- Relative humidity: Average of 74%, higher during autumn and winter
- Elevation: 14.4 meters above sea level

Conclusion: Kula Norinska currently faces a moderate drought risk, especially during the summer season. The combination of high temperatures, seasonal dryness, and dependence on local water sources highlights the need for proactive water management and adaptation in agricultural practices.

**Mid-Term Climate Outlook – Municipality of Kula Norinska (2031–2065)**

- Climate classification: Marine west coast climate with warm summers (Cfb)
- Projected average annual temperature: Expected to rise by 1.2–1.8°C compared to present-day values, reaching approximately 18.1–18.7°C
- Warmest month: August, with projected highs between 34–36°C, indicating increased heat stress
- Coldest month: January, with lows around 3.5–4.2°C, showing milder winters
- Annual precipitation: Slight decline anticipated, averaging 160–170 mm, with more erratic seasonal distribution
- Wettest month: November remains dominant, but with increased intensity of rainfall events
- Driest month: August, with extended dry spells and reduced soil moisture
- Days with precipitation: Expected to decrease slightly to 140–145 days/year, with longer dry intervals
- Relative humidity: Projected to drop to 70–72%, especially during summer
- Elevation: 14.4 meters above sea level (unchanged)

Conclusion: Between 2031 and 2065, Kula Norinska is likely to experience warmer temperatures, longer drought periods, and more concentrated rainfall events, increasing the risk of agricultural disruption and water resource stress. These trends underscore the importance of adaptive land-use planning, efficient irrigation systems, and climate-resilient crop strategies.

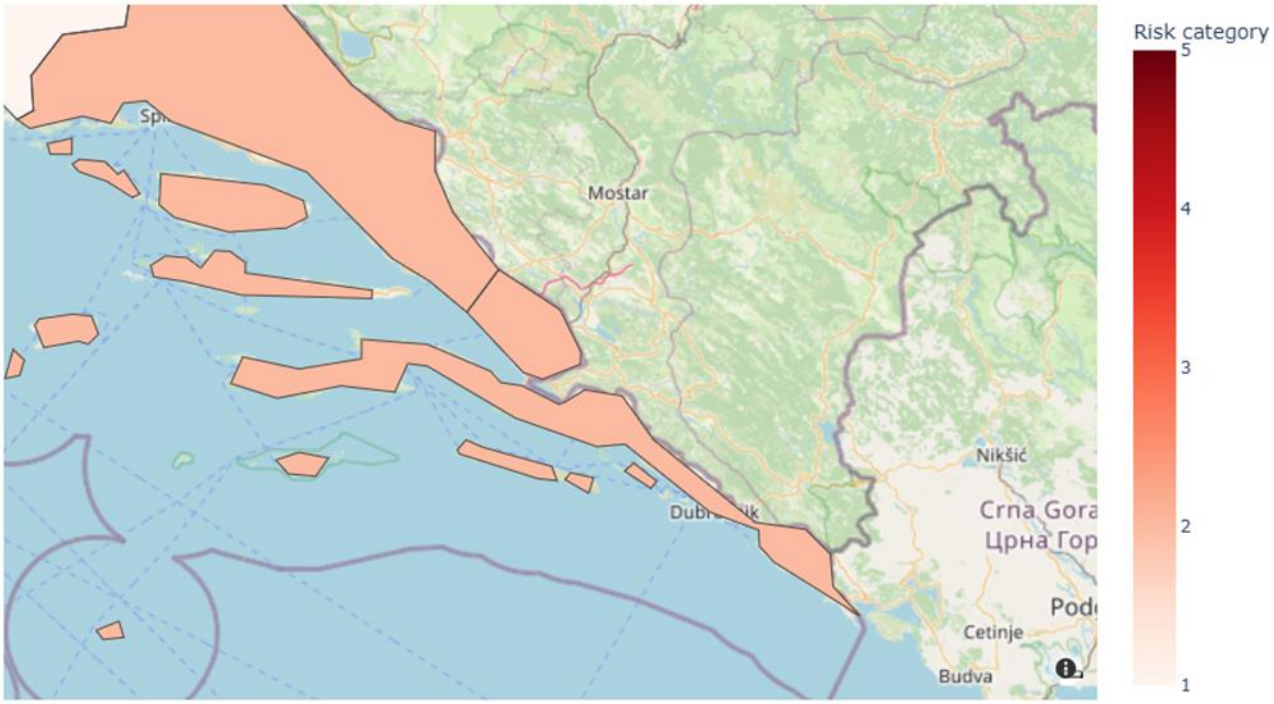


Fig 2-7 Geographic distribution of drought risk in Dubrovnik-Neretva County: current situation

**Far-Future Climate Outlook – Municipality of Kula Norinska (2050–2095)**

- Climate classification: Transitioning toward semi-arid conditions, with intensified Mediterranean features
- Projected average annual temperature: Increase of 2.5–3.5°C compared to present-day, reaching 19.4–20.4°C
- Warmest month: August, with projected highs between 36–39°C, indicating extreme heat stress
- Coldest month: January, with lows around 4.5–5.2°C, reflecting significantly milder winters
- Annual precipitation: Expected decline to 140–155 mm, with erratic and concentrated rainfall events
- Wettest month: November, but with increased risk of flash flooding due to intense precipitation bursts
- Driest month: August, with prolonged dry spells and near-zero rainfall
- Days with precipitation: Likely to drop below 130 days/year, with longer dry intervals and fewer moderate rain events

- Relative humidity: Projected to fall to 66–69%, especially during summer
- Elevation: 14.4 meters above sea level (unchanged)

Conclusion: By 2100, Kula Norinska is expected to face severe climate impacts, including frequent and prolonged droughts, extreme summer temperatures, and heightened water scarcity. These conditions will challenge agricultural viability, increase the risk of soil degradation, and demand transformative adaptation strategies in land use, water management, and rural development.

Considering climate change, population growth, economic development and other indicators) like food consumption, energy consumption, prices) we found **three scenario assumptions** to be the most relevant to the region:

**SSP1-2.6** (Sustainability or Taking the Green Road): development that respects environmental realities, transition from economic growth to human well-being, investment in education and health that accelerates demographic transition, reducing inequality of international and national levels, slower consumption of goods and energy

**SSP3-7.0** (Regional Rivalry or A Rocky Road): global shift toward nationalism with regional conflicts turns countries to achieve their energy consumption and food production goals, lower investment in education and technologic development, low economic and population growth, low environmental concerns lead to environmental degradation in poor regions.

**SSP5-8.5** (Fossil-Fueled Development or Taking the Highway): rise of market competition, economic development leads to massive use of fossil fuels, economic growth, population peak and start of decline, local environmental problems successfully managed

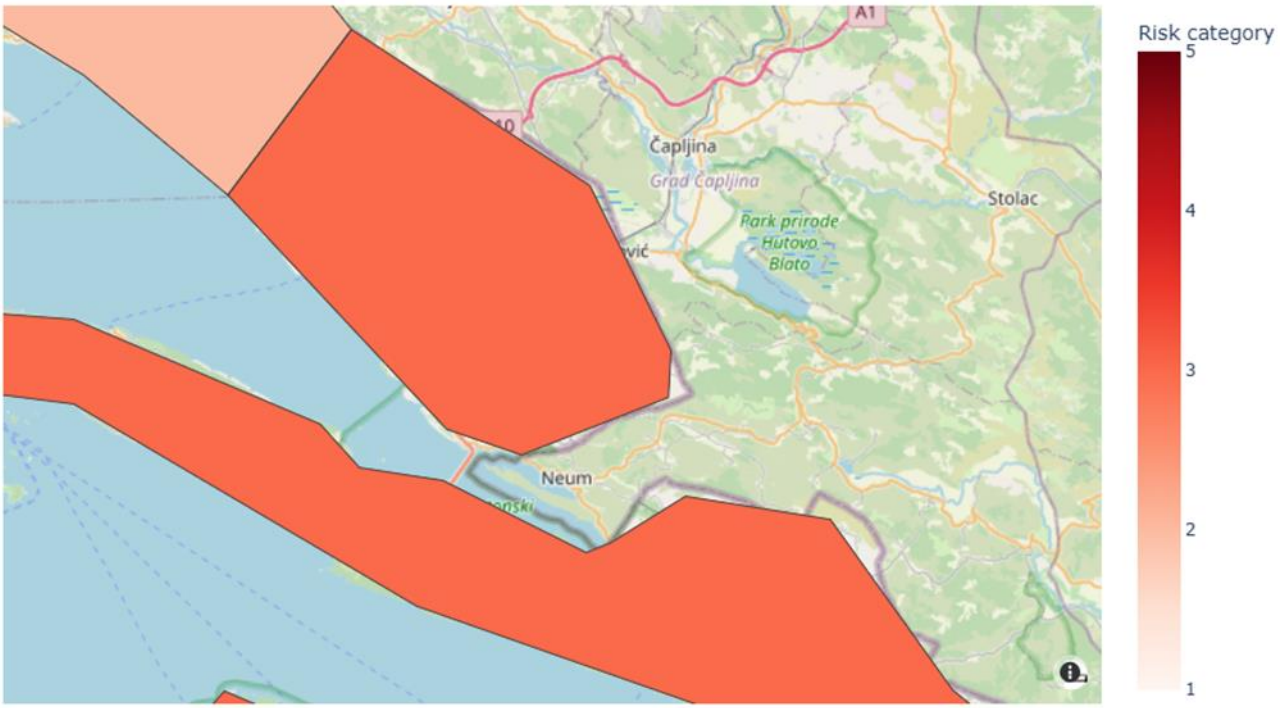

Fig 2-8 Geographic distribution of drought risk in Dubrovnik-Neretva County: for scenario SSP1-2.6 until 2050

