Deliverable Phase 1 – Climate risk assessment

Sustainable Adaptation for Flood Emergencies in Hopa (SAFE-HOPA)

Türkiye, Hopa / Hopa Municipality

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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	SAFE-HOPA delivers a CLIMAAX-compliant, multi-hazard climate risk assessment for Hopa Municipality, focusing on river flooding, heavy rainfall/flash-floods and rainfall-induced landslides. The project develops high-resolution hazard–exposure–vulnerability maps—prioritizing elderly people, people with disabilities and converts these findings into actionable adaptation options, accessible temporary-shelter planning and risk-informed infrastructure upgrades. Outputs feed directly into local policies (strategic/urban plans and disaster management), establish reproducible data workflows for later phases, and strengthen institutional and community preparedness.
Project name	Sustainable Adaptation for Flood Emergencies in Hopa
Country	Türkiye
Region/Municipality	Hopa/Hopa Municipality
Leading Institution	Hopa Municipality
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1.0	…	Hopa Municipality	Deliverable submitted

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Abbreviations and acronyms

Abbreviation / acronym	Description
MGM	Turkish State Meteorological Service
AFAD	Disaster And Emergency Management Presidency
DSİ	General Directorate of State Hydraulic Works
TÜİK	Turkish Statistical Institute
CRA	Climate Risk Assessment
RCP	Representative Concentration Pathway
JRC	Joint Research Centre
NUTS	Nomenclature of Territorial Units for Statistics
ADNKS	Address-Based Population Registration System
İRAP	Artvin Provincial Risk Reduction Plan
TARAP	Türkiye Risk Reduction Plan
HOPAK	Hopa Search and Rescue Team

Executive summary

This deliverable provides a CLIMAAX-compliant, Phase-1 climate risk assessment for Hopa Municipality, focusing on the two most consequential hazards for the district—river flooding and heavy rainfall/flash-floods—and establishing the evidence base to steer Phase-2 high-resolution analyses and Phase-3 adaptation planning. The work combines historical event reconstruction, hazard–exposure–vulnerability overlays and suitability mapping for emergency sheltering to identify priority risk "hotspots", vulnerable groups and actionable near-term measures.

Historical analysis of the 24 August 2015 disaster was spatially reconstructed to delineate flood propagation and its intersections with settlements and infrastructure in the Ortahopa–Sundura corridor. Two risk workflows were operationalized: (i) River Floods Risk Management, using present-day return-period flood layers and future scenario products to map depth/extent and indicative damages; and (ii) Heavy Rain Risk Management, using regional climate information to define intensification of short-duration rainfall and pluvial flood susceptibility in steep, poorly drained and highly impervious areas. Exposure analysis integrated building, road/bridge and critical-facility datasets; Hopa State Hospital lies within a high-exposure flood zone. Vulnerability mapping prioritized people with disabilities and 65+ residents; neighborhood-level child populations (0–6) were compiled from official statistics and will be downscaled to grids/buildings for Phase-2 overlays. A temporary shelter suitability surface—aligned with AFAD technical criteria—was produced and intersected as practicable sites. Using average household size and buildings within the flood-affected footprint, the indicative minimum enclosed area required for emergency accommodation was estimated, demonstrating that municipal land can meet short-term needs. Results explain where hazard intensification and exposure concentrate, who is most at risk, and which assets/routes fail first—evidence that directly informs Hopa's Strategic Plan, urban development plan revision and Disaster Management Implementation Plan, and aligns with İRAP at provincial scale.

The assessment faced constraints common to small coastal municipalities: limited availability of high-resolution climate inputs along the eastern Black Sea coast; restricted access to micro-data (e.g., address-level child records) due to data-protection rules; and capacity gaps in GIS and data governance. Nevertheless, Phase 1 established a reproducible data workflow, validated the two principal hazards, made the exposure of critical assets (e.g., the hospital) explicit, identified shelter options on municipal land that can be deployed in the short term, and produced vulnerability layers sufficient to support co-design with stakeholders in Phase 2.

Floods and extreme rainfall are the primary, recurrent risk drivers for Hopa; vulnerable populations and critical services spatially co-locate with high-hazard zones; existing assembly/shelter points require accessibility-first re-siting; and immediate benefits are achievable by implementing the identified shelter parcels and by updating operational plans (routes, power continuity for medical devices, neighborhood volunteer pairing). Phase-2 will refine hazards with local data and modelling, convert overlays into prioritized interventions and KPIs, and prepare the basis for improved risk management plans and adaptation options in Phase-3.

1 Introduction

1.1 Background

Hopa is a small coastal district located in the northeastern part of Türkiye, on the Black Sea coast and adjacent to the Georgian border. Situated between a narrow coastal strip and steep slopes, the district's geographical structure makes it highly exposed to climate-induced disasters such as floods and landslides. Hopa receives an average annual precipitation of 2,435 mm, which is approximately four times the national average (MGM, 2025) (Hopa Municipality, 2024). This extreme precipitation regime increases the frequency and intensity of hydro-meteorological events such as floods and inundations, posing a threat to numerous sectors ranging from agricultural production to urban infrastructure.

In the regional economy, tea cultivation stands out as the primary activity; however, the slope of the land, small and fragmented production plots, and infrastructural deficiencies jeopardize agricultural productivity and food security. Historical disasters clearly demonstrate this vulnerability. On August 24, 2015, following intense rainfall, Hopa recorded 287.2 mm/m² of precipitation, resulting in the deaths of eight citizens, three people reported missing, and significant damage to infrastructure systems (AFAD, 2015). According to official post-disaster assessments, the material damage in Hopa alone was approximately 60 million TRY (AFAD, 2015). A total of 2,664 sectoral units were affected, particularly in the areas of food, transportation, communication, housing, energy, and production infrastructure. The event was declared a national disaster under the "General State of Emergency" status across Türkiye.

Such extreme precipitation events are not isolated incidents; rather, they are part of systematic climatic trends that occur multiple times annually, particularly during the autumn months in Hopa, rendering flood risk a permanent concern. According to the meteorological assessment published on October 9, 2024, Hopa received 63.5 mm of rainfall per square meter within 24 hours, marking the highest precipitation level recorded in Türkiye on that day (NTV, 2024). Considering all this data, it is evident that no climate adaptation strategy or multi-hazard risk assessment study—based on data and considering the local context—has yet been implemented in Hopa to address the multifaceted impacts of climate change in a holistic manner.

1.2 Main objectives of the project

The primary objective of the SAFE-HOPA project is to identify climate change-induced multi-hazards within the administrative boundaries of Hopa Municipality, assess and understand their impacts—particularly on vulnerable areas and disadvantaged groups—and develop a resilient local system in response. The project specifically addresses the risks faced by socially vulnerable groups such as the elderly, people with disabilities, and low-income households, aiming to enhance their safety and quality of life before, during, and after disaster events.

In line with this objective, the SAFE-HOPA project aims to:

- Strengthen local institutional capacity,
- Implement mapping and analytical methods for the early identification of disaster risks,
- Identify vulnerable areas,

- Quantitatively assess hazard trends,
- Plan adaptation interventions at an early stage.

The project also seeks to redesign existing infrastructure plans and urban development projects considering climate risks, aligning structural measures with the principle of long-term sustainability. Accordingly, spatial interventions such as alternative drainage systems for floodwaters, strategies to avoid settlement in landslide-prone areas, and the designation of temporary shelter locations during emergencies will be planned.

In addition, the project targets the planning of essential services such as healthcare, hygiene, and psychosocial support to ensure post-disaster life sustainability, and aims to assess secondary health risks after disasters to develop preventive scenarios.

All these objectives will be pursued using the methodological tools and data-driven analytical processes provided by the CLIMAAX Framework, thereby contributing to the formulation of integrated adaptation policies for climate risk management at the local level.

1.3 Project team

Dr. Utku CİHAN, Mayor of Hopa Municipality | Lead Coordinator
Dr. Utku Cihan is the Mayor of Hopa Municipality and holds a doctoral degree in Urban Planning. With an academic background combining theory and practice, he has developed expertise in sustainable urban development, spatial planning, and local governance. As the lead coordinator of the project, Dr. Cihan provides overall strategic direction and ensures that project activities are fully aligned with Hopa's development priorities and climate resilience goals. His role in this project is to secure institutional coordination, represent the municipality in international partnerships, and ensure the long-term integration of project outcomes into local policy.

Gökhan KARAİBRAHİMOĞLU, Deputy Mayor of Hopa Municipality | Technical Services
Gökhan Karaibrahimoğlu is a Geophysical Engineer with professional experience in disaster management and municipal technical services. He started his career at the Disaster and Emergency Management Authority (AFAD), where he served as an engineer and later as Acting Head of the Planning, Damage Reduction, and Recovery Department. He plays a key role in communicating directly with institutions such as AFAD, DSİ, and MGM ensuring effective collaboration and technical alignment. His expertise strengthens the municipality's capacity to implement risk-informed strategies and enhance resilience against natural hazards.

Gökhan BAYAR, Director of Technical Services of Hopa Municipality | Infrastructure Analysis & Risk Assessment
Gökhan Bayar is a Civil Engineer with extensive experience in municipal infrastructure planning and management. His work has focused on analyzing past disaster events in Hopa, applying field-based insights to enhance infrastructure resilience and preparedness. In this project, he leads the assessment of historical hazards and infrastructure vulnerabilities, leveraging his deep familiarity with local terrain and field operations. His role involves coordinating the technical analysis of risk data and translating it into actionable infrastructure reinforcement strategies, ensuring that design and maintenance efforts are informed by real-world disaster scenarios.

Serkan KOYUNCU, Director of Social Support Services of Hopa Municipality | Vulnerable Groups Support
Serkan Koyuncu is a trained Class Teacher with extensive experience working in rural schools and socioeconomically disadvantaged areas. He currently serves as the Director of Social Support Services for Hopa Municipality, where he leads efforts to support vulnerable populations. In this role, he is intimately familiar with at-risk groups—such as older adults, individuals with disabilities, children, and communities impacted by climate-related disasters. His deep understanding of local social dynamics enables the project to effectively address and integrate the needs of disadvantaged and disaster-stricken communities into resilient development strategies.

Nilay KADAN, Project Coordinator of Hopa Municipality | Project Coordinator
Nilay Kadan serves as the Project Coordinator for Hopa Municipality, guiding the execution and strategic alignment of municipal projects. In her role, she ensures cohesive project implementation across departments, manages stakeholder communication, and coordinates technical meetings and inter-institutional collaboration. Her work contributes to translating strategic objectives into practical steps, fostering cooperation, and supporting the municipality's resilience efforts.

Burak KAVAKLIOĞLU, M.Sc. | GIS Specialist of EDANOVA Information Technologies JTC | Technical Advisor
Burak Kavaklıoğlu is a GIS Specialist with an M.Sc. in Geomatics and experience in spatial data management, geospatial analysis, and the development of digital mapping solutions. He provides technical guidance on the integration and processing of local geospatial datasets. In the **SAFE-HOPA** project, he supports the design and implementation of geospatial workflows to enhance regional climate risk assessments and resilience planning.

Mert TURUNÇ | GIS Specialist of EDANOVA Information Technologies JTC | Technical Advisor
Mert Turunç is a Geomatics Engineer currently working as a GIS Specialist, with hands-on experience in spatial data analysis, field data workflows, and the development of location-based decision-support systems. He has contributed to various public sector and infrastructure projects, focusing on the practical application of geospatial technologies. In the **SAFE-HOPA** project, he supports the team through the integration of local spatial datasets and the implementation of geoinformation workflows tailored to regional climate risk assessment needs.

