CLIMAAX
climate ready regions

Deliverable Phase 1 – Climate risk assessment

BioProWRAP

Greece / Region of Eastern Macedonia & Thrace (REMTH)

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

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Document Information

Deliverable Title	Phase 1 – Climate risk assessment
Brief Description	This is a deliverable that presents the Phase 1 results of the BioProWRAP project, which was developed under the CLIMAAX framework, and is focused on utilizing public and local data to pave the way for accurate wildfire risk assessment. The aim of the project is to utilize such assessments, in order to guide targeted forest biodiversity monitoring efforts, prioritizing vulnerable areas high in natural and economic value in the Region of Eastern Macedonia and Thrace (REMTH). The work was carried out by the team of REMTH with external consultancy support, provided by the University of Thessaly (UTH), Greece.
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Country	Greece
Region/Municipality	Region of Eastern Macedonia and Thrace (REMTH)
Leading Institution	Region of Eastern Macedonia and Thrace (REMTH)
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Table of contents

List of figures

List of tables

Abbreviations and acronyms

Abbreviation / acronym	Description
BioProWRAP	Biodiversity Protection through Wildfire Risk Associated Planning
CLC	CORINE Land Cover
CLIMAAX	Climate Risk Assessment Framework
CRA	Climate Risk Assessment
CPDR	Civil Protection Directorate of REMTH
DEM	Digital Elevation Model
eDNA	Environmental DNA
EFFIS	European Forest Fire Information System
FAIR	Findability, Accessibility, Interoperability and Reusability
GBIF	Global Biodiversity Information Facility
GCM	Global Climate Model
JRC	Joint Research Centre
ML	Machine Learning
NGO	Non-governmental organization
NGS	Next Generation Sequencing
NUTS	Nomenclature of Territorial Units for Statistics
PESPKA	Regional Plan for Adaptation to Climate Change
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
RDF	Regional Development Fund
REMTH	Region of Eastern Macedonia and Thrace
SPBT	Society for the Protection of Biodiversity of Thrace
UTH	University of Thessaly

Executive summary

This deliverable presents the Phase 1 outcomes of the BioProWRAP project, developed under the CLIMAAX framework, with a focus on wildfire risk assessment and biodiversity protection in the Region of Eastern Macedonia and Thrace (REMTH), Greece. The project addresses the urgent need for integrated climate risk management in the region and proposes a comprehensive, data-driven targeted biodiversity monitoring strategy to support regional climate adaptation.

The assessment builds upon prior initiatives and publicly available sources (NASA, CORINE, ECLIPS-2.0), aiming at further incorporating additional existing local data from previous projects (REPORT, RESIST, WILD LIFE FOR EVER, IOLAOS 2, DARDANOS 2), as well as real-time novel data produced through crowdsourcing (Seek/iNaturalist) and genetic (eDNA metabarcoding) biodiversity monitoring. Key actions currently undertaken include:

- Building a comprehensive Climate Risk Assessment (CRA) through extensive scoping, including:
    - **Objective Specification** – The geographical identification of high risk and value REMTH forest areas, to be prioritized for biodiversity monitoring. This will allow the establishment of a wildfire risk-biodiversity monitoring system to plan for longstanding forest preservation.
    - **Defined Context** – The area of REMTH, specifically within the timeframe 1991-2040 will be considered, based on the increased intensity and frequency wildfires observed.
    - **Clear Participation & Ownership** – The established working team includes members from REMTH and the Civil Protection Directorate of REMTH (CPDR). Additional experts from the University of Thessaly (UTH - Laboratory of Biometry) facilitate the execution of the project, while external resources are also used (MI-factor, iNaturalist, Seek). Engagement of stakeholders and the public was made possible through an introductory stakeholder meeting, multiple questionnaires, social media, the CPDR webpage and newsletters.
- During the risk exploration, methodology technical decisions were made (Hazard Assessment for Wildfire - Machine Learning Approach - ECLIPS dataset, Risk Assessment for Wildfire). Multiple trials of the workflow allowed scenario building and method validation. The CLMcom_CLM climate model was chosen for its reliability in short-term projections (2021–2040), while the integration of vulnerability and exposure data (JRC, OpenStreetMap) produced wildfire risk maps across ecological, economic, and population dimensions.
- Three priority areas were identified—**Dadia-Soufli Forest, Frakto Virgin forest, Central Rodopi mountains and Nestos valley**—based on risk profiles, ecological value, and accessibility.

The findings reveal consistently high wildfire hazard levels across REMTH, with increasing risk projected under both moderate and high emission scenarios. The selected priority areas represent critical zones for early intervention, biodiversity monitoring, and adaptive management. In conclusion, the Phase 1 assessment confirms that REMTH faces severe and urgent wildfire-related risks with cascading ecological and socio-economic impacts. The CLIMAAX methodology has enabled the identification of high-risk, high-value areas for targeted biodiversity monitoring. These insights will guide Phase 2 actions, including real-time data integration and refinement of risk assessment, ultimately contributing to a robust regional adaptation strategy.

1 Introduction

1.1 Background .

Eastern Macedonia & Thrace is a Greek administrative region (REMTH), rich in natural resources, that oversees the entirety of Thrace and the eastern part of Macedonia, making up to 10.7% of Greece. REMTH is covered in 15.6% by forests (European Forest Fire Information System; EFFIS), including areas of enormous ecological value like four national parks (Dadia Forest, Rodopi Mountain Range, Evros Delta, Eastern Macedonia & Thrace National Park) and other protected, or socioeconomically important areas (Nestos Delta, local population villages, etc.). REMTH forests have been devastated by wildfires, losing 174,8kha (EFFIS) only in 2023. Consequently, the vulnerability of REMTH has significantly increased, while the available resources have been rendered limited, since they are distributed to respond to numerous pressing challenges. All the above, make wildfires the primary climate-related risk of REMTH, making the need for sustainable wildfire prevention and mitigation planning, imperative. However, economic and technological constraints, along with limited high-resolution and accuracy data, restrict access to comprehensive risk and vulnerability assessment. Within this context, through the CLIMAAX program, BioProWRAP (Biodiversity Protection through Wildfire Risk Associated Planning «BioProWRAP») aims to bring wildfire risk and biodiversity data together to not only prevent future wildfires, but also establish a sustainable biodiversity monitoring plan that will prioritize high-risk, high-value regions. This systematic plan will enable future forest management and restoration efforts, increasing regional climate adaptation, and enhancing forest resilience.

1.2 Main objectives of the project

The BioProWRAP project, implemented within the CLIMAAX framework, aims to provide a comprehensive CRA specifically focusing on wildfire risks in REMTH.

The main objectives of the project are to:

- **Apply the CLIMAAX multi-risk framework** to map hazards, vulnerable zones and affected communities
- **Integrate high-resolution local data** (climate projections, biodiversity data) for precise risk mapping
- **Develop a wildfire-risk–based biodiversity monitoring plan** that prioritizes high-risk, high-value, areas and supports proactive forest management and restoration.
- **Engage regional stakeholders** (civil protection, academia, agricultural cooperatives, local authorities, NGOs) throughout planning and implementation to ensure locally owned, data-driven decision-making.

Expected Benefits of Applying the CLIMAAX Handbook:

- **Benefit from standardized protocols** through the CLIMAAX risk assessment framework that improve data comparability, reduce duplication of effort and accelerate the production of actionable risk maps.
- **Enhance Stakeholder Awareness:** Strengthen understanding of wildfire risks among farmers, local communities, and businesses, as well as their involvement in practical adaptation strategies.

- **Equip REMTH** with data-based insights and best-practices for monitoring biodiversity alongside fire risk, enabling continuous learning and improvements in prevention and mitigation planning.

1.3 Project team

The interdisciplinary and complementary nature of the project team guarantees the precise implementation of BioProWRAP and timely accomplishment of all deliverables within the scheduled time frame. The core team of the BioProWRAP project is composed of following members (Table 1-1):

Table 1-1 Project Management and Core Team of BioProWrap Project.