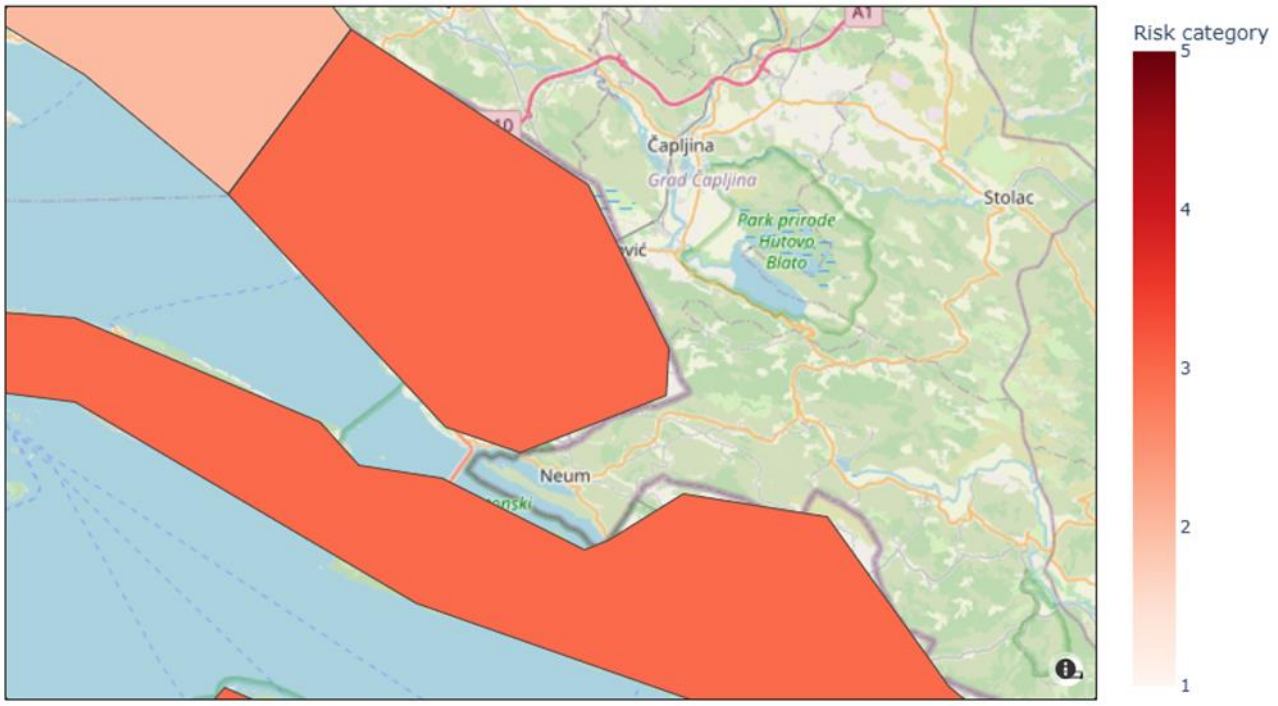


Fig 2-9 Geographic distribution of drought risk in Dubrovnik-Neretva County: for scenario SSP1-2.6 until 2080

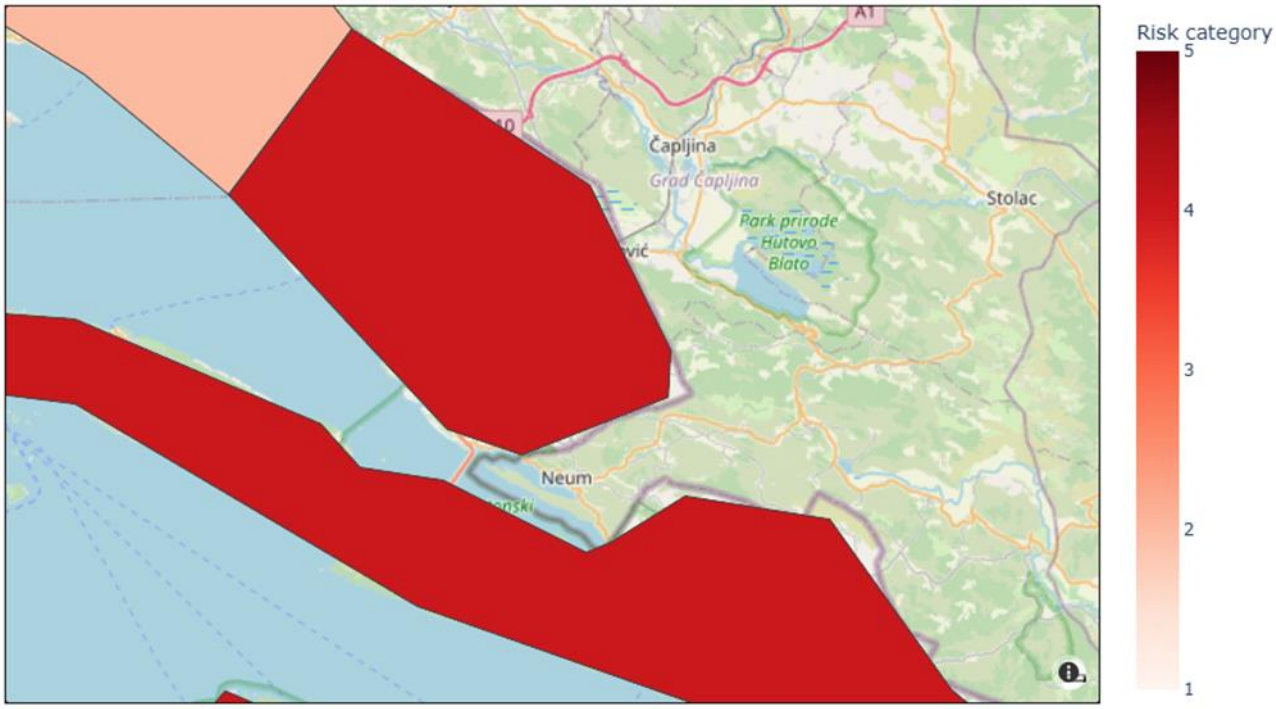


Fig 2-10 Geographic distribution of drought risk in Dubrovnik-Neretva County: for scenario SSP 3-7.0 until 2050