Umut CAN | Project Manager of EDANOVA Information Technologies JTC | Project Technical Coordinator
Umut Can serves as the Technical Coordinator, overseeing the overall execution and technical alignment of the **SAFE-HOPA** project activities. He ensures coordination between technical team and other stakeholders, monitors progress, and supports the integration of technical outputs into the broader project framework.

Prof. Dr. Halil AKINCI, Artvin Çoruh University | Academic Advisor
Prof. Dr. Halil Akıncı has been serving as the Director of the Natural Disasters Research and Application Center at Artvin Çoruh University since 2012. He is an expert in landslide, flood, and forest fire susceptibility mapping, and has authored numerous articles published in international scientific journals. As an academic advisor, Prof. Akıncı contributes to the project team by preparing high-resolution local datasets and providing strategic guidance to ensure the effective progress of the project.

1.4 Outline of the document's structure

The report is structured to first present the context and objectives, then the findings and methods of the Phase-1 climate risk assessment, followed by preliminary monitoring and evaluation, and finally the work plan for the remaining phases. The outline below clarifies what the reader will find in each section and aligns fully with the CLIMAAX framework.

This report is organised as follows: **Section 1 (Introduction)** sets the background explaining geographic and socio-economic context of Hopa, objectives, and the project team; **Section 2 (Climate risk assessment – Phase 1)** presents scoping, hazard/workflow selection, data and methods, historical events/baseline, definition of exposed areas and vulnerable groups; datasets and provenance; pre-processing and quality assurance; analytical methods, assumptions and uncertainty management, preliminary monitoring & evaluation, and the work plan for subsequent phases. **Section 3 (References)** lists all cited sources, and **Section 4 (Annexes)** provides detailed figures/tables, methodological notes, and supplementary materials. The structure follows the CLIMAAX framework to guide readers from context to results and next steps.

2 Climate risk assessment – phase 1

2.1 Scoping

The climate risk assessment conducted within the scope of the SAFE-HOPA project is designed to establish a structured and data-driven process aimed at identifying, analyzing, and mitigating the multiple climate-induced hazards affecting the Hopa district—particularly floods, flash floods, and landslides. This scoping phase defines the overall objectives of the assessment, outlines the regional challenges and limitations influencing its implementation, and summarizes the initial steps taken to involve relevant stakeholders in the process. The process is carried out in alignment with the CLIMAAX Common Methodological Framework, integrating both scientific analyses and community engagement in order to generate context-sensitive and actionable outcomes.

2.1.1 Objectives

The primary objective of this climate risk assessment is to scientifically analyze the socio-economic, environmental, and physical impacts of increasingly frequent hydro-meteorological disasters—particularly floods, flash floods, and landslides—in the Hopa District; to identify vulnerable groups; to compile an inventory of past disaster events; to define preventive and adaptive interventions at the local level; to implement various infrastructure and planning measures to minimize potential disruptions during disasters; to raise disaster awareness among citizens; and ultimately, to integrate this process into strategic decision-making mechanisms. In this context, the project aims for its outcomes to contribute to the climate adaptation policies of Hopa Municipality and other relevant institutions and organizations.

This study is carried out in line with Phase 1 principles of the CLIMAAX Common Methodology, and encompasses several sub-objectives including the identification of multi-hazard zones within the municipal boundaries, spatial analysis of affected infrastructure units, planning of temporary shelter areas, mapping of disadvantaged groups at risk, and development of local policy recommendations.

The project outputs are expected to include the following:

1. *Identification and suitability assessment of temporary shelter areas to be used in the aftermath of disasters;*
2. *Spatial analysis of flood propagation zones, integrated with population, building, and infrastructure data within these areas;*
3. *Spatial identification of vulnerable groups at risk, with a particular focus on individuals with disabilities and elderly people.*

Development of a Flood/Flash Flood Event Inventory

Hopa is a region frequently affected by flash floods, and landslide events due to its geological, climatic, and anthropogenic characteristics. With an annual precipitation total of 2,350 mm, Hopa experiences extreme rainfall conditions compared to other parts of Türkiye. The district holds the national records for extreme precipitation events measured over standard durations of 5, 10, 15, and 30 minutes—recording 50.5 mm, 60.6 mm, 70.7 mm, and 90.9 mm respectively (ULUPINAR et al., n.d.). On August 24, 2015, intense rainfall triggered a major disaster in the districts of Hopa, Arhavi, and Borçka in Artvin Province. The amount of rainfall that caused the flood disaster in the region on that day reached a striking 287.2 mm within 24 hours (ULUPINAR, ÇELİK, AKBAŞ, & KÖSE). Figure 1 illustrates the flood propagation zones corresponding to the flood event that occurred in Hopa on August 24, 2015.

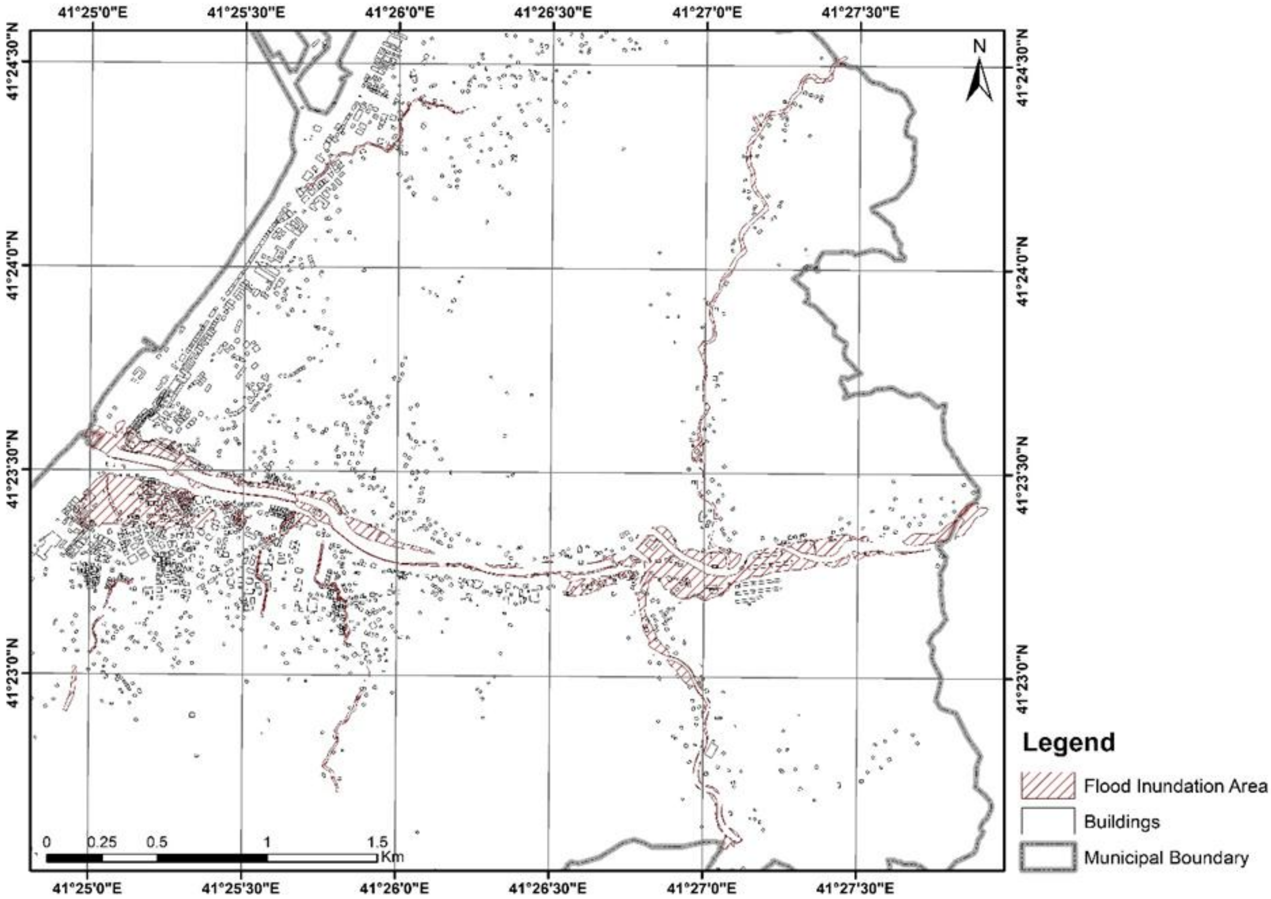

Figure 6: The flood propagation zones corresponding to the flood event that occurred on August 24, 2015 in Hopa

As a result of the flood disaster on August 24, 2015, a total of 11 people lost their lives (8 confirmed deaths and 3 missing people). The number of individuals injured and hospitalized due to the flood was officially recorded as 20.

Public authorities inspected 886 residential units in the affected areas of Hopa, recommending the relocation of 165 homes and the implementation of disaster prevention measures—such as the construction of retaining walls—for an additional 77 houses.

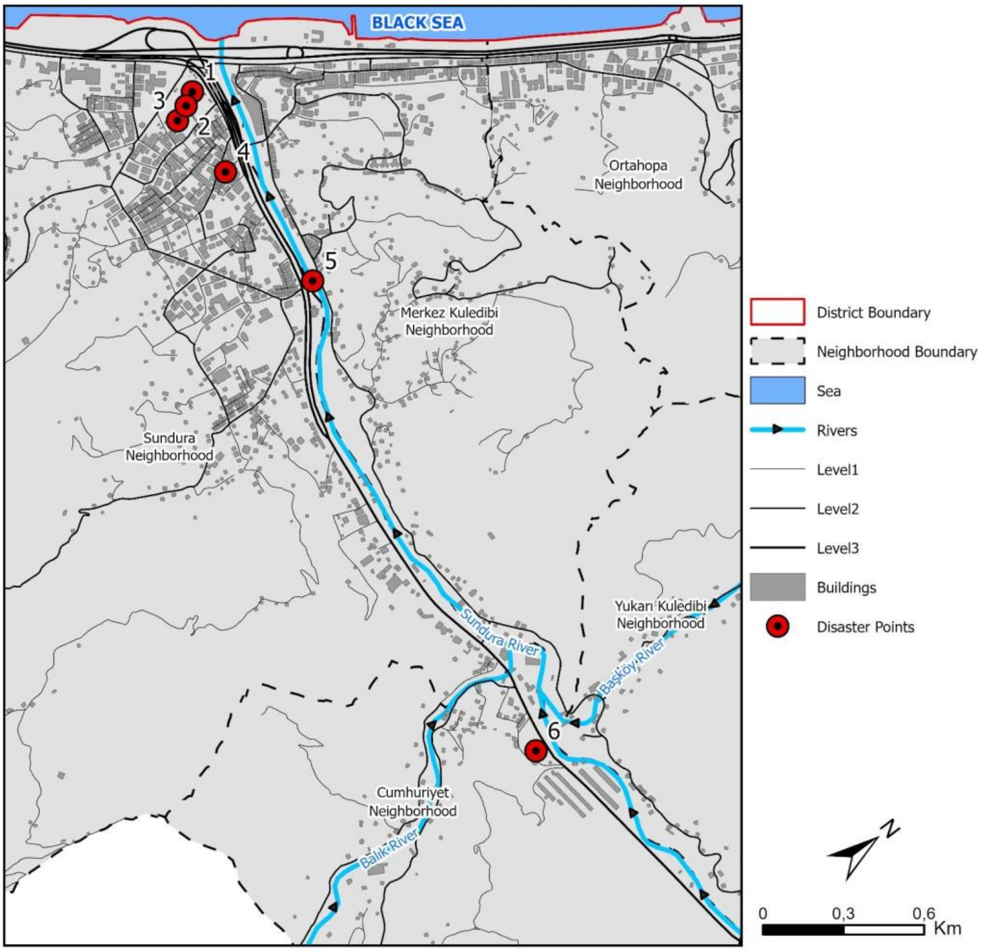

Figure 7.1: Disaster points from the 24 August 2015 flood.