Name	*Department*	*Expertise*	*Assignment in BioProWrap*
Konstantinos Chouvardas (Msc, Med, MBA)	Civil Protection Department	Mechanical Engineer, Director of Civil Protection Department at REMTH	Operational coordinator and Project Manager, overseeing administrative work, stakeholder engagement and representing REMTH in the Project Coordination Committee and project meetings.
Spyridon Arseniou (PhD)	Department for Regional Policy Planning	Agronomist, Civil Servant of REMTH,Deputy Head of the Department for Regional Policy Planning	Administrative work, scheduling meetings, participation in all project actions and represents REMTH in project meetings.
Leonidas Skerletopoulos, (Msc, MBA)	REMTH	Administrator, Marketing and Communications specialist, Special Advisor to the Governor of REMTH	Engaged across all project activities with authority to represent REMTH at project meetings.
Sevastos Mavridis (MSc)	Procurement Department, Financial Directorate, REMTH	IT Engineer,Head of the Procurement Department, Financial Directorate, REMTH	Administrative work, Staff and Timeline management, coordinates procurement processes participation in all project actions and represents REMTH in project meetings.
Fotoula Kyrkoudi (MSc)	Budget and Fiscal Reporting Department, Financial Directorate, REMTH	Financial administrator, Head of the Budget and Fiscal Reporting Department, REMTH	Financial management, budget documentation, participation in all project actions and represents REMTH in project meetings.
Maria Hassanidou (BSc)	Civil Protection Department, Evros Regional Unit	Agronomist	Project management participation in all project actions and represents REMTH in project meetings.
Emmanouil Kargiotidis (BPA)	Civil Protection Department, Rhodope Regional Unit	Administrator-Accounting	Administrative support. Participation in all project actions and represents REMTH in project meetings

Besides the internal team members, REMTH is collaborating with external institutional and academic experts who contribute to the implementation of the BioProWrap project. The stakeholders' roles and contributions are shown in Table 1-2.

Table 1-2 REMTH External Stakeholders and Contributors (processes in this period).

Name	*Department*	*Expertise*	*Contribution in BioProWrap project*
Orestis Chatzopoulos (MSc)	REMTH	Consultant - Geotechnical - Economist	Project Management and Administrative support
Prof. Christos Nakas	Department of Agriculture Crop Production and Rural Environment, UTH	Biostatistician-Biometricin, Head of the Laboratory of Biometry, UTH	Scientific support in statistical analysis and big data modeling.
Ioanna Karamichali (PhD)	Department of Agriculture Crop Production and Rural Environment, UTH	Biochemist-Biotechnologist Bioinformatician. Postdoc Researcher, Laboratory of Biometry, UTH, specialization in biodiversity, Next Generation Sequencing (NGS) data management, and bioinformatics	Scientific Project Coordinator. Literature review, local data collection, result interpretation, reporting. Scientific analyses and the application of the CLIMAAX Climate Risk Assessment (CRA), CLIMAAX workflows' operations, workflow code adjustments, data transfer, Next Generation Sequencing (NGS) data management and output analysis.
Eleni Stefanidou (PhD student, UTH)	Department of Agriculture Crop Production and Rural Environment, UTH	Agronomist, specialization in plant molecular analysis and soil monitoring	Scientific fieldwork coordinator of the nature excursions along REMTH. Dissemination and outreach support.

1.4 Outline of the document's structure

This document begins with an introduction that sets the context by presenting the background of the BioProWRAP project in the Region of Eastern Macedonia & Thrace, outlining its main objectives, and describing the project team and document layout. Following the introduction, the core of the document outlines the climate risk assessment (CRA) methodology, starting with the scoping phase (defining the study area and mapping stakeholders), moving into risk exploration, and presenting focused analyses on wildfire hazards. Next, the document shares its preliminary risk assessment findings and lays out a draft monitoring and evaluation plan. In the closing section, it synthesizes Phase 1 conclusions, reviews progress against initial milestones, and outlines how these insights will guide the next project phases. Finally, the appendices provide supporting materials and a comprehensive reference list, ensuring that every method and result remains transparent and verifiable.

2 Climate risk assessment – phase 1

Following the CLIMAAX Framework, this document focuses on the Scoping, Risk Exploration, Risk Analysis, Key Risk Assessment, and Monitoring & Evaluation steps of the CRA for REMTH, which places special emphasis on wildfire risks.

2.1 Scoping

This scoping phase establishes the fundamental framework for all subsequent steps by defining the assessment objectives and context as well as by identifying the important stakeholders needed for a comprehensive CRA.

2.1.1 Objectives

The principal objective of the BioProWRAP CRA is to provide a clear, data-driven understanding of wildfire risk across REMTH and to guide targeted forest biodiversity monitoring. Even though there are national risk assessment systems in place, we aim to optimize our local systems through this program. By leveraging the CLIMAAX CRA methodology and Toolbox, the project aims to:

Data Harmonization and Integration for Wildfire Risk Assessment

- Harmonize and integrate diverse data sources, especially local data, including live crowdsourced observations, and biodiversity genetic data.

Generate robust wildfire risk profiles-Direct targeted forest biodiversity monitoring

- Identify areas of high wildfire risk,
- Pinpoint vulnerable ecological and socio-ecomonic hotspots, in addition to critical infrastructure,
- Guide targeted biodiversity monitoring in these areas using crowdsourcing and molecular methods.

Enhance public engagement, awareness and inclusion

- Enhance public engagement and awareness, particularly through organized participatory initiatives and workshops.

Strategic Local Partnerships for Enhanced Wildfire Risk Assessment

- Leverage the CPDR and other academic/NGO institutions that can be instrumental in contributing towards wildfire planning.

Strengthening Forest Ecosystem Resilience

- Systematic monitoring allows to document and safeguard forest biodiversity. Furthermore, centralized databases and even biobanks could be further established to preserve local genetic resources, bolster ecosystem resilience, and create a framework for natural regeneration.

Support local socio-economic growth

- The establishment of systematic monitoring, data management and even biobank related commercial activity could boost economic growth and create new opportunities, products, businesses and jobs.
- Wildfire prevention can lead to tourism growth and allow the rearrangement of national economic resources.

Support regional policy-making and adaptation planning

- Empower policymakers through their collaboration with scientists, to develop comprehensive plans to maximize the impact of wildfire prevention efforts,
- Embed findings into REMTH planning.

Limitations and Boundaries: Several constraints that may influence the CRA are:

Data Availability

- Technical difficulties in integrating CLIMAAX datasets with local records and live observations, requiring additional development, testing time and computation power,
- Variability in climate projections introduces uncertainties that must be acknowledged in the analysis and be validated.

Stakeholder Engagement

- Challenges in securing active participation from all stakeholders.

2.1.2 Context

The 15.6% of REMTH is covered by forests (EFFIS), including areas of enormous value, like four Natura 2000 recorded national parks, and other protected or culturally important areas (Aesthetic Forest of Steno Nestos, the Natural Monument of Fractos, local population villages, etc.). REMTH faces significant climate risks, specifically wildfires, droughts, and heat waves. Wildfires have increased in frequency and intensity in the past years. In 2023, Greece lost 174.8kha to wildfires, with 93.9kha being located in REMTH, alone (EFFIS)**.** Wildfires not only threaten public safety and the economy, but also exacerbate climate change by releasing naturally stored carbon, raising CO2 levels. Furthermore, post-fire landscapes face erosion and physical, chemical and microbiological changes, hindering forest recovery. The hydrological cycle is also disturbed in a major way, resulting in droughts and rapid floods (flash floods). Another wildfire related risk is biodiversity degradation, which is significant, because it can lead to ecosystem imbalances, or even species extinction. Additionally, poor public awareness regarding climate change and related risks can increase vulnerability, especially in wildfire-prone areas.

Until now REMTH climate risks has been managed through a patchwork of studies and baseline civil-protection plans within Greece wildfire legal framework, including: **Law 4662/2020:** National Mechanism for Crisis Management and Risk Response, restructuring of the General Secretariat of Civil Protection, upgrading of the civil protection volunteer system, reorganization of the Fire Department and other provisions, **Property Fire Protection Code:** binding prevention and response measures, **Law 4824/2021**: safeguards natural environments and supports affected communities, **Ministerial decisions and circulars:** ensure interagency cooperation and standardize fire-safety rules, Eastern Macedonia & Thrace Climate Adaptation Plan (Regional Plan for Adaptation to Climate Change, PESPKA) is built on **Law 4414/2016**: (climate adaptation policy) and **Ministerial Decision 11258/2017** (implementation guidelines), **Local law implementation, Common Ministerial Decision 39808/2025:** subsidizes Rodopi agricultural holdings damaged by wildfires. Moreover, REMTH also created the Regional Development Fund (https://pta.gov.gr/en/home-english/; RDF), accelerating project financial management of co-financed EU and public investment programs.

Despite invaluable insights from local projects like IOLAOS 2 (2023), DARDANOS 2 (2022) and European initiatives ("DesirMED", "RESIST", "WILD LIFE FOR EVER", "REPORT") on fire behavior, recovery, resilience, and biodiversity, REMTH still lacked limited local resources and an integrated, multi-hazard framework to drive cohesive adaptation planning. High-resolution climate projections were seldom utilized with biodiversity data, especially crowdsourcing and molecular monitoring data, which are not yet part of routine practices. Engagement with local communities, especially vulnerable minorities was largely limited to post-fire relief, rather than upstream prevention. This is where CLIMAAX and BioProWRAP come into play. BioProWRAP bridges these gaps by embedding all prior project datasets (publicity available sources: ECLIPS-2.0, EFFIS, NASA, CORINE) and local biodiversity and land-use data from REPORT, RESIST, WILD LIFE FOR EVER, IOLAOS 2, and

DARDANOS 2 into the CLIMAAX risk assessment framework. This assessment can help identify and prioritize vulnerable and rich biodiversity areas. Furthermore, we can apply guided local forest biodiversity monitoring by focusing on these high-risk, high-value regions, while taking advantage of novel methods (crowdsourcing, e-DNA analysis). Central to BioProWRAP is deep citizen involvement. Local residents and NGOs work together in real time during guided excursions strengthening social cohesion, accelerating early warnings, and feeding continuous model refinement (Lotfian et al., 2021). By doing this, REMTH ensures a future in which biodiversity conservation and wildfire preparedness progress together, supported by shared data, responsibility, and prosperity.