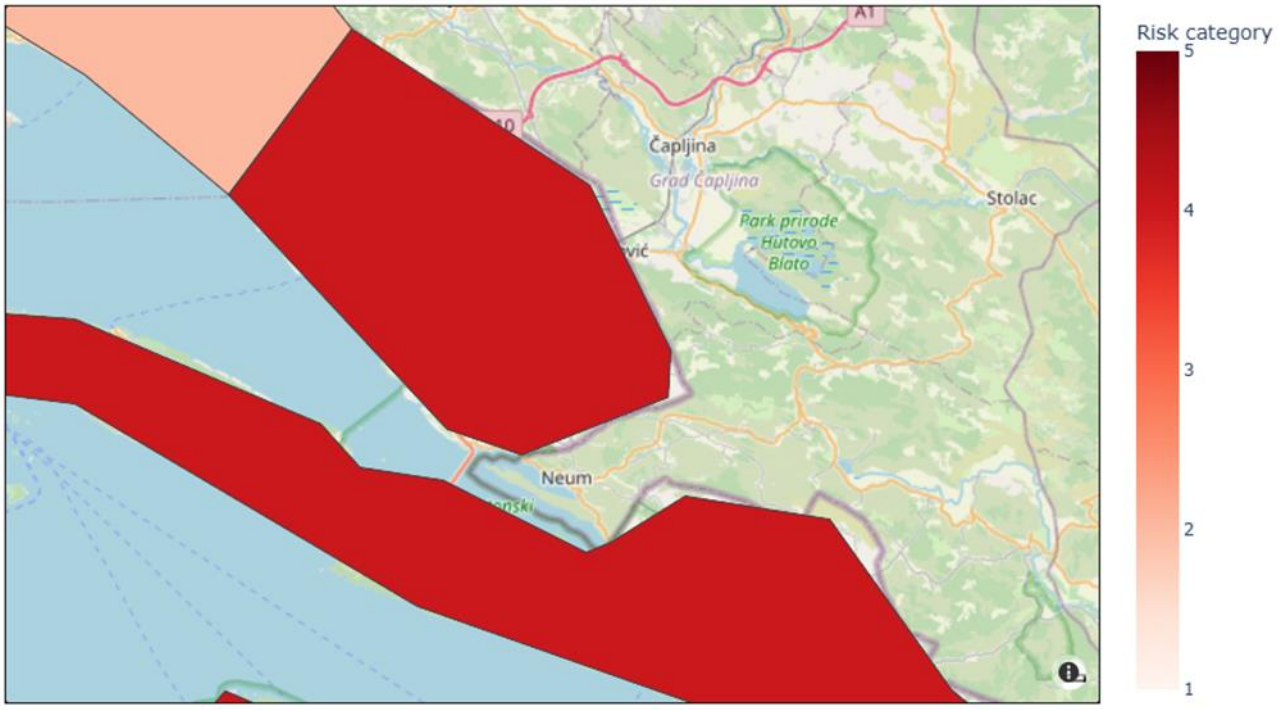


Fig 2-11 Geographic distribution of drought risk in Dubrovnik-Neretva County: for scenario SSP 3-7.0 until 2080

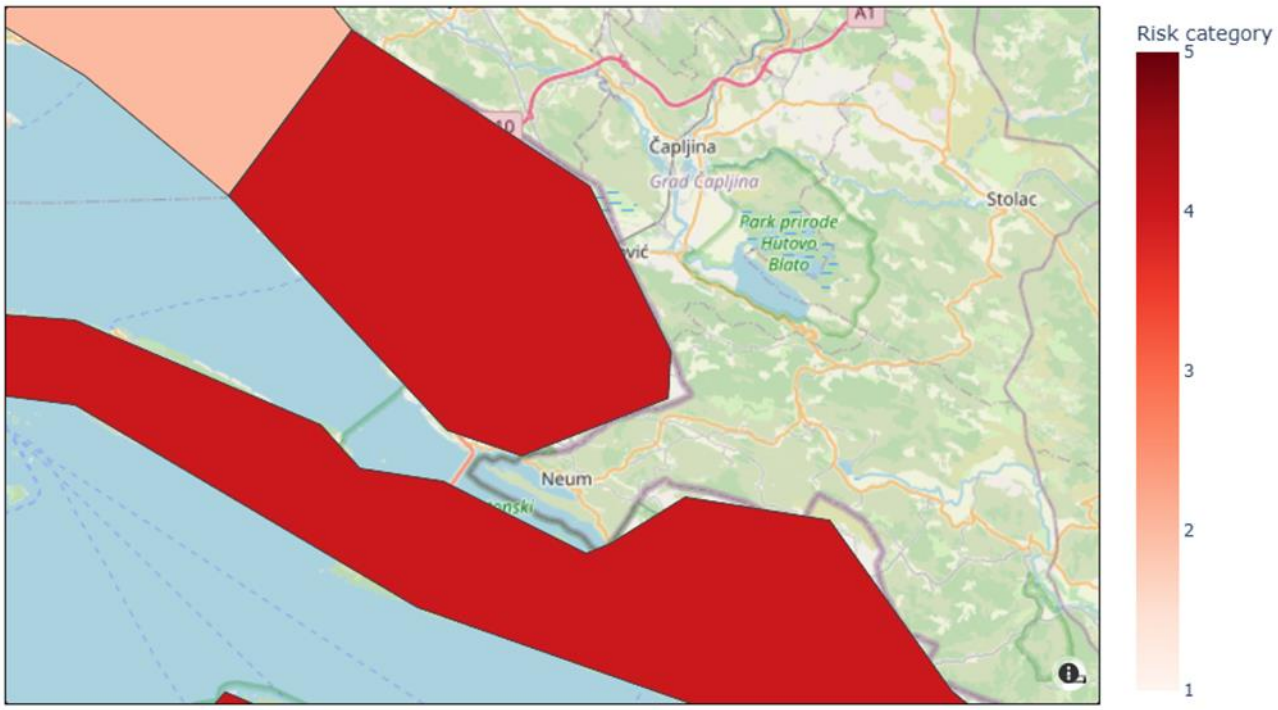


Fig 2-12 Geographic distribution of drought risk in Dubrovnik-Neretva County: for scenario SSP 5-8.5 until 2050

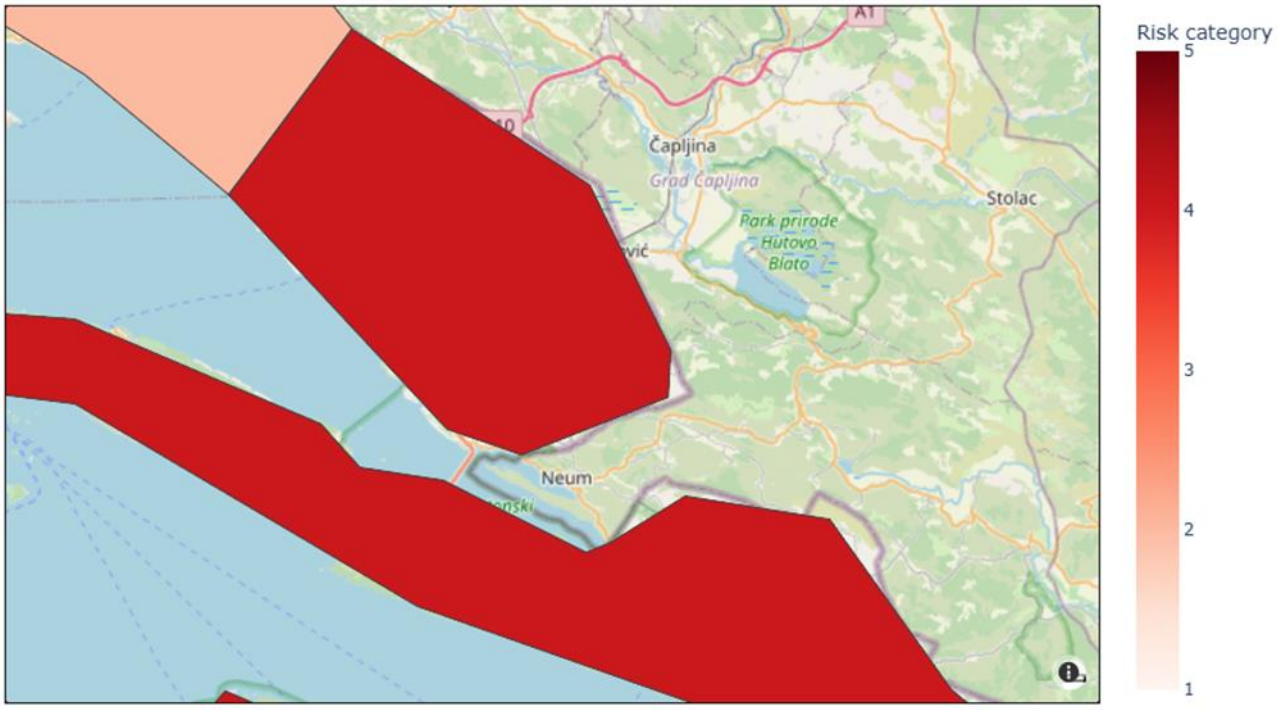


Fig 2-13 Geographic distribution of drought risk in Dubrovnik-Neretva County: for scenario SSP 5-8.5 until 2080

## 2.3 Risk Analysis

### 2.3.1 Workflow #1: Wildfires risk management

#### 2.3.1.1 Hazard assessment

Wildfires hazard analysis in the Municipality of Kula Norinska is done on level of statistic settlements which is the smallest administrative unit in Croatia. The analysis shows three key results:

1) The intensity of wildfires risk ranges from low to moderate all the way to high. Results show no change in the level of the risk till the end of the century.
2) Geographic dimension shows that the risk is the biggest (moderate to high) in the central part of the Municipality which borders the protected wetlands area. The superficies of these two areas combined make up half of the Municipality.
3) The analysis does not consider an anthropogenic element since majority of the wildfires in the wetlands are induced by humans and therefore are unpredictable regarding the intensity and superficies.