Figure 2.2: Photos from the 24 August 2015 flood with disaster points.

Figure source: [Bianet](#) | [BBC](#) | Photo taken by a citizen | [EMO](#) | [Sabah](#) | 08haber

Definitive damage assessments conducted in Hopa, Kemalpaşa, and surrounding villages identified the destruction of 38 buildings (including 38 residences, 1 commercial property, 26 barns, 17 storage units, and 9 haylofts), while an additional 50 buildings were classified as severely damaged (including 60 residences, 8 commercial properties, 14 barns, 18 storage units, and 2 haylofts). The economic loss caused solely in Hopa by this disaster was officially recorded as 59,911,512.11 TRY. The sectoral distribution of these economic damages is presented in Table 1.1 below.

Table 1-1: Sectoral Distribution of Economic Damages Caused by the Flood on August 24, 2015

Sector	***Number of Assets***	***Amount of Damage (EUR)***
Food, Agriculture, and Livestock	1236	4.533.247,54
Industry and Manufacturing	335	7.100.473,58
Energy, Transportation, and Communication	311	2.923.045,42
Culture, Tourism, Education, and Health	26	888.137,41
Housing and Environment	375	2.078.718,30
	TOTAL	**17.523.622,25**

Identification and Planning of Temporary Shelter Areas

Temporary shelter areas are facilities designated to provide short-term accommodation for disaster-affected individuals whose homes have become uninhabitable due to a disaster or who are at risk if they remain in their homes, as well as those subject to evacuation. These areas may be established either individually or collectively, at or near the affected locations, or in alternative locations (Artvin Provincial Directorate of Disaster and Emergency (AFAD), 2021)The primary goal of temporary shelter areas is to offer a safe, healthy environment that meets the social and basic needs of disaster survivors.

In Türkiye, the site selection of temporary shelter areas following disasters is conducted according to technical criteria set by the Disaster and Emergency Management Authority (AFAD, 2015). Geographic characteristics such as proximity to water resources, access to transportation networks, the site's morphological and climatic features, hydrological conditions, and proximity to surrounding structures are all considered in site selection (TMMOB, 2023). The key site selection criteria are as follows:

1. Temporary shelter areas must be connected to existing main road axes;
2. Each temporary shelter area must be no smaller than 500 m²;

3. If possible, the land designated for shelter sites should be publicly owned (in the most urgent and short-term solutions, areas such as mosque or school courtyards may be utilized);
4. The selected site must be at least 3 meters above the rainwater catchment basin;
5. The terrain slope should be between 2% and 6%;
6. The area must be able to support connections to electricity, water, and sewage systems (at a minimum, a septic tank should be feasible);
7. The site should ideally allow for future expansion;
8. The average enclosed space per person in tents or containers located within the temporary shelter area must be at least 3.5 m².

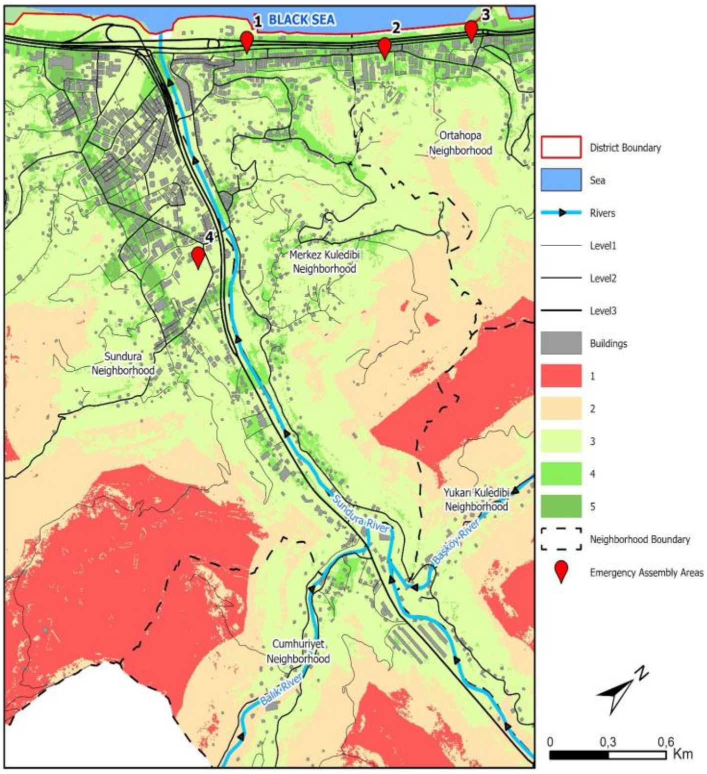

Figure 8: Suitability map for temporary shelter areas for Hopa

The first step in the site selection phase is to estimate the approximate population that would reside in temporary shelter areas and to determine the total area required for establishing such facilities. By overlaying Hopa Municipality's building data with the flood inventory map, it was determined that 601 buildings are located within the flood propagation zone. According to the Turkish Statistical Institute (TÜİK)'s 2024 population and demographic data, the average household size in Artvin is 2.7 (TÜİK, 2025). Assuming an average household size of 3, it is estimated that approximately 1,803 people reside in the 601 buildings located in the flood-prone area. As outlined in the above site selection criteria, the minimum enclosed space per person in temporary shelter areas should be 3.5 m². Therefore, it has been calculated that a temporary shelter area of approximately 6,310.50 m² would be required to accommodate 1,803 individuals.

Taking the site selection criteria into account, a temporary shelter suitability map for Hopa Municipality was produced using spatial analyses conducted in ArcGIS 10.8 GIS software (Figure 3). According to the suitability map, the municipal jurisdiction of Hopa is divided into five categories: very low, low, medium, high, and very high suitability. Since it is preferred that temporary shelter areas be established on publicly owned land, parcel data belonging to Hopa Municipality were obtained. Parcels that are vacant (i.e., without existing structures) and larger than 500 m² were identified and overlaid with the shelter suitability map. As a result, 10 parcels were identified as being moderately, highly, or very highly suitable for establishing temporary shelters, and each parcel is larger than 500 m². The sizes of these parcels range from 509.72 m² to 4,500.3 m², with a total combined area of 11,902.51 m². These results indicate that Hopa Municipality possesses sufficient land area to establish temporary shelter sites.

On the other hand, as also stated in Article 3, in the most urgent and short-term solutions, areas such as mosque courtyards and schoolyards can be used to establish temporary shelter sites. In this context, based on an assessment considering spatial conditions, the following locations have been identified as suitable areas for temporary shelter such as Hopa Vocational and Technical Anatolian High School, with a yard area of approximately 1,500 m², Nuri Vatan Anatolian High School, with a yard area of 1,700 m², Mehmet Akif Primary School, with a yard area of 1,525 m², The schoolyard of Hüsnü Ciner Elementary School, The open parking area built next to the Hopa Youth Center, with a total area of 2,300 m².

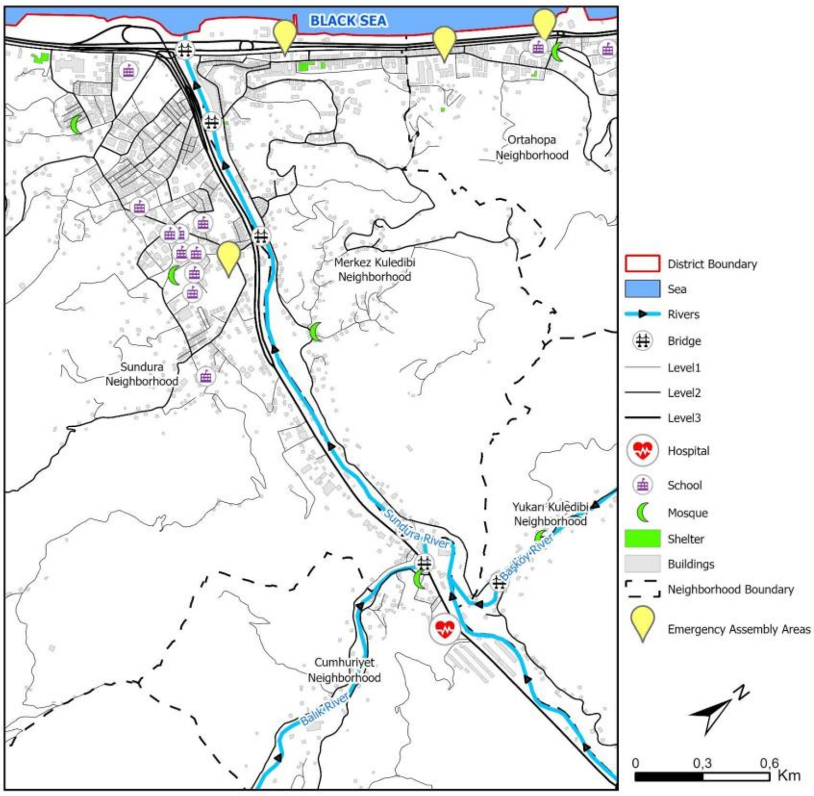

Figure 9: The map legend illustrates the spatial distribution of district boundaries, rivers, bridges, neighborhood divisions, critical infrastructure buildings, and designated emergency assembly areas as determined by AFAD

Within the scope of the preliminary analysis studies, it has been determined that the existing hospital is located in a high-exposure risk zone in terms of flood hazard. In addition, it was found that the majority of the temporary shelter and assembly areas designated by AFAD have become outdated and, due to their physical conditions, are inadequate in terms of disaster response capacity (Figure 4). This situation clearly indicates the need to restructure post-disaster response strategies.

Table 2: Temporary Shelter Areas Designated by AFAD

District	***Description***	***Neighborhood***	***Area***
Hopa	Belediye Park	Merkez Kuledibi	4337.87 m2
Hopa	City Stadium	Sundura	20667.01 m2
Hopa	Hüsnü Ciner Primary School	Ortahopa	10344.41 m2
Hopa	Yavuz Selim Secondary School	Ortahopa	3314 m2

In this context, the project outputs developed are not limited to mapping existing risks but are specifically designed to be directly integrated into decision-making processes. They are structured to inform and update local policies such as Hopa Municipality's Strategic Plan, the urban development plan revision process, and the Disaster Management Implementation Plan. At the same time, they are expected to contribute to regional planning documents such as the Artvin Provincial Risk Reduction Plan (İRAP). CLIMAAX outputs will serve as direct tools for decision-makers in identifying priority intervention areas, proposing infrastructure re-planning strategies, and developing community-based adaptation policies.