2.1.3 Participation and risk ownership

Active citizen participation in risk assessment and management is crucial. The first step in this direction was to define the relevant stakeholder groups; the second was to organize them and clarify their objectives. To achieve this, we cooperated closely with the Civil Protection Directorate of REMTH (CPDR) and selected the most pertinent groups according to their influence, interests, and roles in the assessment. The resulting stakeholder map identifies, specifies, and categorizes key actors and lays a solid foundation for all subsequent engagement activities.

The most pertinent groups were the following stakeholders:

- **Municipal authorities**: Mayor, Vice Mayor for Civil Protection, Civil Protection Office staff,
- **Authorities:** Hellenic Fire Service of Eastern Macedonia and Thrace
- **Vulnerable and Exposed Groups in wildfires:** Rural Communities, agricultural workers, livestock producers, smallholder farmers,
- **Forestry and Agronomy:**The National Forestry of REMTH and several agronomists,
- **Academia and Research Institutes:** Laboratory of Biometry of the UTH,
- **Non-profit organizations**: WWF Greece, Hellenic Red Cross, Hellenic Rescue Team Rodopi, Hellenic Voluntary Firefighters Association-CTIF, Society for the Protection of Biodiversity of Thrace (SBPT) and other environmental and community groups (Figure 2-1).

Figure 2-1 Volunteers after wildfire in Papikio Mountain in Eastern Macedonia and Thrace (August, 2023, source: Fire Department).

An additional main purpose was to inform interested parties and to identify the volunteer teams that would participate in the project. As part of this effort, multiple internal meetings and an informative Stakeholders meeting were held. The latter entitled “Biodiversity Protection through Wildfire Risk Associated Planning «BioProWRAP» was held online on July 8, 2025. Initially, before being introduced to the BioProWRAP program, the participants were given an in-depth overview of the CLIMAAX framework (Figure 2-2). This introduction was crucial in order to explain the essential role of wildfire risk management, the importance of biodiversity monitoring, and the distinct environmental and socioeconomic context of REMTH. Furthermore, we explained how the program aims to protect biodiversity in REMTH through forest fire risk management planning. An interactive segment explaining the practical activities that require active citizen participation was also included. An interesting part of this interactive section was an online questionnaire which was answered during the workshop and an open discussion followed.

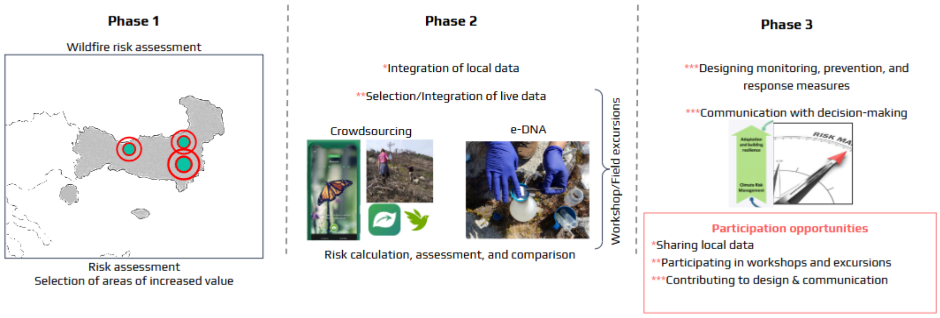


Figure 2-2 Overview of BioProWrap project (Source: Part of Stakeholders meeting presentation workshop on 8/7/2025 copyrights: I. Karamichali).

For this purpose the following online questionnaire was implemented:

- In your opinion, what are the significant climate risks in the region of Eastern Macedonia and Thrace that affect forest fires and biodiversity?
- What factors should be taken into account when designing measures for monitoring, preventing, and combating forest fires?
- How can decision-making centers be included?

The aim of this online questionnaire was to incorporate the members' responses into the final risk assessment. In total 55 individuals from the above mentioned organizations actively participated in the workshop and more than half of them (28 out of 55 in total) answered the questions asked via livestreaming (Figure 2-3). Several issues were raised during the analysis of the questionnaires. Emphasis was placed on climate change per se and on the legislative framework that needs to be defined. Funding and proper mapping of prone areas play an important role in preventive measures. Additionally, the need for participation of the population was pointed out. The possibility of citizen participation has been drastically declined by urbanization, and has to be restored.

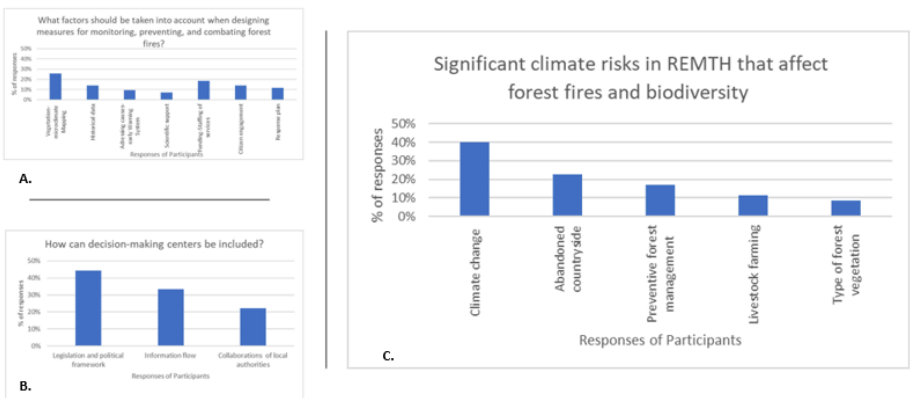


Figure 2-3 Diagrams A, B, C that represent the livestreaming responses (%) of participants.

BioProWRAP Project Implementation initiative

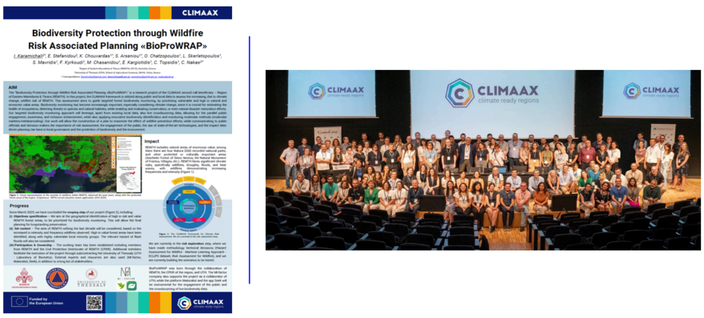
Citizen engagement plays an important role as it strengthens the local community, raises awareness of climate change issues, and helps collect and record area specific data. During the implementation stage in Phase 2, three educational field trips and three training workshops will be conducted. These workshop sessions will cover the theoretical background before moving on to the practical part. Several topics will be introduced:

- Biodiversity and its importance in the forest ecosystem,
- Monitoring biodiversity via advanced technological tools (mobile applications, such as Seek by iNaturalist) and innovative methods (e-DNA metabarcoding),
- Citizens initiatives, local policy planning and new opportunities.

Monitoring biodiversity is a central point of our next steps and is mainly carried out using two methods: **crowdsourcing tools** and **systematic field studies**. More specifically, through citizen participation we will monitor biodiversity through the application "Seek by iNaturalist" (https://www.inaturalist.org/pages/seek_app). We have already established four distinct iNaturalist projects for this purpose: the public **"BioProWRAP_playground"** and **3 private projects** (one for each BioProWRAP field excursion), accessible only to registered participants. In parallel, eDNA analysis will also be utilized for broader forest biodiversity monitoring via the technique called metabarcoding (Vasar et al., 2023). This technique can utilize DNA sequencing to identify plant species from environmental samples.

To facilitate those initiatives, a Google Form was shared at the end of the stakeholders meeting, in order to collect expressions of interest from members regarding the upcoming workshops and excursions. So far, participation has mainly come from firefighters (7 in total), and we are expecting additional registrations from other organizations.

The BioProWRAP team's previous presence in Barcelona on June 10–11, 2025, also contributed to the development of the workshop (Figure 2-4, A). The event, which was held at the CosmoCaixa Science Museum, brought together representatives from 69 European regions and municipalities. Representatives of REMTH, Civil Protection and external project advisors had the opportunity to exchange experiences and discuss the key challenges of climate risks. The BioProWRAP team displayed a poster, presenting the project overview, objectives, progress, and future steps, i.e. a springboard for in-depth exchanges of ideas and perspectives (Figure 2-4, B). The event was also communicated further through a newsletter from CPDR (https://cp.pamth.gov.gr/civil/?p=4609).