*Table 2-1 Data overview workflow #1*

| ***Hazard data*** | ***Vulnerability data*** | ***Exposure data*** | ***Risk output*** |
|---|---|---|---|
| ***Protected area distribution, ecosystem*** | Human, ecological, economic | Buildings, infrastructure, land cover, settlements | Wildfires risk categories (1-5) |

#### 2.3.1.2 Risk assessment

The assessment of the forest fire risk in the municipality of Kula Norinska through FWI provided us with results that were categorized for the entire area of the municipality (Figure 2-2 to 2-4). Integrating hazard, exposure, and vulnerability data provided a comprehensive risk classification into five categories (1 – lowest risk; 5 – highest risk). The geographical analysis shows an even distribution of risk with respect to its categories.

The peripheral settlements of the municipality in the far north and south have a high risk of forest fires. These are areas outside the wetlands: the north is a sparsely populated zone of karst hills covered with very sparse vegetation. On the contrary, the southern edge of the municipality is a densely populated agricultural area covered by large and small rivers (Neretva and Norin) and vast wetlands. Although these two parts are in the same low risk category, they have opposite population, economic and ecological characteristics. Therefore, we can draw two different patterns regarding the risk of forest fires. The first one refers to the northern periphery where the arid karst terrain and shrubby vegetation (Mediterranean macchia) encourage afforestation and the implementation of rainwater harvesting solutions in the settlements. Rainwater harvesting systems should be used by local households and holiday homes as well as firefighters.

The central part of the municipality shows a high to very high risk. This area borders protected wetlands that are often caused by nature or human activity. This area requires urgent action at local, regional and national levels of management due to the periodic devastating burning of protected wetlands that has a devastating effect on biodiversity, forests on the adjacent karst hills, households and sometimes even small plots of arable land. In addition to law enforcement, there are other actions that need to be taken: education of the local population, environmental awareness campaigns, and the development of sustainable ecotourism.

### 2.3.2 Workflow #2: Droughts risk management

#### 2.3.2.1 Hazard assessment

Droughts hazard analysis in the Municipality of Kula Norinska, also done on level of statistic settlements, shows three key results:

1) The intensity of droughts ranges from low to moderate (which is the most common) all the way to very high. Till the end of the century the situation should not change significantly.
2) Geographic distribution of certain values determines the highest risk in the southern and central parts of the Municipality and the lowest in the northern part. This situation is going to be even more distinct till the end of the century. It is an area of the highest population concentration with agricultural significance. At the same time, they also cover the wetlands.
3) Future droughts will have a negative impact on biodiversity in the wetlands. On the other hand, they will increase greenhouse gas emission from dry muddy soil that used to be covered with water.

*Table 2-2 Data overview workflow #2*

| *Hazard data* | *Vulnerability data* | *Exposure data* | *Risk output* |
|---|---|---|---|
| **Precipitation, air temperature, solar irradiance, soil moisture** | Socioeconomic factors, Preparedness level | Population density, land use, agricultural development | Droughts risk categories (1-5) |

#### 2.3.2.2 Risk assessment

Integrating hazard, exposure, and vulnerability data provided a comprehensive risk classification into five categories (1 – lowest risk; 5 – highest risk), as depicted on the relative drought risk maps (Fig. 2.7-2.13).

The droughts risk assessment in the Municipality of Kula Norinska provides us with knowledge of its uneven distribution and endangered areas that may face an absurd situation of water scarcity in the freshwater-rich territory.

Droughts are, and will be, the biggest problem in the Municipality that leans on the wetlands. Their impact would be more negative for biodiversity than the local population and its activities because the water supply system is stable and the agricultural area is very small and divided into small parcels of arable land that is easy to irrigate. On the other hand, water deficiency in the wetlands would cause irreparable damage to the unique and fragile ecosystem.

This issue is furthermore reinforced by the process of salinization of the Neretva River which would cause even more damage to agricultural irrigation and biodiversity of the wetlands.

## 2.4 Preliminary Key Risk Assessment Findings

This **bar diagram** (Figure 2-14, 2-15, 2-16) shows **absolute exposure** under three scenarios: Historical, SSP1-2.6, SSP3-7.0. Sharp upward leap from **Historical** to **SSP3-7.0**, signals almost full **Municipality exposure** while **SSP1-2.6** sits between, hinting at some mitigation but still above baseline. Immediately flags how **future pathways** magnify risk.

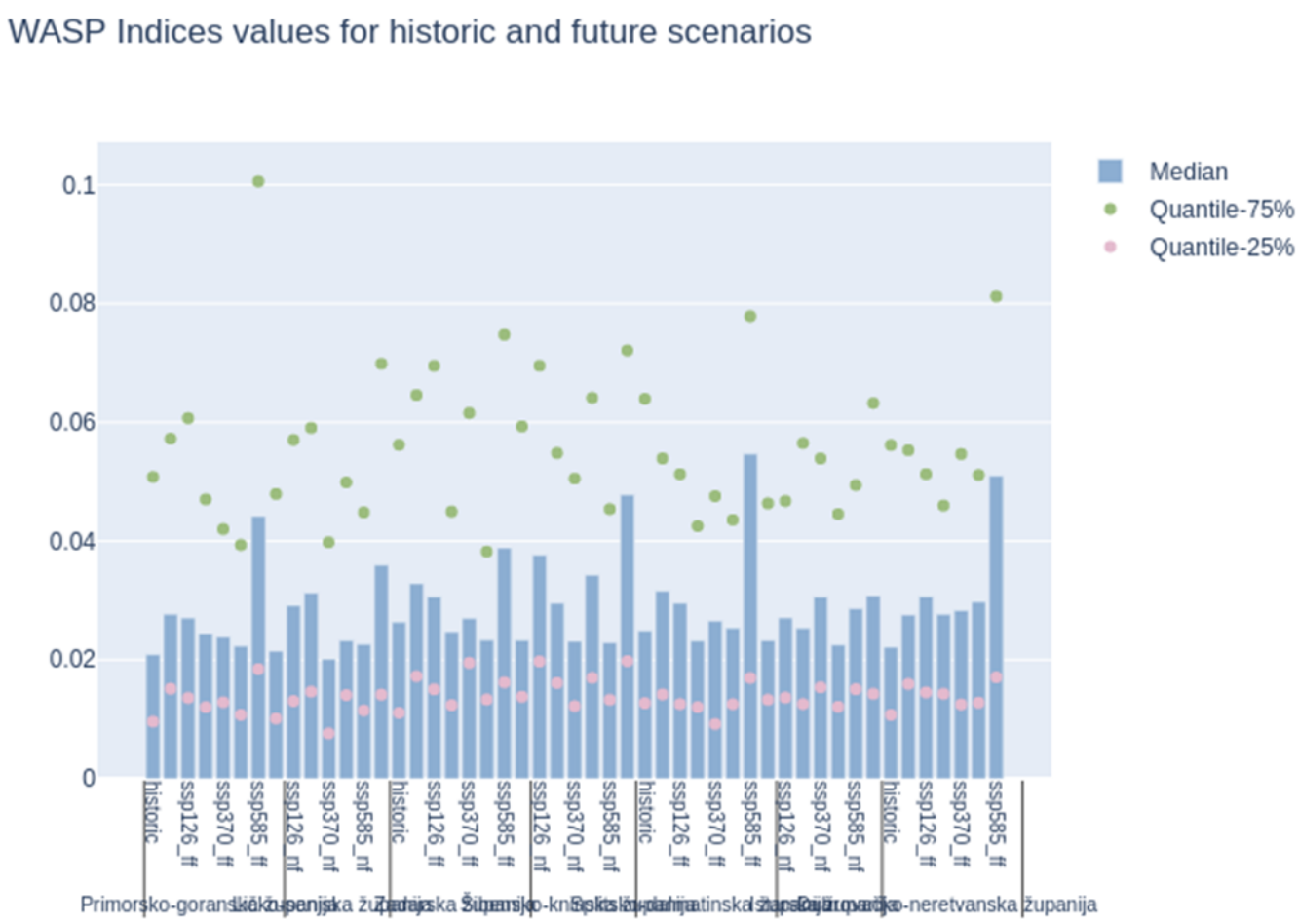


Fig 2-14 WASP indices for historic and future scenario for coastal counties in Croatia including Dubrovnik-Neretva County

**The diagram of stacked bars** (Figure 2-14) breaking exposure into **Low**, **Medium**, **High** categories provide us with historical scenario dominated by **Low** exposure, virtually no **High** slice. Area under **SSP1-2.6**, **Medium** chunk expands noticeably while **SSP3-7.0** tilts heavily toward **High** Exposure Visual Proof of escalating vulnerability.

This diagram provides comparison of absolute drought hazard (WASP value) change in the future. It contains values of median, q25 and q75 risks at NUTS3 level for historic and future scenarios in the NUTS2 area. Absolute higher values mean more severe precipitation deficit for a region compared to the others in the same dataset. Drought hazard metrics are absolute and comparable among datasets and can thus help us to understand if changes on relative drought risk of NUTS3

regions are accompanied by an increasing drought hazard. Changes in exposure and vulnerability also affect drought risk.