Identification and Spatial Analysis of Disadvantaged Groups' Inventory

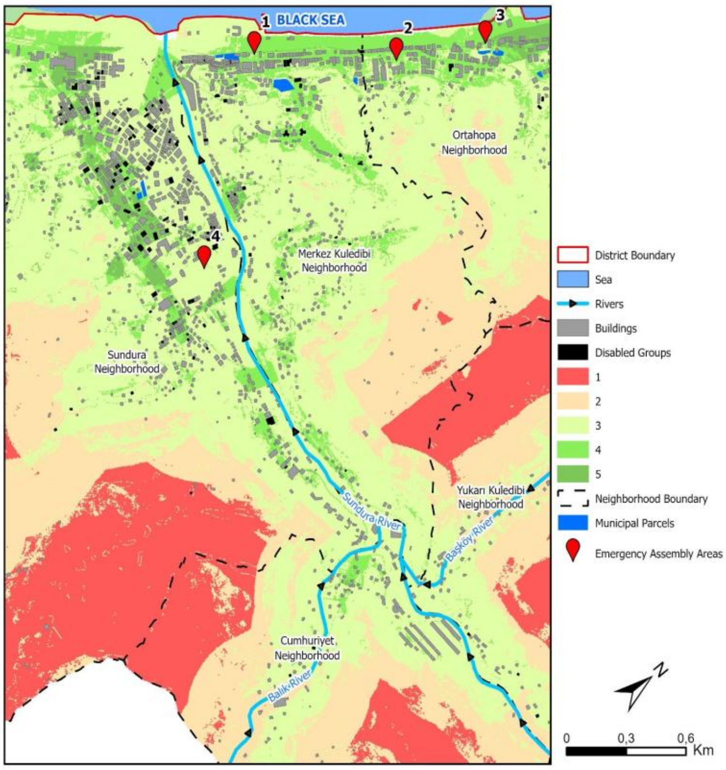

Figure 10: Suitability map for disabled groups with temporary shelter areas determined by AFAD and Hopa Municipality

According to official records, a total of 202 disabled people reside in Hopa. The spatial distribution of these people is concentrated in the Sundura neighborhood, which holds particular vulnerability in terms of disaster risk due to both its high population density and steep topography. Based on map analysis, most of these disadvantaged individuals face significant challenges in accessing the temporary shelter areas designated by AFAD during a disaster, primarily due to their limited mobility. Considering all potential complications that may arise during a disaster event, the evacuation of individuals with physical disabilities presents additional difficulties in coordinating both during and after the emergency.

Using the same method in the 65+ population inventory analysis, it is observed that the elderly population is spatially clustered in the Sundura and Ortahopa neighborhoods, as well as in settlement strips extending along the valleys. The elderly residents, indicated by red dots on the map, live in areas vulnerable to river flooding, short-duration flash floods, and rainfall-induced landslides.

Accordingly, factors such as slow evacuation, uneven terrain, multi-story buildings without elevators, and the need for continuity of medication, medical devices, or care increase the severity of the situation. Therefore, the clustering of 65+ individuals should be assessed in conjunction with the temporary shelter suitability surface and locations that facilitate evacuation. Priority should be given to establishing accessible (e.g., ramps, lighting, 24-hour electricity, quiet environment) assembly/shelter points within a walking distance of 200–400 meters from elderly households.

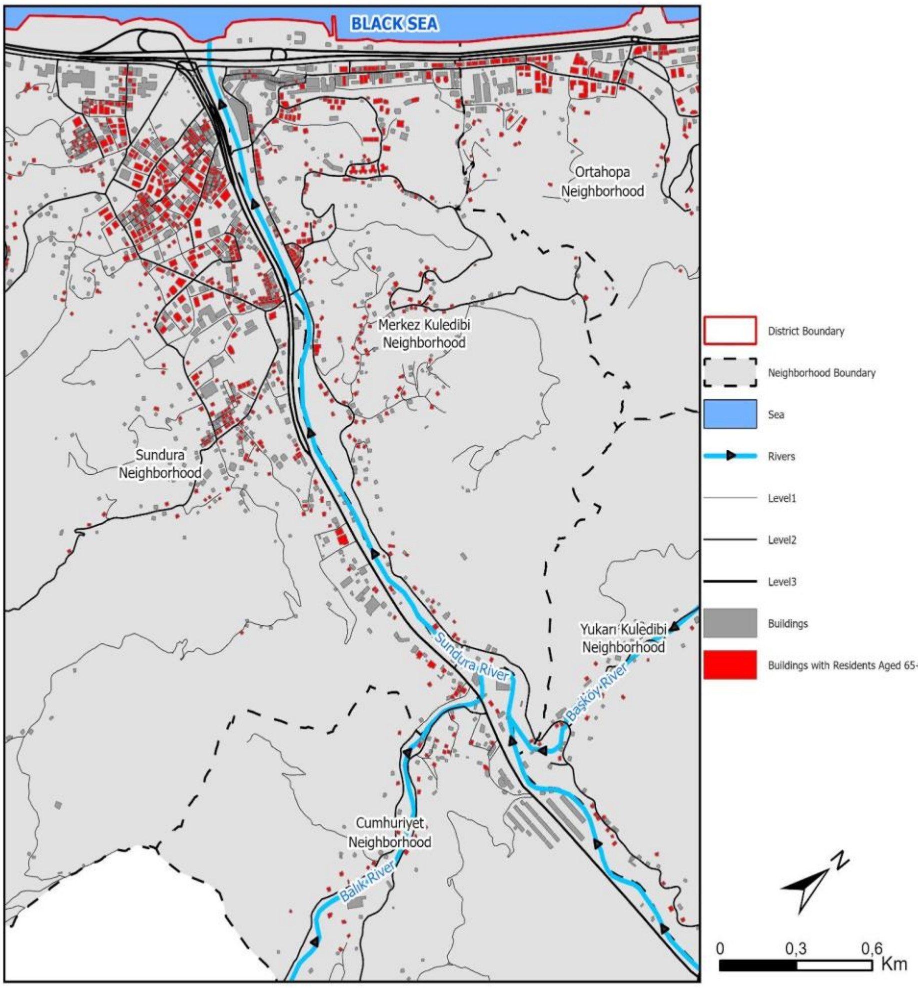

Figure 6: Suitability map for Aged 65+ residents

This map will serve as a direct input for the exposure–vulnerability overlays to be produced under the CLIMAAX framework; it will also form the basis for the reallocation of AFAD/Municipality assembly points based on elderly population concentrations and the design of accessible evacuation scenarios (e.g., prioritized rescue teams, stretcher/wheelchair logistics). Guided by the map developed in accordance with AFAD's technical site selection criteria, the suitability surface shown on the map enables a directly actionable solution aligned with this vulnerability: prioritizing the location of shelter/assembly areas within the green suitability zones and within walking distance of households with people with disabilities, avoiding orange/red risk zones, and ensuring connection to existing main road axes will not only reduce evacuation time but also ensure the safe transfer of individuals requiring assisted/accessible evacuation.

Furthermore, this map will serve as a direct input for Phase II outputs under the CLIMAAX framework, such as exposure maps and vulnerability integration. Based on these findings, AFAD's current assembly point list will be revised, and operational plans will be developed for accessible evacuation routes, pre-assigned meeting points, and continuity of care/medical device operation (including power outage scenarios).

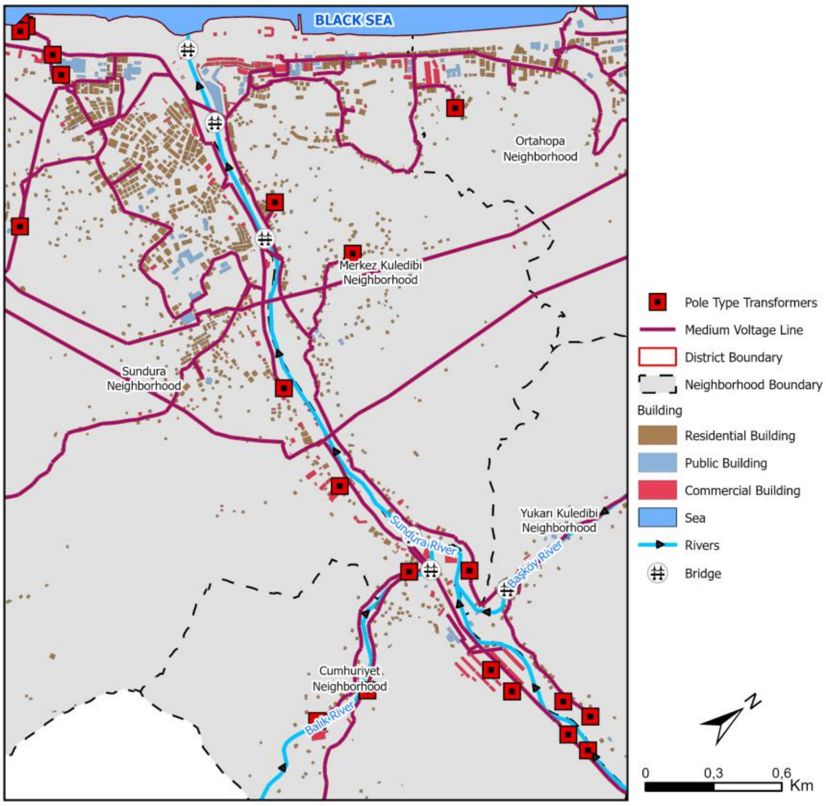

Figure 7: Spatial distribution of medium voltage lines, pole-type transformers, building types (residential, public, commercial), rivers, bridges, and neighborhood boundaries within Hopa Municipality

However, certain limitations exist within the current climate risk assessment process. Hopa Municipality faces a shortage of personnel in its Geographic Information Systems (GIS) infrastructure. Stakeholder participation remains limited in some rural neighborhoods, and external resources are required to support scenario-based modeling due to constraints in accessing climate data.

In the context of these limitations, access to official micro-scale data (address/household level) on vulnerable groups represents the most critical bottleneck. Hopa Municipality has undertaken inter-institutional requests and field visits to obtain data on the 0–6 age group; however, due to personal data protection regulations and institutional data policies, access to address-based microdata could not be secured. Instead, TÜİK's neighborhood-level tables were utilized, and the population of children aged 0–6 in Hopa was compiled at the neighborhood level in the most up-to-date and reliable manner available.

Table 3: Children population by neighborhoods

Neighborhood	*Children*
Bucak	*33*
Cumhuriyet	*24*
Merkez Kuledibi	*352*
Ortahopa	*592*
Sundura	*944*
Yukarı Kuledibi	*28*
Sugören	*47*

A total of 2,020 children show high spatial clustering across neighborhoods: Sundura 46.7% (944 children), Ortahopa 29.3% (592), Merkez Kuledibi 17.4% (352); while the remaining 6.6% are distributed across Sugören (47), Bucak (33), Yukarı Kuledibi (28), and Cumhuriyet (24) neighborhoods. When this distribution is overlaid with river flood, heavy rainfall, and rainfall-induced landslide layers, it simultaneously reveals clusters of highly exposed children and the need for accessible safe areas.

Accordingly, the child exposure index will provide direct data input into decision-making points such as school/kindergarten access safety, family-oriented evacuation routes, and the siting of temporary shelters (within green suitability zones). This approach enables the production of high-resolution exposure maps based on the most up-to-date publicly available statistics, while respecting data privacy, and allows for periodic revisions through annual ADNKS updates.

2.1.2 Context

Hopa, situated on the Black Sea coast, is characterized by a unique topography confined between a narrow coastal strip and steep slopes, which makes it highly exposed to climate-induced disasters, particularly floods, flash floods, and landslides triggered by intense precipitation events linked to climate change. While Türkiye's national annual average precipitation is 593.3 mm (MGM, 2024), Hopa receives up to 2,435 mm, making it one of the rainiest locations in the country (Hopa Municipality, 2024). These extreme meteorological conditions place significant stress on infrastructure systems, particularly in the urban center and several neighborhoods of Hopa, amplifying disaster risk due to structural inadequacies.