A. B.

Figure 2-4 A.Climaax Workshop in Barcelona June 10-11, 2025 B.Poster of BioProWRAP project presented in Climaax Workshop in Barcelona. (Source: https://www.climaax.eu/regions-and-municipalities-meet-in-barcelona-at-the-climaax-workshop)

Communication strategy

Effective communication is as crucial as the science behind BioProWRAP. To ensure effective results dissemination and boost project visibility, the first step was to launch dedicated digital channels on: LinkTree: https://linktr.ee/bioprowrap. The second step was to include our primary audiences: emergency responders (firefighters, civil-protection officers), local communities, especially minorities (e.g., Local population villages), residents of remote settlements, people with disabilities, farmers, agri-business stakeholders, academia, regional and municipal policy makers, NGOs and international partners. To engage each group effectively, we employ the following communication activities:

Introductory large-scale regional stakeholder meeting with over 55 participants to share our results and discuss next steps. **Media and Resource Channels** dedicated to our program have been established. **Academia and Scientific Community** has been engaged via our participation during the CLIMAAX workshop and the present deliverable, which is shared open-access, along with our Phase 1 results, main datasets used and executed notebooks, aiming to promote research collaboration.

In the next steps we plan to organise **three in-person workshops** and **three field excursions** for interested parties from public, academic, profit and no-profit organisations, environmental and community groups, as well as the public**.** Our events will also be communicated via our social channels.

Inclusive Outreach for Vulnerable Groups

- Mobile outreach materials (handouts, large-prints),
- Co-designing messages with local representatives, environmental and community groups and NGOs.

2.2 Risk Exploration

The region is characterized by the following **observed and expected hazards**:

- **Wildfires:** Climate change, increased temperatures, extended and intensified fire seasons, as well as dry storms have increased wildfire risk. Lack of accessibility, limited resources for forest and fuels management, depopulation and lack of awareness, also increase the vulnerability of the area.
- **Extreme temperatures**: REMTH is increasingly exposed to heatwaves and temperature extremes, particularly during the summer months, exacerbating wildfire conditions, threatening vulnerable populations (children, elderly, outdoor workers, emergency personnel), while stressing infrastructure, especially the energy demand in urban centers, while also causing heat-induced crop stress in agricultural zones.
- **Flash Floods**: During heavy rainfall, and due to forest wildfire losses and soil degradation, flash floods have been a recurring hazard of REMTH, especially in areas near the Nestos and Evros rivers.
- **Drought**: Reduced precipitation and rising temperatures reduce water availability, threatening agriculture and water supply.

Main hazards covered in this CRA: At this stage we will focus on the hazard of wildfires, aiming to build a guide by selecting high-risk, high-value areas to guide our targeted, data-driven, real-time biodiversity monitoring efforts during Phase 2.

2.2.1 Screen risks

The hazards that are relevant to our context are all hazards that are connected to the risk of wildfires, either because they increase the risk of them (extreme temperatures, drought), or because they indirectly result from them (flash floods). Currently, wildfire is the most observed and the most devastating hazard in the area of REMTH, especially when it comes to the immediate impact it has on biodiversity. Wildfires have historically affected REMTH, and have been significantly increased in frequency and severity, causing the destruction of 36.8kha of tree-cover area, between the years 2002 and 2023 (EFFIS). Wildfires also endanger public safety, cause

socioeconomic turmoil by affecting disproportionately vulnerable and minority populations, while destroying important infrastructure. Minority villages, especially, are highly vulnerable to wildfires due to their close proximity to forests, and their economic reliance on traditional land-use practices, agriculture, or forestry.
Raising temperatures and frequent, prolonged droughts create ideal wildfire conditions. A characteristic example is the summer of 2023, where unprecedented heat waves contributed to the severe wildfires in the Dadia forest, a major biodiversity hotspot. Even though, the Copernicus Interactive Climate Atlas' (https://atlas.climate.copernicus.eu/atlas) future drought and mean daily temperatures estimations indicate significant increases in drought and temperature, our main focus remains the identification of high risk - high value forest areas of REMTH, in order to facilitate the targeted, rapid and sustainable monitoring of the local biodiversity. At the present moment, we consider wildfire risk assessment as our main priority to achieve this task, even though we might consider including more hazards in the future, to facilitate the specificity of the areas selected.
We have currently collected and analysed through the CLIMAAX Wildfire Machine Learning (ML) workflow, public open access datasets (described in Datasets_Collected.xlsx), available online or through the CLIMAAX toolbox. In the next step, we plan to collect and harmonize local data in order to incorporate them into the Wildfire ML workflow. Those data are already available through previous CPDR activities, and related work (climate change resilience: "DesirMED" and "RESIST", past-wildfires reports and action plans: "Master Plan" and "Forest Plan", biodiversity projects: "WILD LIFE FOR EVER" and "REPORT"). Aiming to enhance the risk assessment, targeted molecular biodiversity monitoring of the selected high-risk, high-value forest areas of REMTH, along real-time crowdsourcing local biodiversity data will be also included in the analysis. In parallel, those activities will enhance the participation of members of the public, facilitating the inclusion of the local population and strengthening their awareness of wildfire and biodiversity degradation risks and related prevention management.

2.2.2 Workflow selection

The workflows for wildfire hazard and risk assessment will be tested utilizing the ML approach. We selected this workflow because we consider it more approachable for the incorporation of novel data during Phase 2, like local, crowdsourcing and genetic biodiversity data. The future scenario, the period, and the climate model used for the hazard assessment were selected in order to fulfill the three principles, as applied by the authors of the ECLIPS2.0 dataset (Chakraborty et al., 2021):

1. **Representation of all available** Regional Climate Models **(RCMs)** and Global Climate Models **(GCMs)**.
2. **Two RCMs nested in the same driving GCM:**
- "Nested" means the RCM uses boundary conditions from a GCM,
- Including two RCMs with the same GCM, allowing for the comparison between different regional models behavior under the same global conditions.
3. **One RCM driven by two different GCMs**, indicating how sensitive a regional model is to the global model it is paired with.

From all possible combinations (Supplementary Material - Figure 7.), we executed 32 different model and scenario combinations (Table 2-1), aiming towards the maximum representation of models and result reliability. For our main scope, which is the immediate direction of data-driven biodiversity monitoring, we considered the historical and the closest future timepoints, mainly

2021-2040, and 2041-2060. However, we also tested for long-term stress conditions (2061-2090). Both Representative Concentration Pathway (RCP4.5: Moderate Emission, RCP8.5: High Emission) (Moss et al., 2010) were tested for most combinations, apart from the cases of the climate models KNMI_RAMCO and DMI_HIRAM, which were only used for long-term high stress testing.

Table 2-1 The different climate models and scenarios tested. Grey color indicates decisions made to ensure maximum representation of models and result reliability.

Representation of all available Climate Models (RCMs and GCMs)						
Climate Model (Code)	*MPI_CSC_REMO2009*	*CLMcom_CLM*	*CLMcom_CCLM*	*KNMI_RAMCO*	*DMI_HIRAM*	*Validation*
RCM	REMO2009	CLM4-8-17*		RACMO22E***	HIRHAM5***	One RCM driven by two different GCMs
GCM	MPI-ESM-LR**		CNRM-CM5	HadGEM2-ES	EC-EARTH	Two RCMs nested in the same driving GCM
Country	Germany**		France	UK	EU	
Comment	good for temperature extremes	widely used, solid performance	good for precipitation modeling	tends to be warmer and wetter	strong ensemble member	-
Selection of RCPs and Time Period						
Representative Concentration Pathway (RCP)	RCP4.5 (Moderate emissions scenario)			RCP8.5 (High emissions scenario)		RCP4.5: optimistic but plausible planning / RCP8.5: stress-testing systems under extreme conditions
	RCP8.5 (High emissions scenario)					
Time Period (Training)	2011–2020					Historical baseline — useful for validation
Time Period (Future)	2021–2040					Near-term; early impacts of climate change
	2041–2060					Mid-century; stronger impacts / Long-term; peak impacts
	2061–2080					

* One RCM driven by two different GCMs | ** Two RCMs nested in the same driving GCM | *** Representation of all available RCMs and GCMs

2.2.2.1 Data accessed

To assess wildfire risk in the REMTH region (Eastern Macedonia and Thrace), we compiled and processed multiple geospatial datasets from public sources. The data collected are presented in the Datasets_Collected.xlsx supporting file.

2.2.2.2 Workflow #1: Hazard Assessment for Wildfire - ML Approach (ECLIPS dataset)

This analysis builds upon the hazard mapping methodologies developed previously (Tonini et al., 2020; Trucchia et al., 2023). The workflow follows the structured sequence below:

- **Data preprocessing**, including the integration of climate, topographic, and land cover datasets,
- **Development of a wildfire susceptibility historic model**, calibrated using current climate conditions (historical period:1991 - 2010) and historical fire events,
- **Projection of susceptibility under future climate scenarios**, enabling forward-looking hazard assessments. Multiple climate models (regional and global), representative concentration pathways and future scenarios were tested to enable historic and future result comparison and guarantee maximum representation and reliability.
- Best representation of **susceptibility results was translated into hazard** by incorporating plant functional types, which serve as indicators of potential fire intensity.