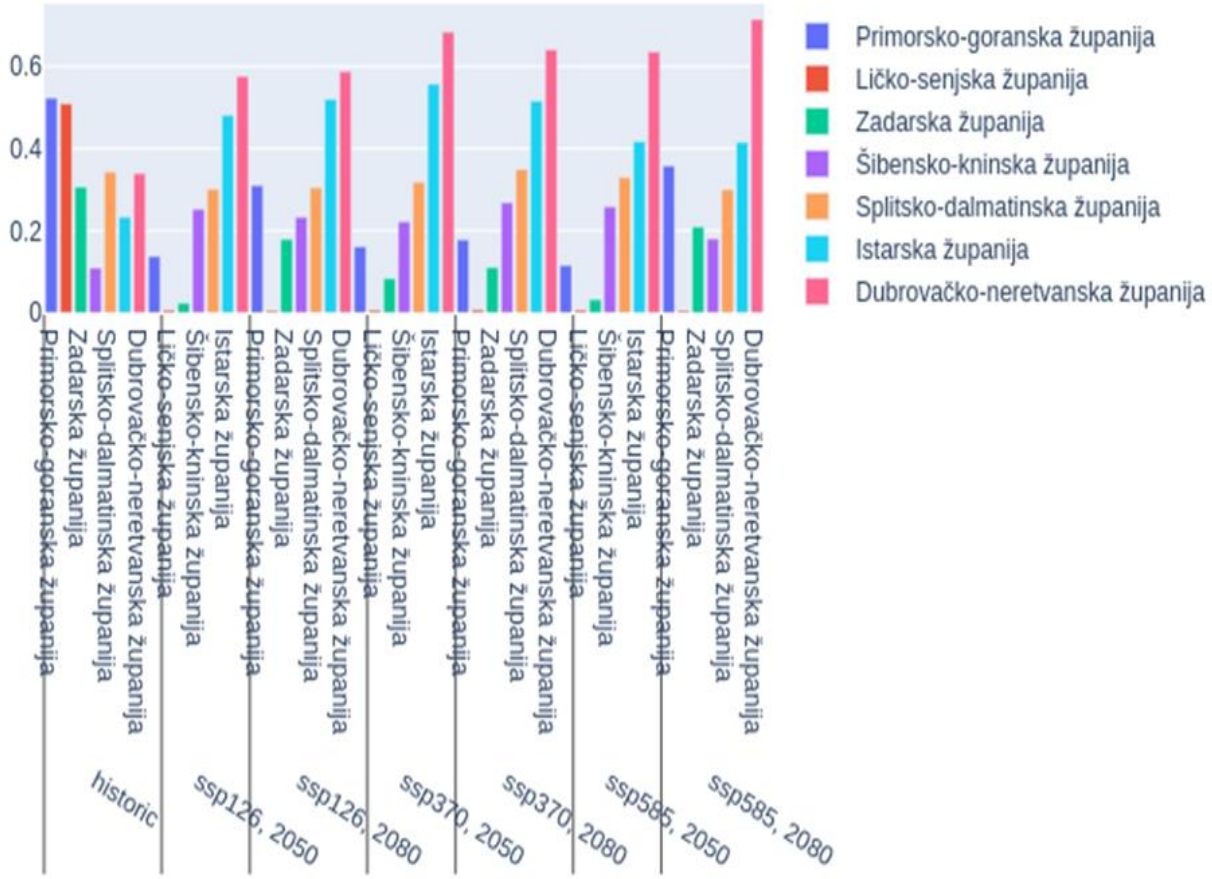


Figure 2-15 Line chart for historic and future relative drought risk in the focal area (NUTS2)

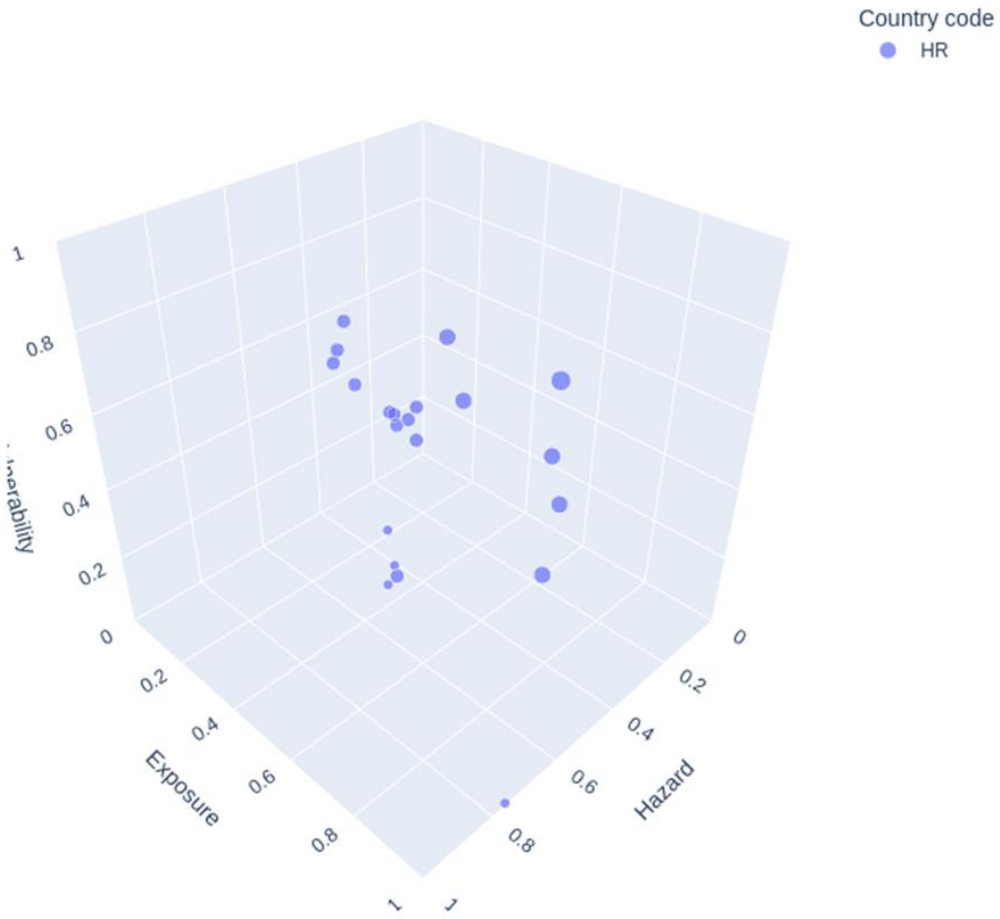


Fig 2-16 Drought risk dimensions (interactive chart; marker size indicates risk category)

**Composite of Hazard and Exposure** (Figure 2-16) This is a static capture of interactive scatter chart where hazard, exposure, and vulnerability are represented by three spatial dimensions and categorized risk is represented by marker size. It is a useful visualization enabling us to explore drought risks at national level.

### 2.4.1 Severity

Considering historical and current trends we can conclude that the risk in the Municipality of Kula Norinska is **severe during the warm part of the year**, especially during the summer months. The risk got more severe from 2020 when air temperature, solar irradiance and droughts during the summer months got more frequent.

Currently climate risk is **not high in impact** in the Municipality of Kula Norinska regarding the financial damage, sectors of economy or human resources. On the other hand, it is devastating for natural resources and biodiversity and has a negative impact on greenhouse gas emissions.

Therefore, it is very hard to measure its total impact especially since the human factor is closely deeply involved in the climate risk impact.
Combined impact of droughts and wildfires **unleash irreversible consequences** in shape of destruction of ecosystems and biodiversity. It is the most severe repercussion that has an especially devastating effect in a unique habitat of legally protected Mediterranean wetlands.

### 2.4.2 Urgency

If the current climate change continues these risks in the Municipality of Kula Norinska could have a **major impact till the end of the decade**. Therefore, it would be necessary to act as soon as possible, primarily to stop the man-inflicted fires in the wetlands. The most important step is to work with stakeholders through raising awareness of how damaging firing of the wetlands is to biodiversity and greenhouse gas emission.
In case of continuing with man-inflicted firing of the wetlands, the fire hazard, combined with droughts, is expected to **worsen significantly soon** and damage to biodiversity would be irreparable.
Climate hazards in the Municipality of Kula Norinska are **not associated with sudden events** but have a certain connection with slow onset processes such as salinization of the Neretva River, the principal watercourse in the delta. The mechanism of salinization of the river and the water sources at the edge of the wetlands is not satisfactory researched by now. Since preliminary research shows no evidence of the sea level rise in the delta area, it is possible that salinization is due to slow depression of terrain. Nevertheless, salinization puts an additional pressure on urgent action because possible salinization of wetlands would additionally damage the wetlands ecosystem and biodiversity.
The two climate hazards **have the potential to persist**. The current year (2025) is the sixth in the row for summer droughts while the problem of fires in the wetlands does not show a sign of permanent satisfactory resolution.