Historical disaster records demonstrate the region's increasing climate risk trends. In particular, the flood disaster of August 24, 2015, revealed the severity of Hopa's disaster vulnerability. According to data from the Turkish State Meteorological Service, 287.2 mm of rainfall per square meter was recorded within 24 hours during this event. Eight people lost their lives, three went missing, and numerous citizens were injured. Among the deceased were two children, one disadvantaged individual, and three elderly residents (AFAD, 2015). A total of 2,664 sectoral units—including housing, agriculture, transportation, education, health, and energy—were affected, and nearly 60 million TRY in economic damages were reported for Hopa alone. In Ortahopa and Sundura neighborhoods, where the impacts were concentrated, critical public infrastructure became inoperable, with economic losses estimated at around 60 million TRY. This event is not an isolated disaster but rather an indication of a systematic climatic risk that frequently recurs in Hopa, particularly during the autumn months. Indeed, during the intense rainfall of October 9, 2024, Hopa was recorded as the district with the highest 24-hour precipitation in Türkiye, reaching 63.5 mm/m² (NTV, 2024).

Despite the level of risks described, no comprehensive climate risk assessment or adaptation strategy based on a multi-hazard approach has yet been developed in Hopa. Existing practices and interventions are mostly concentrated during and after disaster events, lacking systematic pre-assessment, scenario modeling, or adaptation-oriented spatial planning tools. In 2024, Hopa Municipality took its first steps to address this gap by preparing a Disaster Action Plan, thereby establishing an institutional intervention framework for the first time. At a broader scale, strategic documents such as the Provincial Disaster Risk Reduction Plan (İRAP) and the Agricultural

Adaptation Plan (TARAP) have been prepared for Artvin Province; however, due to limited local data and capacity, these plans have not been effectively localized to Hopa's specific context. Hopa's climate vulnerability is deepened not only by the frequency of natural hazards but also by the limitations in the municipality's capacity to respond to such events. To date, no guiding mapping system for disaster risk reduction, no multi-stakeholder coordination structure, and no integration-based Disaster Coordination Center have been established in the district. This deficiency weakens all stages of disaster management—including preparedness, emergency response, and post-disaster recovery—and creates a systematic protection gap, particularly for vulnerable groups such as the elderly, children, women, and people with disabilities.

Disaster management should be strengthened not only through structural measures (e.g., retaining walls, sewage systems) but also through community-based capacity-building approaches. In this context, civil society organizations such as the Hopa Search and Rescue Team (HOPAK) represent significant potential for advancing disaster awareness, fostering solidarity networks, and enhancing the protection of vulnerable groups.

On the other hand, Hopa's role as a regional logistics hub and a key transit point between the Eastern Black Sea and Georgia makes the transportation and trade sectors directly exposed to climate risks. Moreover, tea cultivation—the dominant activity in the regional economy—faces risks of soil erosion, crop loss, and reduced productivity due to extreme weather events. The widespread presence of energy and communication lines in rural areas, which are frequently damaged during disasters, generates cascading impacts on regional systems. According to data from the Hopa District Directorate of Agriculture, the flood event of 24 August 2015 damaged 1,500 decares of agricultural land and affected 600 farmers. The region's sensitivity to climate risks is not limited to natural systems; the urban development model also reinforces these risks. Unplanned urbanization, the expansion of coastal land reclamation, construction on steep slopes, and inadequate drainage infrastructure are direct drivers of disaster vulnerability. Decades of unplanned urban growth, irregular construction patterns, and horizontal urban sprawl in the district have intensified population density in high-risk areas, thereby amplifying the potential physical and social impacts of disasters. Taken together, these factors clearly demonstrate that building climate resilience in Hopa can only be achieved through a multi-actor, inclusive, and systemic approach.

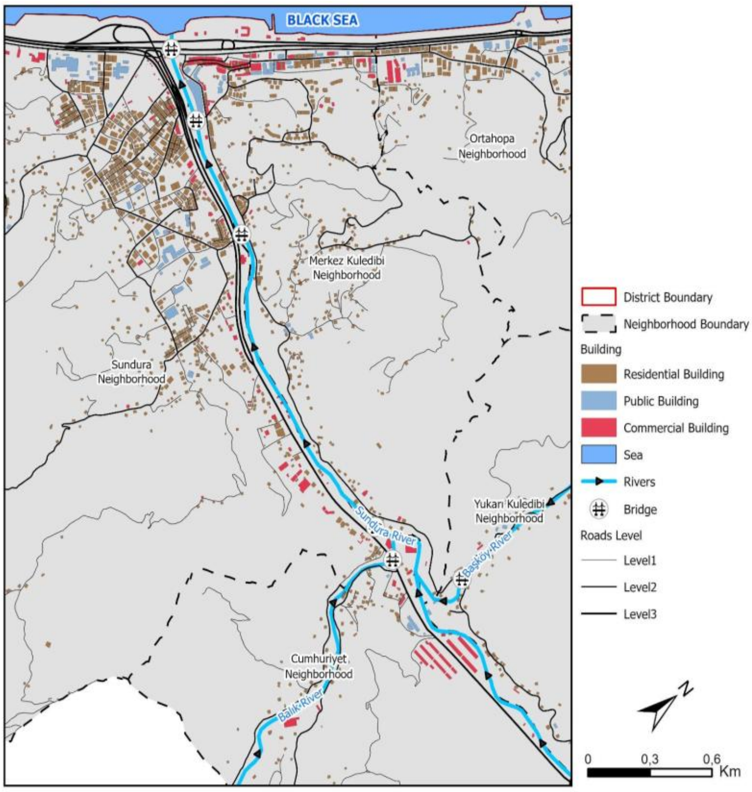

Figure 8: Building Inventory of Hopa

The region's sensitivity to climate risks is not limited to natural systems; the urban development model also plays a reinforcing role in amplifying these risks. Unplanned urbanization, the expansion of coastal land reclamation, construction on steep slopes, and inadequate drainage infrastructure are direct factors triggering disasters. The long-standing patterns of unplanned urban growth, irregular construction, and horizontal sprawl in the district have increased population density in high-risk areas, thereby exacerbating the potential physical and social impacts of disasters. Taken together, these elements clearly demonstrate that building climate resilience in Hopa can only be achieved through a multi-actor, inclusive, and systemic approach.

In this context, the risk assessment conducted under the CLIMAAX framework encompasses not only scientific analysis but also spatial and sectoral recommendations designed to guide policy-making. The project outputs will provide direct inputs to Hopa Municipality's Strategic Plan, the urban development plan revision, the Disaster Management Implementation Plan, and the alignment of the Provincial Risk Reduction Plan (İRAP). Furthermore, the project is expected to contribute to the municipality's international climate commitments under frameworks such as the Covenant of Mayors and Making Cities Resilient.

2.1.3 Participation and risk ownership

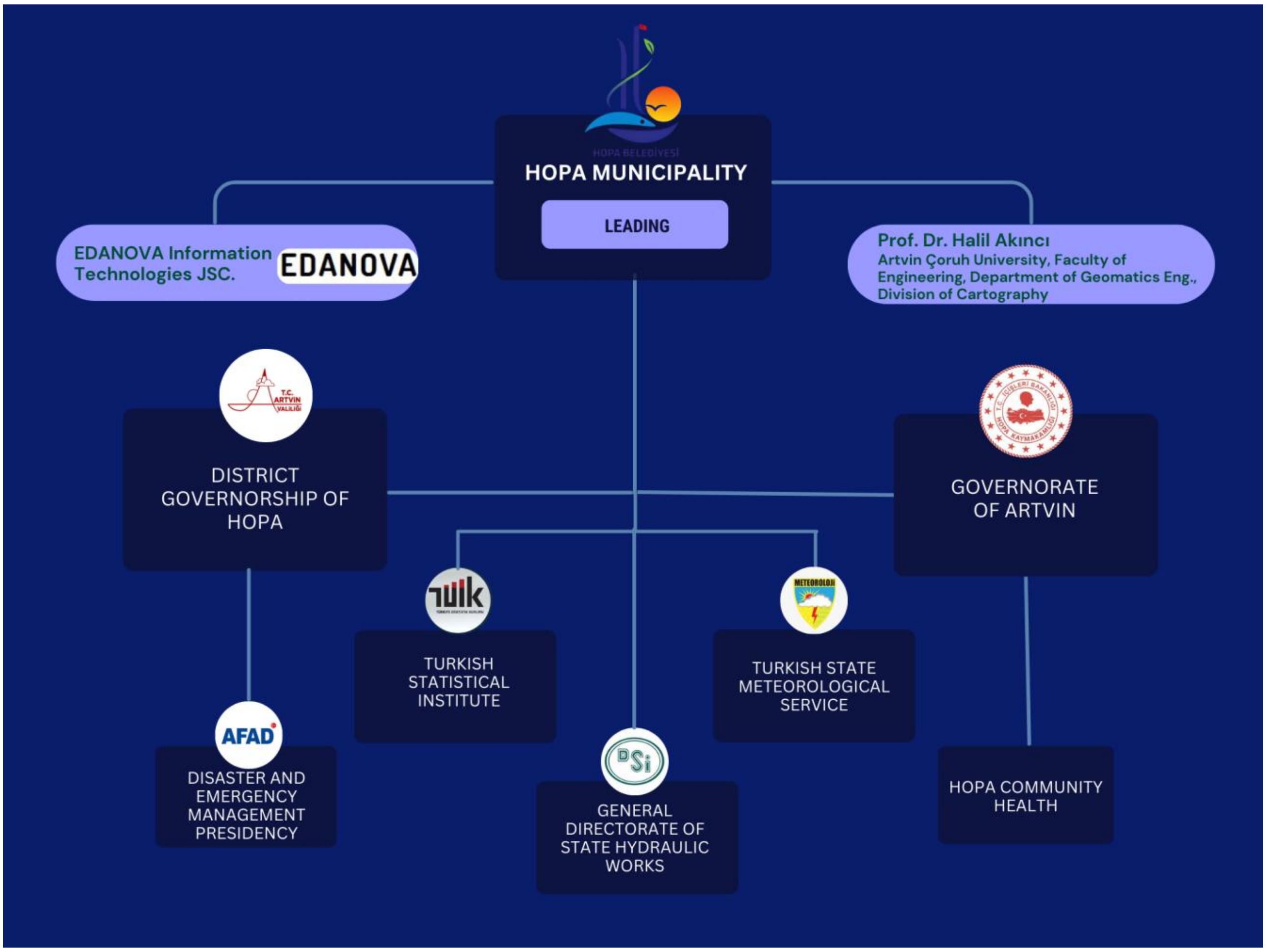

Figure 9: Organogram of participation and risk ownership

In the early stages of the SAFE-HOPA project, stakeholder involvement was initiated through formal visits and correspondence with relevant public institutions. Informative letters were sent in line with the institutional procedures of Türkiye. Initial coordination efforts included visits to the Governorship of Artvin, the District Governorship of Hopa, the Regional Directorate of State Hydraulic Works (DSİ), the Regional Directorate of Meteorology (MGM), the Provincial Directorate of Disaster and Emergency Management (AFAD), and the Hopa Community Health Center. These engagements helped clarify each institution's potential contribution and responsibilities. Stakeholders were identified, and responsibilities were defined (Milestone 2). Visits were conducted to all key institutions as part of the outreach and engagement process (KPI).

Within the Hopa Municipality, an internal coordination framework was activated to facilitate the effective implementation of the SAFE-HOPA project. Regular meetings were held with the Directorate of Public Works, Directorate of Climate Change and Zero Waste, Directorate of Disaster Management, Directorate of Zoning, and Directorate of Social Support Services. These units played integral roles in providing technical data, local infrastructure plans, social vulnerability assessments, and policy input relevant to flood risk and climate adaptation planning.