In more detail, the regional shapefile and the reference Digital Elevation Model (DEM) were harmonized and incorporated in the workflow. Slope and aspect layers were then obtained, and climate and land cover data were resized. Land cover data were also masked, removing non-burnable areas based on clc code as provided by the CORINE Land Cover inventory. Historic fire data of the area of REMTH were also processed and finally all datasets were used to develop the wildfire susceptibility model of the area. The model was first used with historical climate data (ECLIPS2.0, historical period:1991 - 2010, Figure 2-1 and 2-2, top left).
Furthermore, projections of susceptibility were also visualized under different future climate scenarios, as analysed in section 2.2.2 and Table 2-1. More detailed results of those analyses are presented in Supplementary Material Figures 8 to 12. Figure 2-1 and 2-2 serve as a validation of the compatibility of the climate models used in comparison to the historic model build, under high (RCP8.5, Figure 2-1) and moderate (RCP4.5, Figure 2-2) emission scenarios. In both cases, we observed relative consistency between climate models, however, CLCcom_CLM seems to simulate a bit better the historic model, independently of the emission scenario used.

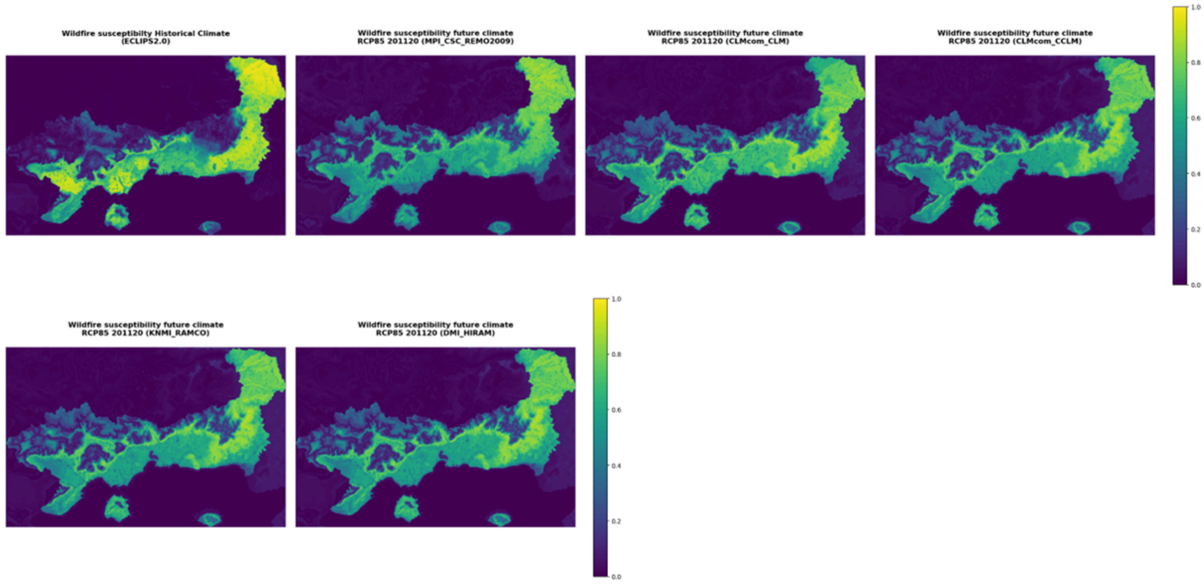


Figure 2-1 Validation of available climate models (Order: Historic, MPI_CSC_REMO2009, CLCcom_CLM, CLMcom_CCLM, KNMI_RAMCO, DMI_HIRAM), comparing the historic model of susceptibility with multiple climate scenarios (RCP8.5).

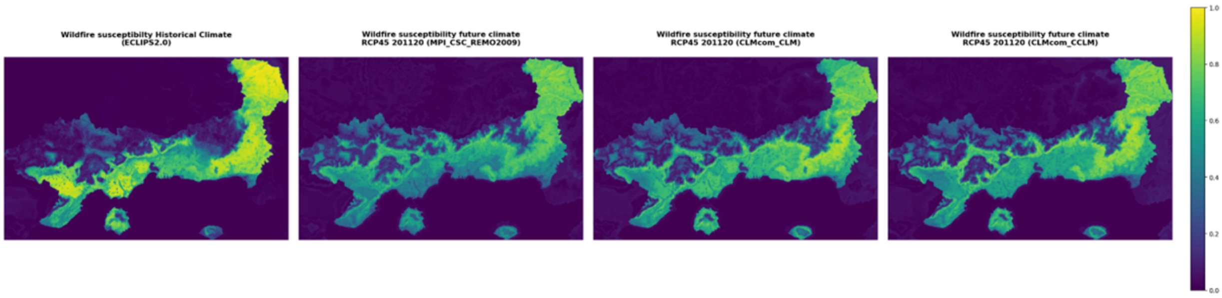


Figure 2-2 Validation of available climate models (Order: Historic, MPI_CSC_REMO2009, CLCcom_CLM, CLMcom_CCLM), comparing the historic model of susceptibility with multiple climate scenarios (RCP4.5).

Figure 2-3 present timelapses of the selected climate model. The selection was based on result comparisons between projections, or between projections and the historic estimation of susceptibility, while the fact that the available projections either shared a common RCM (CLMcom_CCLM, CLCcom_CLM) or a common GCM (CLMcom_CLM, MPI_CSC_REMO2009) was also used for validation purposes. Each case was analysed for both low emission and high emission scenarios.

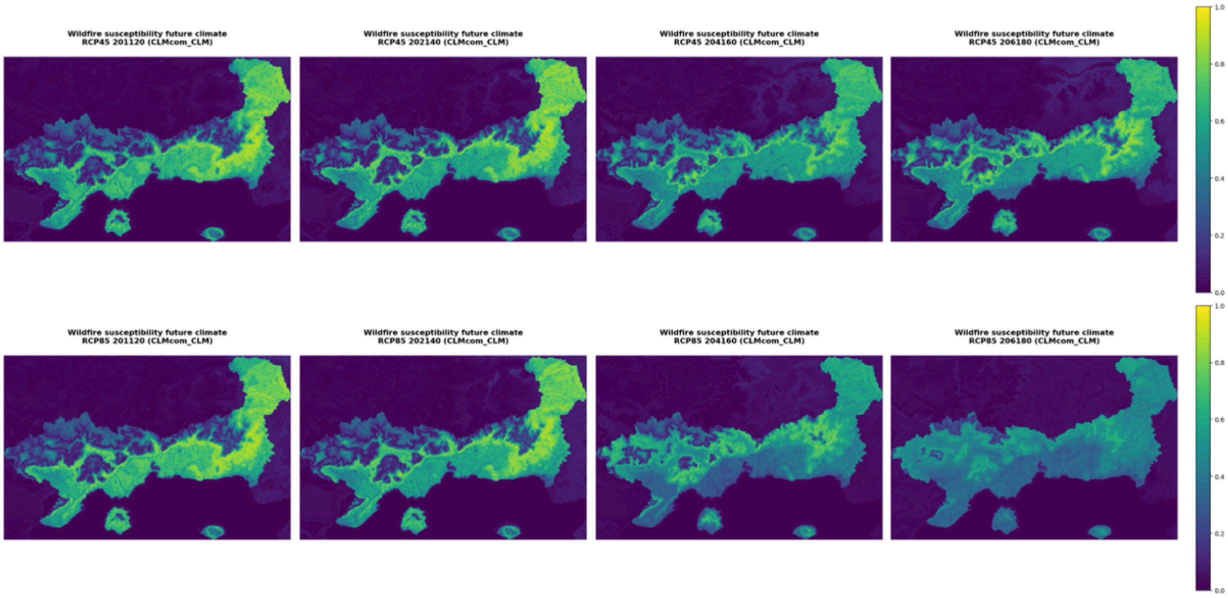


Figure 2-3 Timelapse progression of susceptibility using climate model CLCcom_CLM projections (Order: 2011-2020, 2021-2040, 2041-2060, 2061-2080), using the scenarios RCP4.5 (top) and RCP8.5 (bottom).

Independently of the scenario used, we can see that with time, the predictions seem less vibrant, meaning that perhaps we could not rely on long-term predictions, as much as the ones closer to the present. This causes no problems for our project since we are mostly interested in immediate danger detection, in order to guide more sufficiently the biodiversity monitoring efforts of REMTH. Comparisonwise, the model CLCcom_CLM is in a better validation position, since it shares RCM and GCM with the climate models CLMcom_CCLM, MPI_CSC_REMO2009, hence the results provided can be verified in multiple levels.