### 2.4.3 Capacity

Now, our climate risk management measures are **still in the planning stage**. Our idea is to establish a consortium for the wetlands preservation that would involve all the relevant stakeholders. Such an informal body would have a function of communication among various parties and support for environmental projects and sustainable development.
The Municipality of Kula Norinska does **not have sufficient financial capacity** necessary to address the respective climate risks. These aspects demand continuous cooperation of the Municipality with financial institutions on national and EU levels. There is a **human capacity** that still needs to be upgraded especially in the sense of raising awareness, knowledge and using the existent learning potential. On the other hand, **natural** (resource management and ecosystem health) and **physical** (ability to forecast and warn and provide critical infrastructure and services) capacities are sufficient just as **social capacities** (social inclusion, equity, representation, favourable policy environment, willingness of decision makers to address the problem).
Our region has **specific interventions** in the form of various documents and financial aid in case of natural hazards. However, a set of detailed hazard mitigation and adaptation plans and acts are still missing. The climate change policy in the region is still primarily reactive instead of active and it is primarily set toward dealing with consequences instead of acting in advance to diminish the climate hazards.

## 2.5 Preliminary Monitoring and Evaluation

We **learned from the first phase** of the climate risk assessment what we already know from our previous research: that dealing with stakeholders can sometimes be very demanding, hard and even frustrating. It is to some extent astonishing and even fascinating how nowadays, when scientific development has reached spectacular heights, certain population groups are still deeply rooted in various preconceptions and behavioural patterns that are opposite to the scientific truth. One of these attitudes is total denial of scientific understanding of contemporary climate change and which serves as justification against any kind of behavioural change.

On the other hand, we **encounter most difficulties** collecting data from weather stations – it is still slow and bureaucratized process.

The **feedback** that we have **received from the stakeholders** varies regarding their attitudes concerning the way that nature protection impacts their way of living and activities. There are disparate responses ranging from positive and favourable, skeptical and distrustful all the way to negative and confronting. However, speaking generally, positive and affirmative feedback prevails among the stakeholders with many of them expressing content that such type of the EU project was conducted in a small peripheral rural Municipality like theirs.
At this stage of the analysis, we assess that we have successfully determined and addressed all the relevant stakeholders. We will keep on with additional research to check on and, if necessary, correct our current knowledge about the relevant stakeholders.

There is **no new data available** regarding the risks, or the system researched in the area although additional climatological data would certainly be useful for our research in the future. Continuous communication with stakeholders and research into their attitudes is always welcome to achieve the necessary behavioural change.

## 2.6 Work plan

The Individual Follow Up Plan for phase 1 included the implementation of the following activities

**Phase 1: Initial Climate Risk Assessment**

In Phase 1, Kula Norinska will collaborate with regional academic partners and utilize the CLIMAAX Toolbox to conduct a standardized climate risk assessment. The focus will be on gathering baseline data using national-level climate information relevant to the Neretva Delta.

This will involve:

• Collecting and analysing existing environmental and climatic data.

• Identifying key climate-related vulnerabilities in the municipality, particularly regarding flooding, drought, and saltwater intrusion.

• Engaging with local experts and stakeholders to validate the data and preliminary findings.

**Milestones Phase 1 (M1–M6)**

**Milestone 1. Establishment of the project team, including the hiring of key personnel such as the Project Manager and Technical Coordinator.**

**Milestone 2. Development of ToRs for both Kula Norinska personnel and subcontractors.**

**Milestone 3. Finalization of contracts for key subcontracting roles.**

**Milestone 4. Full implementation of Phase 1 activities, utilizing the CLIMAAX toolbox.**

**Milestone 5. Active attendance and engagement in the CLIMAAX workshop in Barcelona (May–June 2025) to exchange knowledge and best practices.**

**Milestone 6. Organization and completion of the first workshop to engage local stakeholders, gather input, and discuss climate risks.**

**The work plan for the remaining phases of the project** consists of workshops with stakeholders combined with the field work. We aim to research the biodiversity of local wetlands and present it on the Internet and personally to the relevant stakeholders to make the research results public and available. We also want to introduce citizen science concepts to the local population, especially to younger generations. The benefits of its implementation would be multiple: incite people (especially teenagers) to spend more time in the open air and to use modern technology, primarily mobile phones, in the manner that is useful for environmental conservation and nature protection.

We are not planning to study the process of salinization of fresh water in the delta region. There are a few reasons for that. The first one is a result of the time limit just as insufficient financial and human resources. Such a process should be researched and monitored during a period of several consecutive years. Therefore, it demands adequate scientific equipment and trained personnel. The second reason is the fact that salinization cannot be directly linked to climate change but must be understood as part of the epeirogeny movements, the movements of terrain. It is necessary to measure such movements through longer periods of years and to use sophisticated equipment to obtain valid results.

# 3 Conclusions Phase 1- Climate risk assessment

This climate risk assessment as the Phase 1 of the CLIMAAX project in the Municipality of Kula Norinska, provided us with knowledge and better understanding of local issues generated the global climate change. Our research was conducted in a small area when considering the superficies and the population number with exclusively rural settlements. Such a restricted area is extremely interesting and rewarding for scientific research because of diversity of landscapes (from karstic hills and alluvial river plain to the Mediterranean wetlands) and immense biodiversity.

At the end of this climate risk assessment, we may draw some **conclusions regarding climate hazards and risks** in this small Municipality.

1. Better understanding of climate data obtained from nearby weather stations is insufficient without communication with indigenous population who depend on local nature resources, and scientists who research local wetlands. This so-called local knowledge helps us to see a wider picture of climate change in a small area.

2. Our preliminary field research showed that the Municipality is primarily exposed to two climate hazards: droughts and fires. Work on climate risk assessment confirmed our previous knowledge and showed that the two hazards are interconnected. Combined impact of these two hazards has devastating effect on local wetlands and their biodiversity.

3. The research showed that the impact on nature, especially on biodiversity and ecosystem of wetlands, is higher than that impact on humans and their activities such as farming and tourism. This fact puts additional pressure on climate change adaptation and mitigation policies since a part of the local population is not willing to support policies that do not directly benefit the local population.

4. Devastating impact of certain individuals on the wetlands can be addressed accordingly and confronted using scientific knowledge. There is a willingness to cooperate among majority of stakeholders that should be accepted and deepened.

5. Climate risk assessment did not address the issue of salinization of the Neretva River since it is necessary to conduct more comprehensive research during a longer continuous period to get valid data. Such research is not complete without understanding geological and geomorphological dimensions of the issue.

The first phase of the project also provided us with some **key findings** that we hold as an important base for further research. Primarily it is important to point out that stakeholder analysis showed the involvement of a good few stakeholder groups: local and regional decision makers, environmental NGOs, farmers, tourism sector, individuals who use nature resources (such as hunters). Since we deal with limited areas and the small number of inhabitants the number of stakeholders involved in the process is surprisingly high.
The issue of man-inflicted fires in the wetlands, as one of two most important climate hazards in the Municipality proved to be especially delicate. Although such acts are illegal and in addition extremely devastating for local wetlands this issue has not been satisfactory addressed by now. There is a

certain half-heartedness among local and regional law enforcers when dealing with this issue because both do not want to enter conflict with the local population. Therefore, it is going to be necessary to deal more with certain stakeholders to challenge and hopefully defeat their preconceptions and unscientific concept regarding climate change and biodiversity conservation. On the other hand, we found out that there is a solid ground for dissemination of valid scientific knowledge among the local population.

A small peripheral rural Municipality lacks financial and human (scientific) resources to deal with all the issues that we address in this deliverable. The support of the local government is steady and immensely significant just as willingness to cooperate with the scientific Municipality to deal with named issues. With such support we are firm in our view that those issues can be appropriately addressed and dealt with.

# 4 Progress evaluation and contribution to future phases

**Connection Between the Delivery of the Document for Phase 1 and Subsequent Phases**
The focus of Phase 1 was a comprehensive assessment and clear definition of fire and drought risks in the Kula Norinska region, which is part of the Dubrovnik-Neretva County. The deliverables, including detailed risk maps, vulnerability profiles, and clearly defined high-risk areas, provide a strong foundation for targeted planning and implementation of adaptive interventions in the upcoming phases.

The specific output document of this delivery, such as the spatial identification of high-risk areas (Kula Norinska, part of Dubrovnik-Neretva County), detailed vulnerability mapping, and clarity on the urgency and severity of risks—directly informs future project activities. These results will be crucial for guiding Phase 2, which focuses on deeper data integration, enhanced predictive analyses, and refinement of adaptation strategies.

Phase 3 will build upon this by involving stakeholders through participatory processes, capacity-building workshops, and the joint development of adaptive policies tailored specifically to the identified high-risk areas.