The project has been coordinated and carried out jointly by these municipal departments to ensure alignment with ongoing strategic plans and to mainstream climate risk considerations into local decision-making processes.

An institutional stakeholder organogram was developed to visualize how local and regional actors are interconnected in the climate risk assessment and management process (organogram photo).

To represent vulnerable and high-risk groups, the head of the Hopa Disabled People Association was consulted to provide experience-based input on the needs and priorities of individuals with disabilities. Furthermore, active communication was established with the current local authority of the Ortahopa and Sundura neighborhoods. Findings of the project were shared on a neighborhood-specific basis with these representatives to ensure transparency and local alignment.

Risk ownership is regulated through an institutional division of responsibilities. While Hopa Municipality leads the development of local adaptation strategies and proactive planning, operational coordination during disaster events falls under the responsibility of AFAD. Supporting institutions such as DSİ and MGM contribute with technical data and forecasting, whereas social vulnerabilities are addressed in coordination with health and social service units.

In Phase 3 of the project, the results will be communicated under the framework of local adaptation strategy development. The findings will first be shared with public authorities, followed by broader dissemination to the public. One-on-one briefings will be organized with relevant institutional stakeholders to ensure targeted and effective knowledge transfer.

2.2 Risk Exploration

Risk exploration initiates the process of climate risk assessment by carefully selecting and determining climate-related risks, exposures, and vulnerabilities that are relevant to Hopa. In order to make sure that the assessment concentrates on the most important and obvious threats affecting the area, this step entails engaging with important stakeholders and taking public concerns into account. This helps to guide subsequent in-depth assessments and focused adaptation measures.

2.2.1 Screen risks (selection of main hazards)

The **SAFE-HOPA** project covers climatic threats that have a major influence on Hopa's community vulnerability, economic stability, and agricultural output. Through discussions among stakeholders and initial environmental evaluations, a thorough assessment of climate-related hazards was carried out as part of the **SAFE-HOPA** project. This process identified **River Flooding** and **Heavy Rainfall** as the most relevant and pressing climate risks affecting the Hopa region.

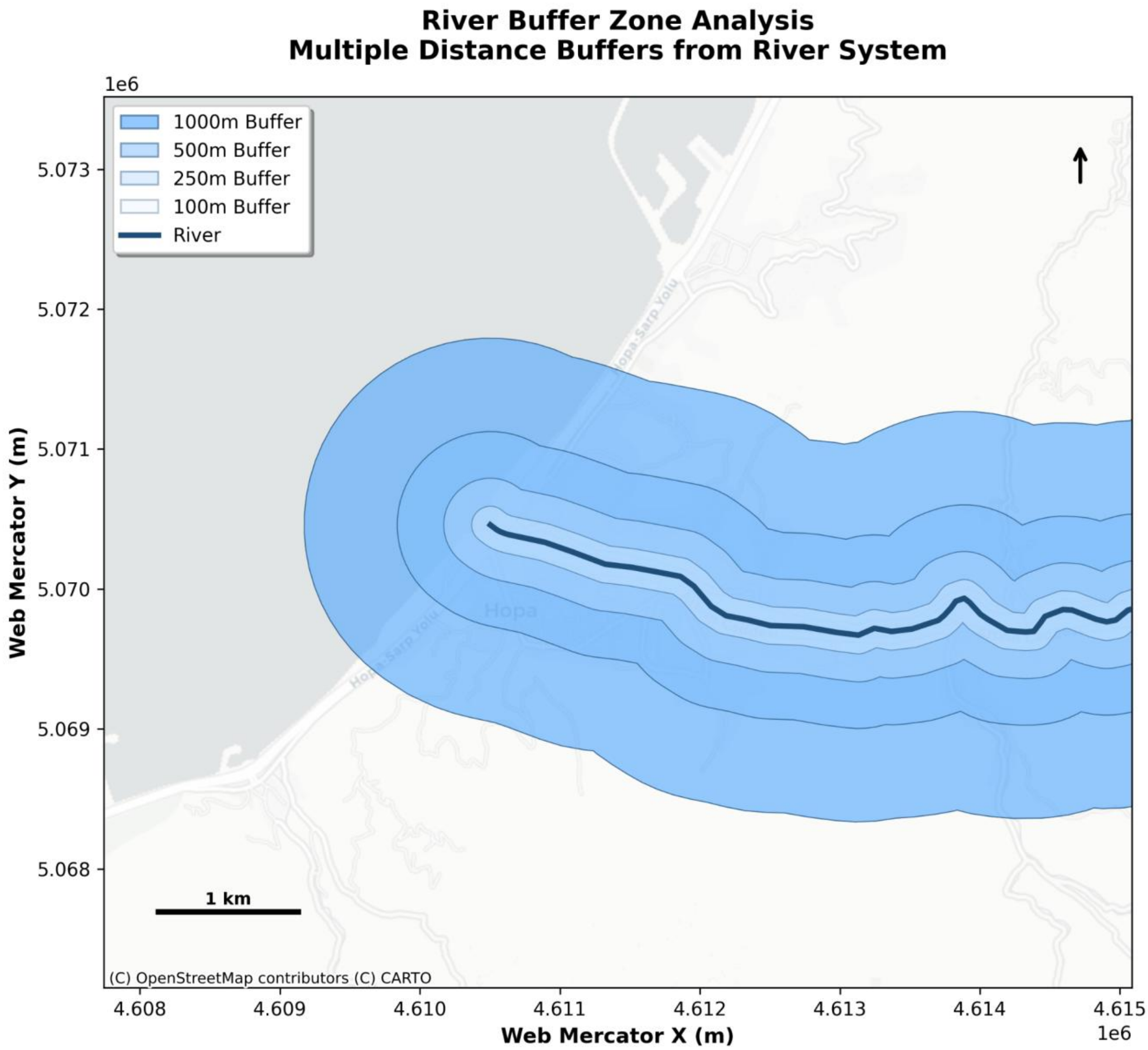

Figure 10: River buffer zone analysis multiple distance buffers from river system

The climatology map shows that the Hopa region experiences between 40 to 90 days annually with heavy precipitation exceeding 10 mm. The highest frequency of heavy precipitation days occurs near the coastal areas, particularly towards the **Çoruh River**, indicating the significant influence of the Black Sea's moisture and orographic effects. Inland areas show fewer heavy precipitation days, likely due to elevation and reduced maritime influence. These patterns highlight the region's susceptibility to intense rainfall events, which have implications for flood risk and water resource management.

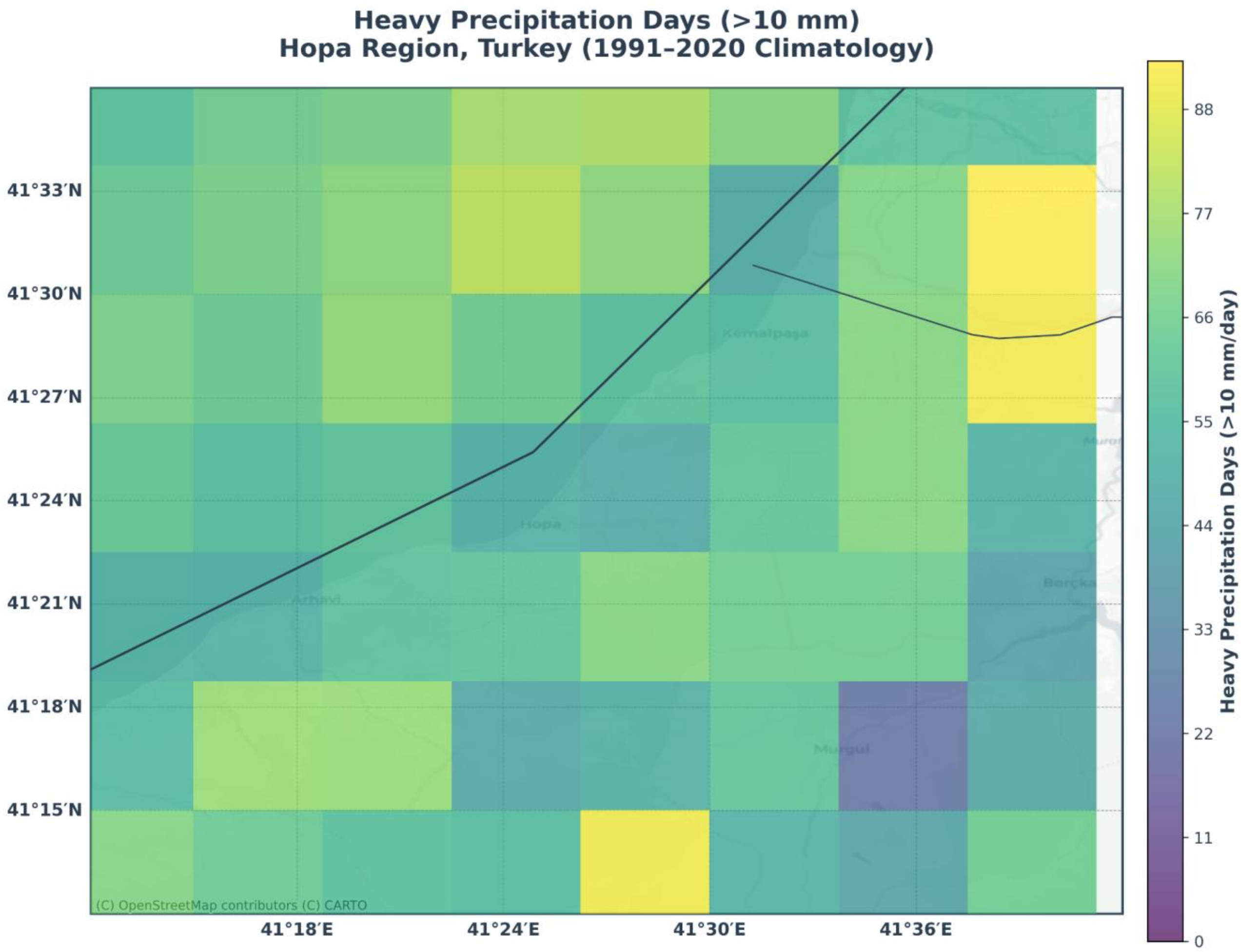

Figure 11: Heavy Precipitation Days (>10 mm) Hopa Region, Türkiye (1991-2020 Climatology)

Heavy Rainfall—characterized by intense and often short-duration precipitation events—has been increasingly observed in recent years, driven by shifts in regional climate patterns. These events contribute to excess surface runoff, soil saturation, and erosion, posing significant threats to agricultural productivity, infrastructure stability, and overall land management.

River Flooding, often a direct consequence of prolonged or extreme rainfall events, has emerged as a critical hazard in the Hopa region. Overflow from local rivers disrupts transportation networks, damages agricultural fields and settlements, and overwhelms water management systems. The increasing frequency and intensity of such flooding events are attributed to both climatic drivers and evolving land-use practices, including deforestation and urbanization in flood-prone areas.

While multiple climate-related stressors are present, **river flooding has been identified as the most significant and recurring challenge**. Its far-reaching implications for water security, food systems, infrastructure resilience, and socioeconomic stability underscore the necessity of prioritizing it within the scope of this risk assessment.

This evaluation will therefore concentrate on understanding the drivers, impacts, and potential adaptation strategies related to river flooding, while also addressing the interconnected role of heavy rainfall in exacerbating these risks.

Observed and Expected Hazards: Current observations in the Hopa region reveal an increasing frequency and intensity of **heavy rainfall events** and associated **river flooding**. These phenomena have resulted in recurrent disruptions to agricultural activities, damage to infrastructure, and heightened challenges in local water and land management systems. Hydrometeorological data from national meteorological administration and stakeholder input also indicate changing rainfall patterns, increased stormwater runoff, and greater variability in river discharge levels.