2.2.3 Choose Scenario

According to our observations during the comparisons of the different scenarios and climate models used, we have concluded that we will focus on the climate model CLMcom_CLM. We are mostly interested in immediate biodiversity protective action through prioritizing high risk forest areas, hence we will mostly utilize short-term future projections, and mainly the available timepoint 2021-2040, which also seems to be the most reliable. We will continue analysing all timepoints available in order to extract safe conclusions around climate, population and socioeconomic aspects of the region, as well. Based on the scenario chosen we have analysed the wildfire hazard historic and future projections, as well. We have utilized all available timepoints, the selected climate model, and both moderate and high emission scenarios (Figure 2-4). The wildfire hazard observed for the area of REMTH seems very high and extends in most of the region.

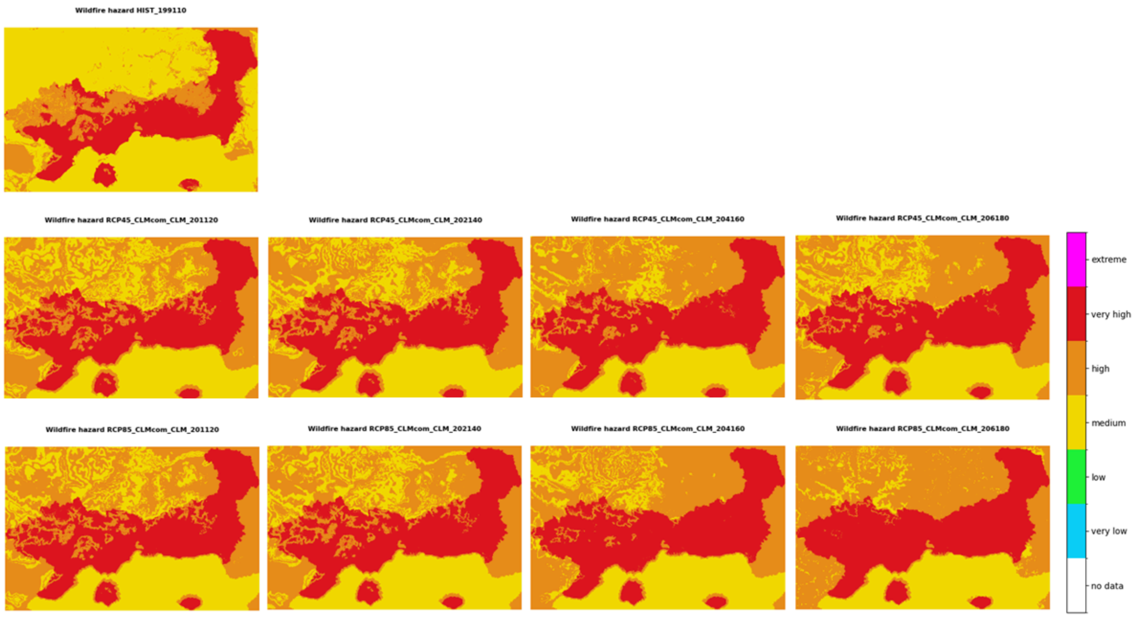


Figure 2-4 Timelapse progression of wildfire hazard projections using the climate model CLCcom_CLM (Order: 2011-2020, 2021-2040, 2041-2060, 2061-2080). Both scenarios RCP4.5 (top) and RCP8.5 (bottom) were tested.

2.3 Risk Analysis

The risk assessment is based on the hazard classes determination, which are then used for the calculation via the formula:

Risk = Hazard * Vulnerability * Exposure

The intensities of hazard used were defined by the ML algorithm, using the selected scenario (RCM: CLMcom_CLM, timepoint: 2021-2040) and the moderate emission level (RCP4.5), in order to retain some distinction between the levels of risk, since the totality of the area is characterized by high hazard levels. In the next step, we incorporated the vulnerability and exposure data, which were obtained respectively from the Joint Research Centre-JRC (Costa et al., 2020) and OpenStreetMap (OpenStreetMap contributors, 2021). Shapefiles for each vulnerability point of interest (Hospitals, Hotels, Schools, Primary roads, Secondary roads, Tertiary roads, and Shelters) were cleaned and clipped. This allowed the identification of exposed elements intersections in specific areas of REMTH, while evaluating their wildfire hazard levels using vulnerability curves, and overall calculated risk (Figure 2-5).

Different layers were used to analyze for different vulnerability aspects like "Population vulnerability", "Ecological vulnerability", "Economic vulnerability", and "Ecological-economic vulnerability". These layers have a resolution of approximately 12.5 km (available by EURO-CORDEX, https://euro-cordex.net). The risk calculation methodology presented is the one of categorized vulnerability (Risk = Hazard × Vulnerability-categorized), while the one of categorized roads with assigning a matrix of damage was also calculated (Supplementary Material, Figures 18 and 19). The results are aggregated also at the level of the REMTH municipalities, based on NUTS level (Supplementary Material, Figure 17).

2.3.1 Workflow #1: Hazard Assessment for Wildfire - ML Approach (ECLIPS dataset)

Table 2-2 Data overview workflow #1: Hazard Assessment for Wildfire - ML Approach (ECLIPS dataset)

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Historical Fire Data: NASA dataset used for 1991–2010	Joint Research Centre (Costa et al., 2020), including layers: Population, Ecological, Economic, and Ecological-Economic vulnerability	1) Land Cover Data 2) OpenStreetMap via Overpass Turbo data for Hospitals, Hotels, Schools, Primary/Secondary /Tertiary roads, Shelters 3) NUTS level data	Mainly Maps of categorized vulnerability (12.5 km res.), including Population, Ecological, Economic, and Ecological - economic vulnerability. NUTS level and categorized vulnerability for roads analysis were also performed (Sup. Material)

2.3.1.1 Hazard assessment

Analysing the wildfire hazard for the area of REMTH based on the scenario chosen (RCM: CLMcom_CLM, timepoint: 2021-2040) and both the moderate and high emission levels (RCP4.5, RCP8.5), we observed that for both the historic and the projected hazard, observations remain in **very high** levels (Figure 2-4). This is the case for almost the entirety of the region, even though we could also observe some areas of simply **high** wildfire hazard, that mostly include high elevation areas. Time progression and higher emissions seem to exacerbate wildfire hazard even further.

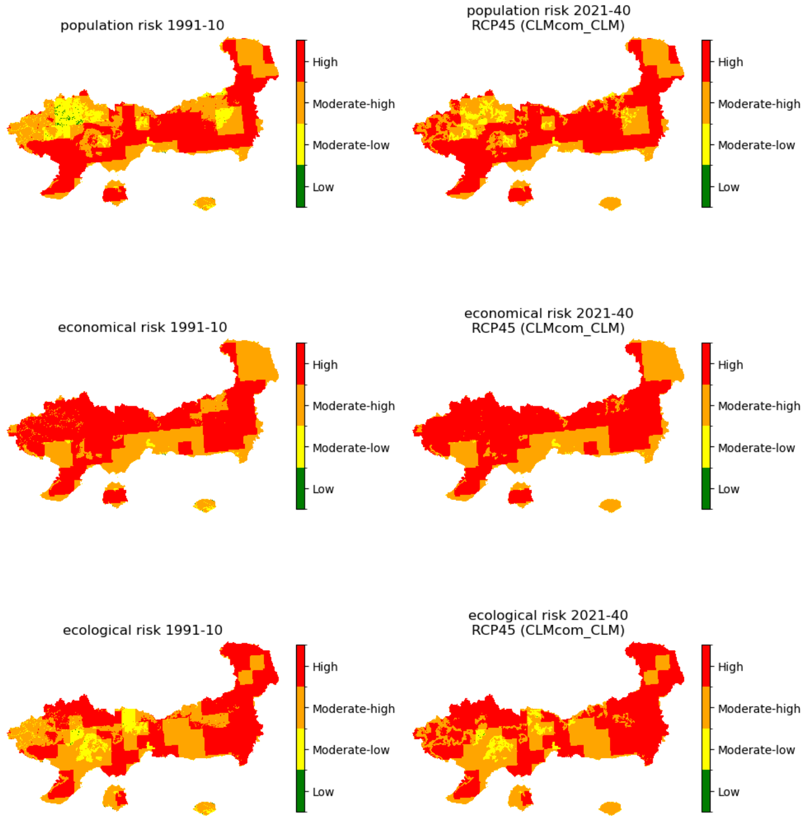


Figure 2-5 Area specific wildfire risk assessment for REMTH. The selected hazard scenario was used (RCM: CLMcom_CLM, timepoint: 2021-2040, Emission level: moderate-RCP4.5). The layers presented are Historic Population Risk, Projected Population Risk, Historic Economical Risk, Projected Economical Risk, Historic Ecological Risk, Projected Ecological Risk (by order). The resolution of the layers is approximately 12.5 km.