**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* |
|---|---|
| *Designation of Climate Risk Assessment* | *Completed* |
| *At least two workflows successfully applied and documented: (I) Data Collection Workflow; (II) Risk Assessment Methodology* | *Completed* |
| *Over 50 stakeholders (including farmers, NGOS, public officials) engaged in workshops and consultations by month 22 (December 2026)* | *Completed* – in the Phase 1 engaged 31 stakeholders, rest to be included in the Phase 2 |

*Table 4-2 Overview milestones*

| *Milestones* | *Progress* |
|---|---|
| *1. Establishment of the project team, including the hiring of key personnel such as the Project Manager and Technical Coordinator* | *Completed* |

| *Milestones* | *Progress* |
|---|---|
| *2. Development of ToRs for both Kula Norinska personnel and subcontractors* | *Completed* |
| *3. Finalization of contracts for key subcontracting roles* | *Completed* |
| *4. Full implementation of Phase 1 activities, utilizing the CLIMAAX toolbox* | *Completed* |
| *5. Active attendance and engagement in the CLIMAAX workshop in Barcelona (May-June 2025) to exchange knowledge and best practices* | *Completed* |
| *6. Organisation and completion of the first workshop to engage local stakeholders, gather input, and discuss climate risks* | *Completed* |

**Comprehensive Initial Assessment of Fire and Drought Risks:**
A baseline has been established that includes precise identification of fire and drought hazards, vulnerabilities, and exposed sectors. This comprehensive foundation serves as the basis for Phase 2 activities, where further integration of updated climate and socioeconomic data will improve assessment quality and prediction accuracy.

**At least two workflows successfully applied and documented: (I) Data Collection Workflow; (II) Risk Assessment Methodology:**
Detailed spatial mapping clearly identified districts that require urgent adaptive interventions. Phases 2 and 3 will directly build on these results by developing targeted adaptation and risk management plans specifically tailored to the identified high-risk areas.

**Stakeholder Engagement:**
Comprehensive mapping as well as preliminary consultations and analyses carried out in Phase 1 provide a clear plan for involving more than 50 relevant stakeholders during Phase 2 and 3. The first workshop engaged 31 stakeholders and during workshops in the future more than 50 stakeholders (as proscribed by the Individual Follow Up Plan will be engaged (till December 2026). The workshops will validate findings, co-design adaptive interventions, and facilitate knowledge transfer, with an emphasis on practical applicability and acceptance of recommendations developed in earlier phases.

This deliverable from Phase 1 significantly contributes to future phases by:

- Providing baseline data and comprehensive vulnerability analyses, directly facilitating targeted, informed adaptation planning and resource allocation in subsequent phases.

- Offering clear geographic and thematic prioritization (identification of high-risk areas for fires and droughts), which leads to targeting interventions, adaptive practices, and socio-economic resilience-building measures.
- Supporting the planning and implementation of stakeholder engagement activities, including capacity-building workshops, enabling local stakeholders to actively participate in refining and validating future risk assessment outcomes.
- In summary, the completion of Phase 1 establishes a strong foundation that enables the CLIMACHANGE project to effectively proceed with detailed assessments and adaptation strategies, ultimately enhancing regional climate resilience, economic sustainability, and long-term stability of the Kupa Norinska municipality area within the Dubrovnik-Neretva County

# 5 Supporting documentation

All outputs produced during the first stage of CLIMAAX project – risk assessment – are classified and listed in this section. It includes:

**Main report**

Climate risk assessment for climate hazards in the Municipality of Kula Norinska – Phase 1
A comprehensive analysis that contains identification of climate hazards and their geographic dimensions, definition of stakeholders, mapping of exposure and vulnerability, risk exploration and analysis, and preliminary findings.

Format: PDF

**Visual Outputs (infographics, maps, diagrams)**

Fire risk in Municipality of Kula Norinska (three maps)

Drought risk in Municipality of Kula Norinska (seven maps)

These maps show geographic dimensions of the relevant hazards.

Hazards exposure and vulnerability in Municipality of Kula Norinska (three diagrams)

Diagrams that provide further information regarding the climate hazards in the Municipality.

Format: .jpg

**Communication Outputs**

Official press release by the Municipality of Kula Norinska from 1st of April 2025 with general information about the project.

OPĆINA KULA NORINSKA MEĐU ODABRANIM EUROPSKIM REGIJAMA U OKVIRU CLIMAAX PROGRAMA - kulanorinska.hr

All the outputs listed are prepared for sharing in the Zenodo repository.

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**Stakeholder Mapping and Analysis (Phase 1)**

The key stakeholder groups for the C-RAKUN project were identified as:

- **Local Authorities (Kula Norinska Municipality)** – the lead entity in governance, infrastructure and public services. High-level policymakers in the municipality will be both highly interested in and highly influential over project outcomes.
- **Croatian Waters (Hrvatske vode)** – the national water-management agency responsible for river regulation and salinity control. As the authority on water distribution and flood control, it has high influence and a strong interest in the project's focus on salinization and water resources.
- **Farmers and Agricultural Producers** – local growers (especially vegetable farmers in the Neretva Delta) highly vulnerable to flooding, drought and saltwater intrusion. They have very high interest in adaptation measures, while their direct influence is moderate.
- **Tourism Operators** – local businesses (hotels, tour guides, etc.) dependent on the delta's natural beauty and climate. These stakeholders have moderate interest in climate impacts (e.g. on seaside amenities or wetland sites) and moderate influence, given the economic importance of tourism.
- **Hunters and Fishing Communities** – local hunting and fishing clubs concerned with biodiversity and water quality. They are highly interested in ecosystem health but have relatively low formal influence.
- **Local NGOs and Environmental Groups** – civic organizations active in conservation and education. They are very interested in the project (advocating sustainable policies) but generally have low formal decision-making power.
- **Neighbouring Municipalities (Croatia and Bosnia-Herzegovina)** – nearby local governments sharing the Neretva watershed. They have medium interest in transboundary issues (water management, biodiversity) and modest influence, highlighting the need for collaborative outreach.
- **Academic and Research Partners** – regional universities and CLIMAAX experts supplying technical support (e.g. University of Dubrovnik, University of Split). They possess high interest in research outcomes and medium influence via guidance.

These groups were plotted on an influence–interest matrix. As expected, Kula Norinska's municipal leaders and Hrvatske vode fall in the *high-influence/high-interest* quadrant ("Manage Closely") due to their central roles. Farmers, local NGOs, hunters/fishers and tourism operators occupy the *high-interest/low-to-moderate-influence* segment ("Keep Informed/Consult"), since they stand to benefit greatly from adaptation measures. Neighbouring municipalities and academic partners lie at moderate levels, requiring ongoing updates and engagement. The matrix thus guides targeted engagement: e.g. close collaboration with the municipality and water authorities, regular consultation and feedback loops with farmers and NGOs, and information-sharing with tourism and academic partners. This categorization aligns with CLIMAAX guidelines on stakeholder analysis.

| Stakeholder Group | Interest Level | Influence Level | Engagement Strategy |
|---|---|---|---|
| Kula Norinska Municipality | High | High | **Manage closely** (active involvement in planning and decisions) |
| Croatian Waters (Hrvatske vode) | High | High | **Manage closely** (joint planning, data-sharing) |
| Farmers & Agricultural Producers | High | Medium | Keep informed / consulted (workshops, training) |
| Local NGOs & Environmental Groups | High | Low | Keep informed / involved (awareness campaigns) |

| Stakeholder Group | Interest Level | Influence Level | Engagement Strategy |
|---|---|---|---|
| Tourism Operators | Medium | Medium | Keep informed (integration with sustainable tourism planning) |
| Hunting & Fishing Communities | High | Low | Keep informed / involved (community consultations) |
| Neighbouring Municipalities (HR/BIH) | Medium | Low | Keep informed (regional meetings, coordination) |
| Academic & Research Partners | High | Medium | Collaborate (technical guidance, joint studies) |

The above mapping ensures that stakeholder interests are matched with appropriate engagement approaches. For example, the municipality and Croatian Waters are engaged directly in project governance, while groups like farmers, NGOs and hunters are regularly informed of progress and consulted for local insights.

**Workshop Report**

A stakeholder workshop was held on 15 July 2025 at Kula Norinska. The workshop opened with welcoming remarks by Mayor Nikola Krstičević, followed by a presentation of the C-RAKUN project by project lead Zoran Mateljak. The agenda brought together roughly 30 participants from municipal departments, Hrvatske vode, farmer cooperatives, NGOs, tourism businesses, hunting/fishing clubs, academic partners and neighboring local governments (see the participant list and agenda below).