Future climate projections for the region suggest:

- A continued rise in the frequency and magnitude of **heavy precipitation events**, particularly during seasonal transition periods;
- An increased likelihood of **riverine flooding**, especially in low-lying and poorly drained catchments;
- Greater risks of **soil erosion, sedimentation**, and localized infrastructure failure due to the combined effects of intense rainfall and river overflow.

These projected hazards highlight the urgency of designing and implementing effective adaptation strategies to enhance the resilience of both ecological and socio-economic systems.

This **Climate Risk Assessment** explicitly focuses on **river flooding**, given its substantial and recurring impacts on the region's agricultural systems, built environment, and community well-being.

Available Data and Knowledge: The available datasets in Zenodo repository.

Further Data and Knowledge Needs: Despite the availability of various environmental and climate datasets, several critical information gaps persist, limiting the depth and accuracy of this risk assessment. In the case of Hopa, efforts to obtain **administrative data**, **disaster-related records**, and **statistical data on past disaster events** were unsuccessful. The absence of such data constrains a comprehensive understanding of historical exposure, response capacity, and long-term vulnerability trends within the region.

Addressing these limitations is essential for improving future climate risk assessments. Access to detailed and region-specific data —particularly related to disaster incidence, local governance structures, and population exposure— would enable more robust scenario modeling and support the design of context-sensitive adaptation strategies. Bridging these gaps will be crucial in enhancing Hopa's capacity for anticipatory flood risk management and climate resilience planning.

2.2.2 Workflow selection

This section outlines and discusses in detail the risk workflows chosen from the CLIMAAX Handbook that pertain to the recognized threat of drought. Furthermore, it specifies the particular vulnerable groups and at-risk regions that will be dealt with in these workflows.

2.2.2.1 Workflow #1: River Floods Risk Management

Exposed Areas: This workflow focuses on regions within the Hopa district that are systematically exposed to river flood risks, primarily as a result of climate change-induced increases in extreme precipitation events. In particular, the **Ortahopa Stream** and **Sundura Stream** have emerged as recurrent sources of flood hazards. Historical events, such as the severe flood on 24 August 2015, which caused significant destruction in the Hopa city center—resulting in loss of life and widespread infrastructure failure—have underscored the urgency of addressing river flood risks in the area.

Areas identified as having high exposure to river flooding include the vicinity of the former municipal square, the surroundings of **Hopa City Hospital**, **Sundura** and **Ortahopa** neighborhoods, **the truck parking zone**, **the industrial area**, and **the coastal strip**. These zones are characterized by limited flood management infrastructure, the narrowing of riverbeds, and unregulated urban expansion, all of which significantly increase flood vulnerability.

Vulnerable Groups: The relative flood risk workflow prioritizes the protection of socially and economically vulnerable groups who are disproportionately affected by river flood events. These include the **elderly**, **people with disabilities**, **women**, and **children**—particularly those residing within high-risk zones identified through preliminary mapping. Rural and peri-urban farming communities, especially those located near the **Sundura Stream**, are also notably affected due to their dependence on agricultural lands situated adjacent to flood-prone waterways. Flood events directly threaten their livelihoods and food security through crop loss and land degradation.

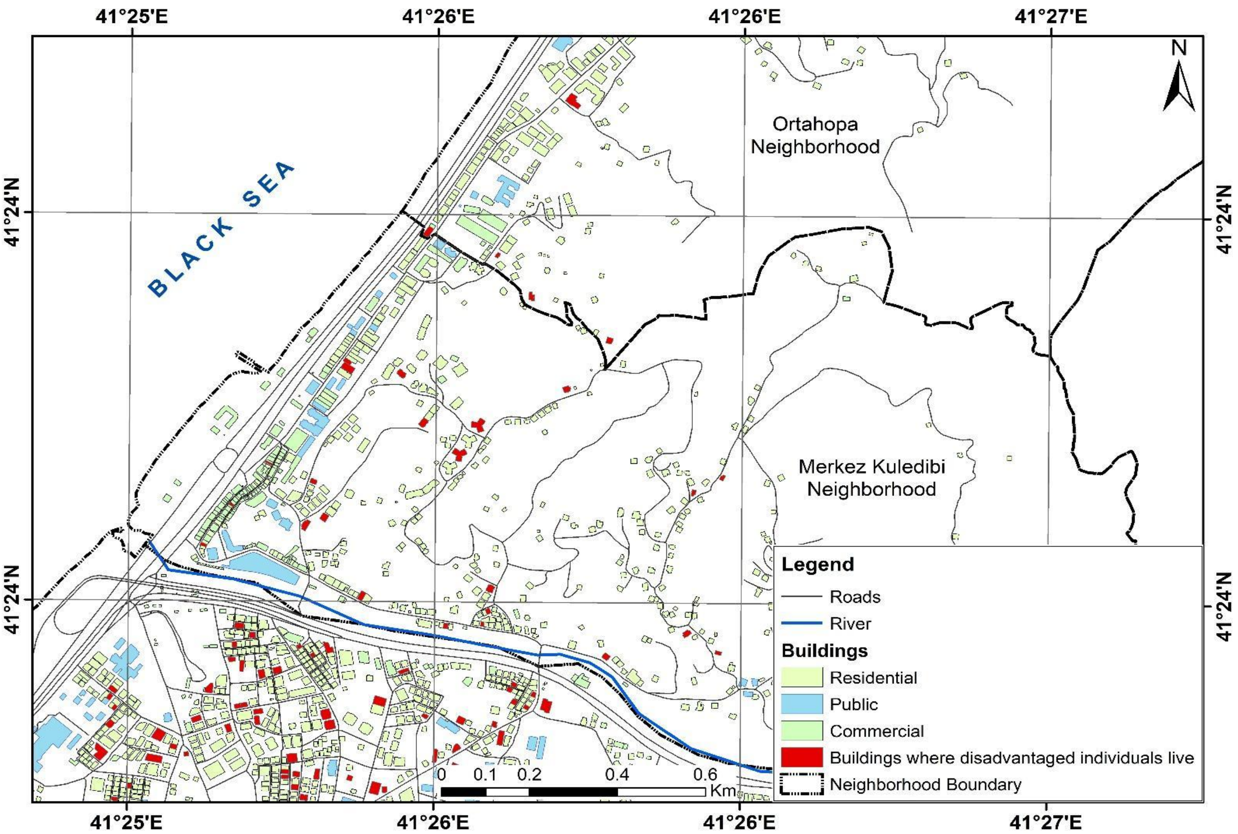

Figure 12: Spatial distribution of buildings where disadvantaged individuals live within the boundaries of Hopa Municipality

Livestock producers and **small-scale tea farmers** operating in erosion-prone flood basins face increased risk of economic disruption due to the destruction of fodder supplies, damaged infrastructure, and the loss of productive land. Moreover, low-income households residing in structurally vulnerable housing and in close proximity to drainage channels are subject to elevated physical and economic risks. The compounding effects of inadequate housing resilience, limited access to resources, and poor drainage infrastructure amplify the socio-economic consequences of flooding across these communities.

2.2.2.2 Workflow #2: Heavy Rain Risk Management

Exposed Areas: This workflow targets areas within the Hopa district that are recurrently affected by intense and prolonged rainfall events, which are becoming more frequent due to climate change. Key zones of concern include **steep-sloped rural settlements**, **poorly drained urban corridors**, and **road infrastructure linking** Hopa city center to upland communities. Critical sites such as the **central transportation routes**, **hillside housing clusters**, and **inadequately engineered stormwater systems** are particularly susceptible to rain-induced surface runoff, landslides, and localized flash flooding.

Regional-scale analyses indicate that the majority of landslides occurring in various districts of **Artvin**, including **Hopa**, are directly triggered by extreme precipitation events (Artvin Governorship Disaster and Emergency Management Directorate, 2021, p. 64). Although such events typically occur over small areas and develop suddenly, they frequently result in loss of life and disrupt the functioning of access routes and infrastructure systems due to the region's steep topography and the proximity of settlements to streams and slopes. In particular, soil saturation in settlements constructed on steep slopes in Hopa leads to small-scale landslides, causing direct damage to living spaces.

Vulnerable Groups: Populations at heightened risk from heavy rainfall impacts include **hillside residents** in structurally insecure housing, rural households along landslide-prone slopes, and daily commuters reliant on disrupted transport infrastructure. **Socio-economically disadvantaged groups**—especially women, the elderly, and low-income families—experience amplified vulnerability due to limited adaptive capacity, reduced mobility, and insufficient access to early warning systems. **Agricultural laborers** and **seasonal workers** are also affected, as extreme rainfall frequently disrupts land access, damages crops, and interrupts work cycles essential for livelihoods.

2.2.3 Choose Scenario

Scenario selection for the Hopa region was guided by both climatic and socio-economic considerations, aiming to ensure that the analysis supports long-term risk-informed decision-making. The medium-term time horizon, defined as the year 2050, was chosen to align with the RPACC framework and reflects the timeframe within which public policies and investment planning can be realistically implemented. In addition, hazard assessments using return periods of 50, 100, and 500 years offer insights into both medium- and long-term risk exposure.

To account for the effects of future climate change, the high-emission **RCP8.5** scenario was selected. This pathway represents a conservative estimate of climate risks, including more intense and frequent extreme weather events. In the context of Hopa, two specific hazard workflows are particularly relevant: **river flooding** and **heavy rainfall**, both of which are expected to increase under future climate conditions.

Socio-economic assumptions, while not quantitatively modeled in this phase, are recognized as important contextual factors. **Population growth**, **urban expansion into hazard-prone areas**, and increasing demand for infrastructure and services are expected to amplify the vulnerability of the region. Moreover, regional economic development and changes in **food and energy consumption patterns** may influence both exposure and resilience to climate-related hazards.

Therefore, the selected scenario assumptions incorporate both physical hazard projections and broader socio-economic trends, ensuring a comprehensive understanding of future risks in the Hopa region.

2.3 Risk Analysis

This section outlines how the selected risk workflows from the **CLIMAAX Handbook** were systematically applied in the **Hopa district** to assess **relative river flood risk**. The analysis integrates hazard, exposure, and vulnerability data to produce a spatially explicit flood risk assessment. All primary datasets used conform to the methodologies specified in the CLIMAAX Handbook.

Risk assessment elements: The following core attributes were systematically analyzed:

- **Hazard Assessment:**
  River flood hazard was assessed using historical river flood depth maps from the Joint Research Centre (JRC), covering return periods of 10 to 500 years. Additionally, future climate-based flood projections from the Aqueduct Floods dataset (RCP4.5 and RCP8.5 scenarios for 2030, 2050, and 2080) were used to understand potential shifts in hazard severity.
- **Exposure Assessment:**
  The exposure layer included detailed land use data (residential, agricultural, industrial), with a specific focus on **flood-prone infrastructure zones** in Hopa such as the **city hospital**, **coastal strip**, and **peri-urban agricultural lands**. The economic value of different land use types was integrated using country-specific valuation tables.
- **Vulnerability Assessment:**
  Vulnerability was assessed through demographic and socio-economic indicators, focusing on **vulnerable population groups** such as the **elderly**, **children**, **people with disabilities**, and **low-income households**. Rural households dependent on **agriculture and livestock**, especially along **Sundura Stream**, were also considered due to their increased exposure to economic disruption and land degradation.