2.3.1.2 Risk assessment

By integrating data on hazard, exposure, and vulnerability, a comprehensive classification of wildfire risk was achieved, segmented into five distinct levels (from 1 – lowest risk to 5 – highest risk), as illustrated in the relative wildfire risk maps (Figure 2-5). Hazard intensities were determined through the ML algorithm, based on the selected regional climate model (RCM: CLMcom_CLM) for the 2021–2040 period under the moderate emissions scenario (RCP4.5). The moderate emission level (RCP4.5) was selected, in order to retain some distinction between the levels of risk, since the totality of the area is characterized by very high and high hazard levels. This approach was essential to preserve meaningful differentiation across risk levels, given the uniformly high hazard conditions observed throughout the study area. The comparative maps reveal a notable increase in wildfire-related risks across all categories—population, economy, and ecology—between the historical period (1991–2010) and the projected future (2021–2040). During the progression of time, projections indicate that several zones will transition from moderate to high risk, particularly in ecological and economic dimensions.

2.4 Preliminary Key Risk Assessment Findings

The primary objective of this project is to integrate wildfire risk assessment into the routine actions of REMTH to enhance climate change resilience. Additionally, the project aims to identify highly vulnerable forest areas that are either protective areas or of high ecological or socio-economic value, to prioritize them for biodiversity monitoring.
To achieve these goals, we applied the CLIMAAX framework, and through the steps of scoping, risk identification and risk assessment we combined geospatial data with ecological and socio-economic criteria. During our work we focused on wildfire risk assessment using the ML method and the ECLIPS climate projections. Multiple comparisons between historic and future susceptibility assessments under different scenarios, allowed us to choose a reliable scenario (RCM: CLMcom_CLM, timepoint: 2021-2040) for which both moderate and high emission level future projections (RCP4.5, RCP8.5) of hazard were considered. The area of REMTH suffers from high wildfire susceptibility and, as observed, the hazard of both historic and future wildfire hazard remains in **high** and **very high** levels. The moderate emission level (RCP4.5) was selected, in order to retain some distinction between the levels of risk, to enable the identification of specific high-risk, high value areas. The comparative maps reveal a notable increase in wildfire-related risks across all categories—population, economy, and ecology—between the historical period (1991–2010) and the projected future (2021–2040). During this analysis, we could identify three areas of specific interest, which we could consider to prioritize for biodiversity monitoring, a step essential for Phase 2. The areas to be prioritized based on their assessed wildfire risk, their ecological or economic importance, and their accessibility are:

Dadia–Soufli Forest:

- **Risk Profile**: High ecological-economic vulnerability and wildfire risk, especially following the 2023 wildfire. It is an active conservation hub.
- **Ecological Importance**: The forest supports over 360 plant species, and is part of the Natura 2000 network (GR1110002).
- **Accessibility**: Easily accessible via Soufli, with structured ecotourism infrastructure including the Dadia Ecotourism Centre and marked trails.

- **Justification**: Combines exceptional biodiversity with active conservation and community engagement.

Fraktos Virgin Forest:

- **Risk Profile**: High ecological vulnerability and wildfire risk, due to isolation and climate stress.
- **Ecological Importance**: The only virgin forest in Greece, part of the Natura 2000 network (GR1140001), and a candidate for UNESCO World Heritage status.
- **Accessibility**: Remote but reachable via Paranesti; access is regulated through the Drama Forest Directorate and supported by the Fraktos Visitor Centre, but REMTH can have access.
- **Justification**: Fraktos offers unmatched biodiversity and structural complexity.

Central Rhodope Mountains & Nestos Valley:

- **Risk Profile**: Mostly high ecological and economical risk, with pressures from land use and climate change.
- **Ecological Importance**: Hosts over 2,000 plant species and it is part of the Natura 2000 network (GR1140008).
- **Accessibility**: Well-connected via Paranesti, Stavroupoli, and Livaditis; includes hiking trails and forest villages like Prasinada.
- **Justification**: This expansive corridor supports species migration and genetic exchange, while including vulnerable to wildfire populations in remote villages.

These areas represent intersections of **vulnerability and value**, allowing for early detection and response to wildfire threats, through the monitoring and protection of biodiversity under climate stress. Prioritizing them allows for climate stress adaptation, through:

- Early detection and response to wildfire threats,
- Monitoring and protection of biodiversity,
- Safeguarding of economic assets and human well-being.

2.4.1 Severity

The risk of wildfires in REMTH is severe, considering both historical and future trends. The region has experienced significant ecological losses, endangering local biodiversity and the ability to adapt under climate stress. Economically, the impacts extend to critical sectors such as agriculture, infrastructure, and tourism. The potential for irreversible consequences, including the destruction of ecosystems and cascading effects like local species extinction, flash floods and social unrest, further underscores the high severity of this climate risk.

2.4.2 Urgency

The risks associated with wildfires in the REMTH region are expected to have a major impact in the near future, necessitating immediate action to minimize damages. The climate hazard is projected to worsen significantly, with increased frequency and intensity of wildfires. These hazards are associated with sudden events like heavy rain, which can exacerbate the wildfire connected phenomenon of flash floods, as well as slow onset processes like prolonged droughts. The persistence of these climate hazards underscores the urgency for proactive measures to mitigate their effects and protect the regional biodiversity and economic assets.

2.4.3 Capacity

REMTH has implemented several climate risk management measures to tackle wildfire risks, considering financial, social, physical, and natural aspects. Financially, the region has established the Regional Development Fund (RDF) to support co-financed EU and public investment programs. Socially, there is active citizen participation through civil protection and red cross volunteering programs. Human capacity is strengthened through research programs like BioProWRAP, which includes workshops and field excursion initiatives, enhancing community awareness and engagement. Collaborations with academic institutions like the University of Thessaly, also enhance the adaptation capacity of the region. Physically, the region has developed hazard warning systems and critical infrastructure to forecast and respond to wildfires, which will be further enhanced by incorporating novel risk assessment methods like the ML workflow, provided by CLIMAAX. Natural capacity is bolstered by integrating biodiversity monitoring with wildfire risk assessments, ensuring ecosystem health and economic resource management.
Despite these efforts, the region continues to face challenges in addressing climate risks comprehensively. The capacity to respond to wildfires demands financial means for preparation and response, human availability and capacity for awareness and learning, and the capacity for resource management. Additionally, there are limitations in high-resolution data and technological constraints that hinder comprehensive risk assessments.

2.5 Preliminary Monitoring and Evaluation

The first phase of the climate risk assessment provided valuable insights into the wildfire risks within REMTH. We encountered challenges in integrating high-resolution local data with the CLIMAAX datasets, which required additional computational power that we do not possess. Stakeholder feedback highlighted the need for their active participation, especially for data exchange (Phase 2) and during the development of relative local adaptation strategies (Phase 3). Additionally, more comprehensive public engagement, as well as the inclusion of additional local data sources and maybe testing for additional hazards, could enhance the accuracy of the risk assessment. Moving forward, more stakeholders will be actively involved, and historic as well as real-time local data regarding wildfires, biodiversity, and socio-economic factors will be incorporated to refine the assessment.

2.6 Work plan

The BioProWRAP project follows a structured work plan divided into three key phases. Concluding Phase 1, with the wildfire risk assessment in REMTH using the CLIMAAX handbook methodology, we are moving forward with Phase 2. In Phase 2 we will enrich the wildfire risk assessment with additional pre-existing and novel real-time local data. This includes data from previous environmental initiatives and publicly available sources like GBIF. Dissemination and communication activities will engage the public through social networks, websites, and media, including organized nature excursions and educational workshops. Novel biodiversity data will be collected and harmonized with the CLIMAAX ML workflow, making the final dataset available in a FAIR manner. The refined regional high-resolution analysis and risk assessment will be reported in Deliverable 2.1 (D2.1). Given time restraints, we might also execute workflows for additional hazards like drought and heatwaves. Finally, Phase 3 will explore local adaptation options to address identified risks, focusing on biodiversity monitoring and preservation, prioritizing vulnerable areas of REMTH.

3 Conclusions Phase 1- Climate risk assessment

The BioProWRAP project, implemented within the CLIMAAX framework, has successfully completed its first phase, focusing on the climate risk assessment for the Region of Eastern Macedonia and Thrace (REMTH). This phase aimed to integrate wildfire risk assessment into the routine actions of REMTH to enhance climate change resilience and prioritize vulnerable forest areas for biodiversity monitoring.

Throughout this phase, we applied the CLIMAAX handbook methodology, utilizing a Machine Learning (ML) approach to estimate wildfire risks. The analysis was based on different scenarios of European climatologies (ECLIPS), with refined parameters to ensure accuracy. The implementation of the CLIMAAX common methodology for multi-risk assessment and the analysis of the results are reported in the present report (Deliverable 1.1; D1.1). The primary objective was to identify areas of high ecological or economic value that are at significant risk of wildfires.