Presentations by experts framed the local climate context. Prof. Višnja Bukvić spoke on “Importance of climate and climate change”, and Doc. Ivan Vučković addressed “Restoration of aquatic ecosystems”. In the afternoon, Prof. Nikola Glamuzina discussed “Wetland habitats in climate adaptation” and later presented preliminary results from the Phase 1 risk assessment for Kula Norinska. Prof. Bukvić also presented on “Impacts of climate change on biodiversity”. These talks underscored the roles of flooding, drought, saltwater intrusion and habitat loss in the Neretva Delta.

The final session was an interactive discussion. Participants provided constructive feedback and raised key issues:

- A farmer representative noted that **earlier spring water releases** and **prolonged dry spells** have stressed rice crops in recent years, seeking more reliable irrigation support.
- The local **Croatian Waters** official emphasized a need for shared monitoring data (river salinity levels, groundwater tables) and welcomed coordination on flood control infrastructure.
- An **environmental NGO** attendee advocated public education on wetlands, citing community interest in restoring marshes to buffer floods and supporting wildlife.
- A **tourism operator** asked about ecosystem-based tourism opportunities (e.g. birdwatching on restored floodplains) and expressed concern about mosquito outbreaks in stagnant waters.
- Members of the **hunting and fishing communities** remarked on declining fish stocks and rising saltwater signs in the river; they offered to participate in biodiversity monitoring.
- A council member from a **neighbouring Bosnian municipality** discussed cross-border water-management issues, expressing willingness to coordinate on shared flood warnings.

Overall, attendees praised the project’s emphasis on ecosystem restoration and expressed enthusiasm about applying the CLIMAAX toolkit locally. Many saw the workshop as a valuable forum to exchange ideas. In response to queries, the project team clarified next steps, including further

data collection and follow-up meetings. A communal lunch allowed informal networking among stakeholders. The workshop's outcomes included an agreed list of local climate concerns and a commitment from participants to stay engaged in project activities.

**Bilateral Consultations Summary**

Following the initial stakeholder analysis, the project team conducted one-on-one consultations to refine data and capture specific needs. These bilateral meetings (March–May 2025) covered the project scope and local priorities. A summary is given below:

| Date | Stakeholder | Format | Key Topics / Outcomes |
|---|---|---|---|
| 21 Mar 2025 | Mayor of Kula Norinska (Nikola Krstičević) – Municipality office | In-person meeting | Discussed major climate hazards (sea-level rise, floods, salinity) and municipal adaptation goals. Mayor emphasized needs for improved irrigation infrastructure and updated flood warning systems. |
| 31 Mar 2025 | Hrvatske vode – Regional Water Management Office | Video conference | Reviewed hydrological data (river discharge, salinity profiles). Jointly identified data gaps on saltwater intrusion. Agreed on future data-sharing and technical support. |
| 10 Apr 2025 | Kula Norinska Farmers' Cooperative | Farm-site visit | Farmers reported decreased freshwater availability and crop damage from saltwater. Collected input on vulnerability hotspots (e.g. low-lying rice fields). Highlighted priority adaptations (canal lining, drought-tolerant crops). |
| 18 Apr 2025 | **Vipera NGO** (Local environmental NGO) | Online call | Discussed wetland conservation and community awareness. NGO shared historical maps of delta wetlands and offered to help map current marsh locations. Suggested public outreach (school programs, info boards). |
| 25 Apr 2025 | Neretva Tourism Board | Municipal office | Tourism operators expressed interest in eco-tourism linked to climate resilience (nature trails, birdwatching). Raised concerns about floodplain accessibility in tourist season. Agreed to incorporate sustainable tourism themes into adaptation plans. |
| 05 May 2025 | Kula Norinska Hunters & Fishermen Club | Clubhouse meeting | Hunters/fishers detailed observed declines in native fish and bird populations. Reported soil erosion impacting game habitats. Requested integration of habitat restoration (e.g. reed planting) in project strategy. |
| 12 May 2025 | Neum Municipality (BiH) – Environmental Dept. | Online meeting | Exchanged views on river management and cross-border flood risk. Neum reps shared data on upstream dam releases. Both sides agreed on setting up a joint communication channel for Neretva water levels. |
| 20 May 2025 | University of Dubrovnik – Dept. of Biology | Laboratory meeting | Presented local climate studies (e.g. soil salinization monitoring). Scientists provided high-resolution data and suggested methodologies for biodiversity assessment. Confirmed academic collaboration on data analysis. |

These meetings helped validate risk scenarios (e.g. confirming salinity trends) and shaped the Phase 1 assessment scope. They also built rapport: for instance, fishermen's input on species changes and farmers' notes on irrigation were fed back into risk screening. This approach follows CLIMAAX practice of early bilateral engagement.

**Stakeholder Questionnaire**

A short questionnaire was distributed to stakeholders in April 2025 to gather baseline perceptions of climate risks and priorities. The survey consisted of closed and open questions such as:

1. **Primary climate concerns:** Which of the following are most concerning for Kula Norinska? (Options: Sea-level rise/saltwater intrusion; River flooding; Drought/heat; Extreme storms; Other).
2. **Priority sectors:** In your view, which sector needs the most urgent adaptation support? (Agriculture; Water management; Biodiversity/conservation; Tourism; Infrastructure; Other)
3. **Awareness and preparedness:** How informed do you feel about local climate change impacts? (Likert scale: Very low–Very high)
4. **Willingness to engage:** Are you willing to participate in future project activities (workshops, field days, monitoring)? (Yes/No/Maybe)
5. **Open comments:** Please list any specific local issues or adaptation measures you consider important (open text).

Of the ~25 respondents (including farmers, municipal staff, NGO members, etc.), the aggregated findings indicated strong alignment with project objectives:

- **Saltwater intrusion and water management were top concerns:** 80% of respondents rated *saltwater encroachment* (sea-level rise effects) as a major threat, and 70% cited *drought and irrigation shortages* as high priority. Flood risk was seen as moderate by 40%. This reflects the known vulnerability of coastal delta agriculture.
- **Agriculture and water infrastructure lead adaptation priorities:** 75% identify *irrigation improvements* (e.g. canal modernization) as an urgent need. About 60% prioritized *biodiversity/wetland conservation* (consistent with local NGO emphasis), and 50% noted *flood protection* as important. Tourism resilience was selected by 35%, indicating it is secondary to farming and ecosystems.
- **Information gap is moderate:** A majority felt only somewhat informed about climate impacts, underscoring the need for awareness activities (as planned).
- **High willingness to participate:** Over 90% answered “Yes” or “Maybe” to future involvement. For example, most farmers and NGO members volunteered for workshops or joint field monitoring.

In open comments, farmers frequently mentioned **poor drainage and soil salinity** as urgent problems, while NGOs emphasized **school education on wetlands** and **community tree-planting**. These results confirm that stakeholders view water/irrigation issues and ecosystem health as primary. The questionnaire thus provided a baseline of local priorities, guiding the project to focus its initial adaptation strategy on water resource management, habitat restoration, and stakeholder training.

**Ongoing Engagement**

After the July workshop, the project team maintained active communication with stakeholders. A series of regular online consultations (e.g. monthly video calls) was established with different groups: continuing dialogues with farmers’ associations, NGOs, and municipal departments. In these virtual meetings the team provided updates on progress and sought additional input. Informal feedback collected after the workshop was generally positive. For instance, several farmers followed up to report this year’s crop stress due to changing irrigation schedules, and an NGO representative shared recent wildlife survey data. These inputs echoed findings in other CLIMAAX projects, where informal stakeholder feedback on hazards and capacity gaps is actively used.

Stakeholders appreciated the participatory approach: many noted that hearing the scientific presentations helped them understand long-term risks. However, some suggested improvements. For example, farmers requested more hands-on demonstrations (such as field trials of salt-tolerant crops), and NGOs asked for materials in simple language. In response, the engagement plan was

adapted. The team scheduled additional field visits for Phase 2, arranged practical training (e.g. irrigation management workshops).

This iterative process, collecting informal feedback and adjusting outreach, reflects the CLIMAAX emphasis on inclusive participation. By continuously consulting stakeholders (online and by phone) and responding to their concerns, the project has built trust and ensured that its approach remains grounded in local needs. The adjustments made (more field-based events, tailored communication) aim to maximize relevance and stakeholder ownership of the adaptation strategies going forward.

Kula Norinska Hunters & Fishermen Club - Clubhouse meeting

Mayor of Kula Norinska – Municipality office


Stakeholder workshop at Kula Norinska

Progress in Data Collection (KPI Reference: D.1)

During Phase 1, significant progress was made in identifying, accessing, and pre-processing datasets required for the regional drought risk assessment in line with CLIMAAX recommendations.

*Key Achievements:*

- *Official historical data on the measurement of average monthly air temperature and monthly precipitation from nearby weather stations of Metković, Opuzen and Ploče. (Croatian Meteorological and Hydrological Service)*