One of the main challenges addressed during this phase was the integration of high-resolution local data with the CLIMAAX datasets. This required additional development and testing time, but it was essential for creating a comprehensive risk assessment. Increased computational power could significantly increase the resolution of the analysis (25km from 100km). Stakeholder feedback highlighted the need for more comprehensive engagement and the inclusion of additional local data sources to enhance the accuracy of the risk assessment.

The preliminary key risk assessment findings identified three priority areas within REMTH:

- The **Dadia-Soufli Forest,**
- The **Frakto Virgin forest,** and
- The **Central Rodopi mountains and Nestos valley.**

These areas were selected based on their wildfire-ecological and economic risks, their ecological and economic importance, and their accessibility. In particular, the Dadia–Soufli Forest stands out as a conservation stronghold that has suffered significant wildfire damage during the past years, combining rich biodiversity with structured conservation efforts. The Fraktos Virgin Forest, located in the remote highlands of Drama, represents a unique ecological sanctuary. As the only untouched forest ecosystem in Greece, it holds exceptional scientific and genetic value, yet faces emerging risks due to climate stress and isolation. Lastly, the Central Rhodope Mountains and Nestos Valley form a vital ecological corridor, supporting species migration and hosting diverse habitats. This region is increasingly exposed to land-use pressures and climate-driven hazards, while it includes remote and vulnerable to wildfire populations.

The severity of wildfire risks in REMTH is underscored by significant ecological losses, endangering local biodiversity and the regional ability to adapt under climate stress. Economically, the impacts extend to critical sectors such as agriculture, infrastructure, and tourism. The potential for irreversible consequences, including the destruction of ecosystems and cascading effects like local species extinction, flash floods, and social unrest, further emphasizes the high severity of this climate risk.

The urgency of addressing these risks is evident, with projections indicating a significant worsening of wildfire frequency and intensity. Immediate action is necessary to minimize damages and protect the regional biodiversity and economic assets. The persistence of climate hazards, including sudden events like heavy rain and slow onset processes like prolonged droughts, underscores the need for proactive measures.

REMTH has implemented several climate risk management measures, including the establishment of the Regional Development Fund (RDF) to support co-financed EU and public investment programs. Active citizen participation, training programs, and collaborations with academic institutions have strengthened the human and regional adaptation capacity. The region has also developed hazard warning systems and critical infrastructure to forecast and respond to wildfires. However, challenges remain, including limitations in high-resolution data and technological constraints.

The first phase of the climate risk assessment provided valuable insights into the wildfire risks within REMTH. Moving forward, it is essential to involve more stakeholders and incorporate additional local data to refine the assessment. The next phase will focus on enriching the multi-risk assessment with historic and real-time local data, engaging the public through dissemination and communication activities within the selected areas of priority for biodiversity monitoring, and exploring local adaptation options to address identified risks. Additional hazards might also be explored.

In conclusion, the BioProWRAP project has made significant progress in understanding and addressing wildfire risks in REMTH. The insights gained from this phase will guide the next steps, ensuring a comprehensive and effective approach to climate risk management and biodiversity preservation.

4 Progress evaluation and contribution to future phases

This deliverable enabled us to get familiar with the CLIMAAX methodological framework and the CLIMAAX workflows. Applying the framework we were successful in engaging with significant stakeholders of our region and gaining feedback regarding the important hazards of the area and how an adaptation plan could look like. We could also attract attention to our biodiversity focused approach and gained interest in active participation during our workshops and our natural excursions. This participation will be crucial during Phase 2. Our first attempt in working with the CLIMAAX workflows, also enables us to move forward by selecting the areas we need to prioritise for biodiversity monitoring. Those areas will serve as pilots for the execution of our crowdsourcing and genetic biodiversity monitoring during Phase 2. Those real-time biodiversity data, along with local data collected by REMTH and collaborating Stakeholders, will allow us to take advantage of the wildfire risk assessment workflows even further, by incorporating them into the workflows and hopefully maximize risk assessment accuracy. The present analysis will be used during Phase 2 as a benchmark to assess the improvements in performance after adding additional locally sourced data. Socio-economic aspects and wildfire prevention measures will be also explored, however we mainly aim towards proposing a concrete biodiversity monitoring plan based on risk assessment surveillance (Phase 3), which we believe will revolutionize the way public authorities protect their natural biological resources.

Table 4-1 Overview key performance indicators.

Key performance indicators	*Progress*
Hazard and Risk Workflows successfully applied (Phase 1)	1. Hazard Assessment for Wildfire - Machine Learning Approach (ECLIPS dataset),and 2. Risk Assessment for Wildfire (Completed)
[>9] stakeholders engaged (CLIMAAX Consortium, REMTH, UTH, *Civil protection agency, Industry-corporate and non-profit* *organizations, Academia, Media and communication outlets,* *Minorities-local communities, and the general public) (Phase 1-3)*	1st initial stakeholder workshop (Completed). Participants: **Non-profit organizations:** WWF Greece, Hellenic Red Cross, Hellenic Rescue Team Rodopi, Hellenic Voluntary Firefighters Association-CTIF, Society for the Protection of Biodiversity of Thrace (SBPT) and other environmental and community groups. **Municipal authorities**: Mayor, Vice Mayor for Civil Protection, Civil Protection Office staff,Hellenic Fire Service of Eastern Macedonia and Thrace **Academia:** UTH **Forestry and Agronomy**:The National Forestry of REMTH and several agronomists
[5] organisations involved in nature excursions to collect biodiversity data using the application Seek by iNaturalist (Phase 2)	One organisation already registered in our online form (https://forms.gle/8vhBE1oVqrjZeAqM7) (In Progress)
[5] communication actions taken to share results with your stakeholders (Phase 1: 2, Phase 2: 1, Phase 3: 2)	1) Stakeholders introductory meeting (Completed) 2) CLIMAAX workshop in Barcelona (Completed)

Key performance indicators	Progress
[11] dissemination actions (Phase 1: 2, Phase 2: 7, Phase 3: 2)	1) Publish project in the REMTH Civil Protection Agency (https://cp.pamth.gov.gr/civil/?page_id=4602) 2) Press release (https://cp.pamth.gov.gr/civil/?p=4609)
[>66] social media posts and digital campaigns to disseminate project progress (Phase 1-3)	Social media created: 1. Facebook (https://www.facebook.com/profile.php?id=61577942947696) 2. Instagram (https://www.instagram.com/bioprowrap) 3. LinkedIn (https://www.linkedin.com/company/bioprowrap) 4. LinkTree (https://linktr.ee/bioprowrap) 5. iNaturalist (https://www.inaturalist.org/projects/bioprowrap_playground)

Table 4-2 Overview milestones.

Milestones	*Progress*
Milestone 1 (M1.1): Stakeholders introductory meeting	Achieved
Milestone 2 (M1.2) Testing the wildfire workflows	Achieved
Milestone 3 (M1.3) Procurement launched for subcontracting services (scientific support, field & lab work)	In Progress (Tender to be published*)
Milestone 4 (M1.4) D1.1 – Implementation of the CLIMAAX common methodology for multi-risk assessment and analysis of the results report completed	Achieved
Milestone 5 (M2.1) Workshops and natural excursions completed (soil, biodiversity, climate risk assessment data), 60+ participants and 9+ Stakeholder identified and engaged	In Progress
Milestone 6 (M2.2) Lab results from ITS metabarcoding finalized	Not Started
Milestone 7 (M2.3) D2.1 – Refined regional/local high-resolution analysis and risk assessment and comparison of results report delivered	Not Started
Milestone 8 (M3.1) Biodiversity adaptation strategies identified	Not Started
Milestone 9 (M3.2) D3.1 – Contribution to local adaptation strategies and improved risk management plans report delivered	Not Started

*The subcontracting procedures were delayed due to the fact that the Directorate of Civil Protection of REMTH had to address an exceptionally demanding wildfire prevention and response period, during which numerous fire incidents occurred. As a result, the Directorate was unable to complete the necessary procedures within the initially foreseen timeframe.

5 Supporting documentation

All the outputs produced during this stage are shared in the Zenodo repository (10.5281/zenodo.16981091). Those outputs are listed below, arranged in the same order as in Zenodo :

- Main Report: CLIMAAX_M6_Deliverable_FSTP_BioProWRAP_final.pdf
- Datasets collected (Excel or CSV)
- Input Shapefile: REMTH_adm_3035.shp
- FIRE Hazard Assessment Workflow notebook with modifications and additions: Hazard_assessment_FIRE_ML_REMTH.ipynb
- Supplementary Visual Outputs: Supplementary Material.pdf
- FIRE Risk Assessment Workflow notebook with modifications and additions: Risk_assessment_FIRE_ML_REMTH.ipynb
- Overpass-turbo (OpenStreetMap contributors, 2021) queries used to access the OpenStreetMap (OSM) data interactively (Date of Access: 07/2025): Overpass_turbo_vulnerability_data_export_queries.txt
- Input DEM file: REMTH_100_3035_clip.tif

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