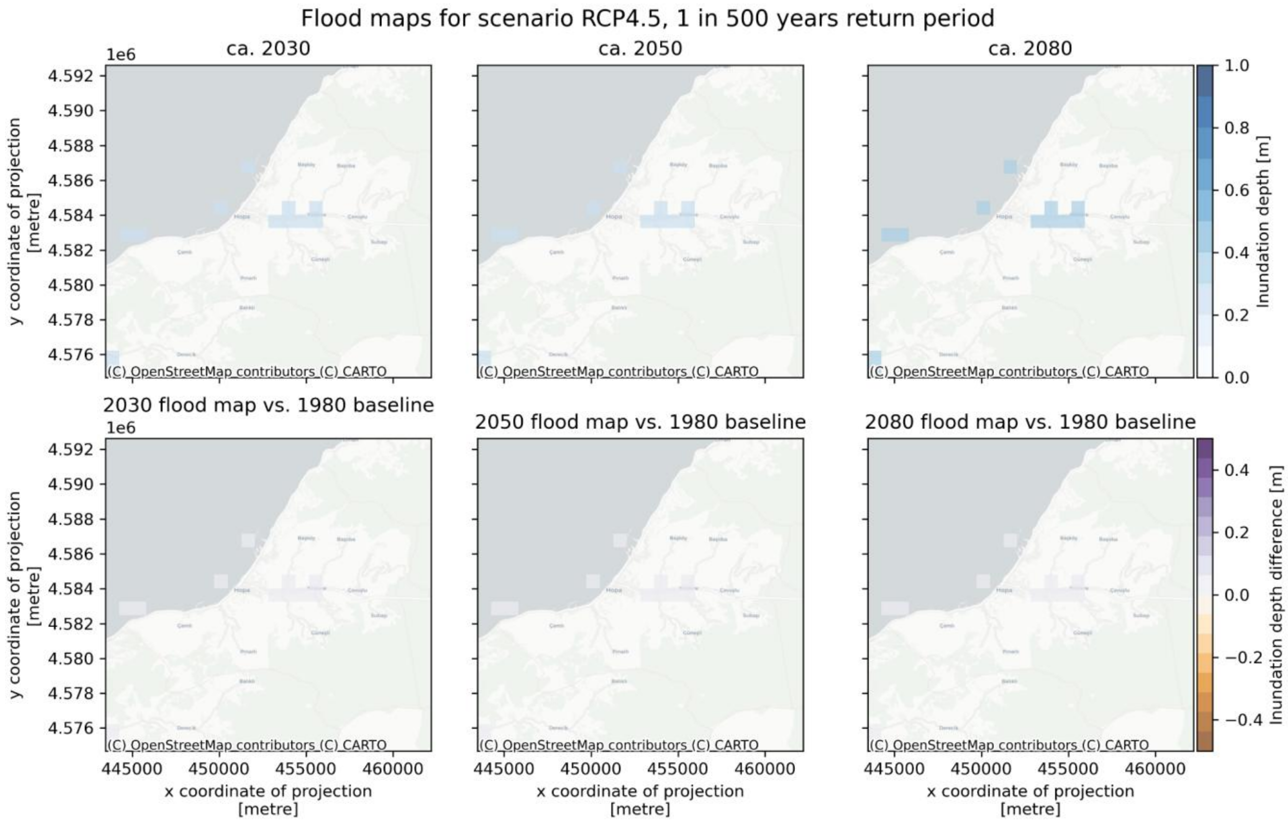

Figure 13: Flood maps for scenario RCP4.5, 1 in 500 years return period

Figure 14: River flood potential for different return periods (present-day scenario ca. 2018)

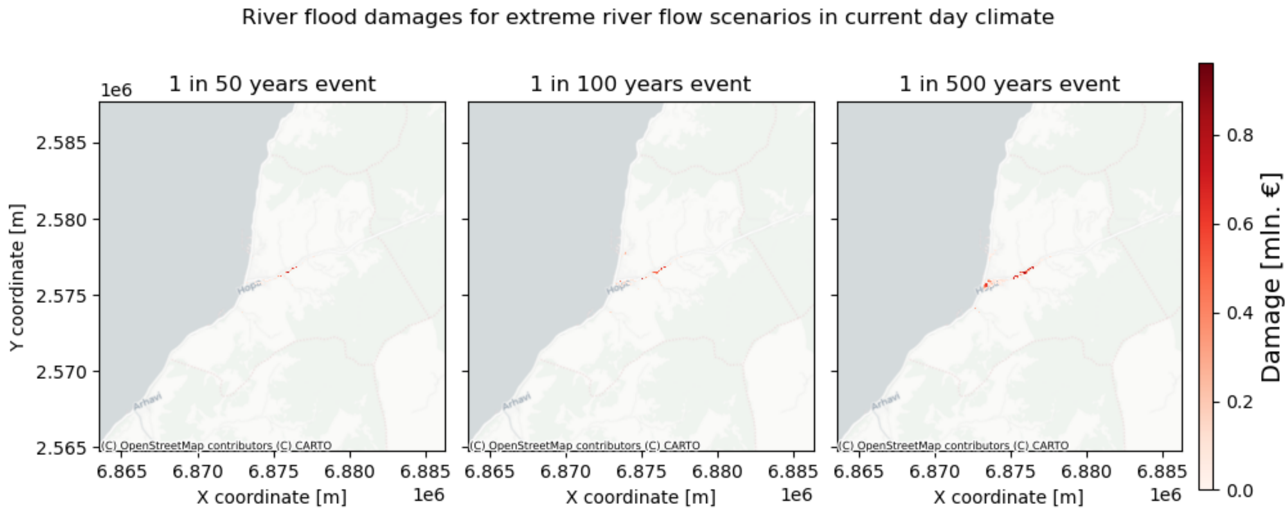

Figure 15: River flood damages for extreme river flow scenarios in current day climate

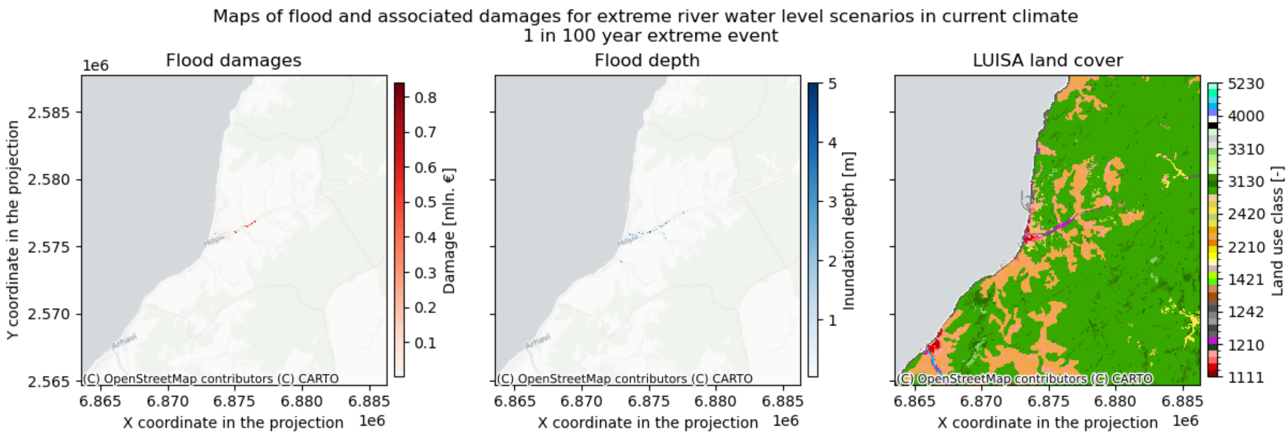

Figure 16: Maps of flood and associated damages for extreme river water level scenarios in current climate 1 in 100 years extreme event

2.3.1 Workflow #1: River Floods Risk Management

This workflow focuses on river flood risks in the **Hopa district**, with particular attention to areas exposed due to extreme precipitation events, **unregulated urban expansion**, and **limited flood infrastructure**. Historical floods—especially the severe event on 24 August 2015—have highlighted the region's flood vulnerability. Critical exposure zones include **Ortahopa Stream**, **Sundura Stream**, the **city center**, **industrial zone**, **Hopa City Hospital** vicinity, and **coastal settlements**.

This assessment integrates spatial hazard data, socio-economic vulnerability, land-use exposure, and economic valuation to identify high-risk areas and population groups.

Table 4: Data overview workflow #1

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Historical river flood maps (JRC; 10–500 yr return)	Flood depth-damage curves (JRC)	Land use (LUISA), Economic value of land use (country-specific)	Spatial economic flood damage estimates (€/km²) for various return periods

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Future river flood maps (Aqueduct; RCP4.5 & RCP8.5)	…	…	Comparative analysis of flood risk change under climate scenarios (2030, 2050, 2080)

2.3.1.1 Hazard assessment

Key findings include:

- **High-resolution flood maps** indicate considerable flood exposure along the Sundura stream.
- **Frequent inundation zones** are concentrated in the **Sundura and Ortahopa neighbourhoods**, aligning with historical flood events.
- **Flood depths increase substantially with higher return periods (≥100 years), especially in low-lying agricultural areas.**
- The **Aqueduct scenario-based projections** suggest that under RCP8.5, flood depth and extent are likely to intensify by 2050 and 2080, particularly in the central parts of the region.
- Hazard maps do **not account for existing flood protection infrastructure**, requiring local interpretation.

2.3.1.2 Risk assessment

By integrating hazard, vulnerability, and exposure datasets, a comprehensive risk map for the Hopa district has been developed. The workflow identifies both spatial hotspots of **economic damage** and **vulnerable populations** disproportionately affected by floods.

Interpretation of Flood Risk Zones:

- **High-Risk Zones (Category 4–5):**
  - Include **Sundura and Ortahopa neighbourhoods**, the former municipal square, the **hospital surroundings**, industrial and old truck parking area.
  - These zones combine high flood exposure with **vulnerable infrastructure**, dense population, and low adaptive capacity.
- **Moderate Risk (Category 3):**
  - Found in **peri-urban agricultural zones**, especially along the **Sundura Stream**. These areas support **livestock and small-scale tea farming** vulnerable to crop loss and economic disruption.
- **Lower Risk (Categories 1–2):**
  - Represent **higher elevation residential areas** with better-built structures and relatively reduced flood exposure.

2.3.1.3 Workflow #2: Heavy Rain Risk Management

This workflow addresses the projected changes in **extreme precipitation patterns** due to climate change and their potential impacts on urban and flash flooding, especially in areas with limited drainage capacity. The analysis uses high-resolution regional climate projections to determine how the **frequency and intensity of short-duration heavy rainfall events** may evolve under various future climate scenarios.

The goal is to identify where and when **critical rainfall thresholds**—those beyond the coping capacity of urban infrastructure or natural systems—may be exceeded, increasing the risk of **pluvial flooding**, especially in densely built or vulnerable zones.

Table 5: Data overview workflow #2

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
EURO-CORDEX precipitation flux projections (12 km resolution; RCP4.5, RCP8.5)	…		Areas at risk of pluvial flooding under future rainfall extremes; exceedance of critical thresholds
Rainfall intensities by duration and return period (e.g. 1h, 3h, 6h events)	…		

2.3.1.4 Hazard assessment

Key findings include:

- EURO-CORDEX model data (12 km resolution) for RCP4.5 and RCP8.5 scenarios indicate a clear intensification of 1-hour to 6-hour rainfall events by 2050 and 2080.
- The frequency of 10- and 20-year return period rainfall events is projected to increase, especially during late summer months.
- Urban and coastal zones, particularly those with high sealed surface percentages, are most vulnerable to short-duration high-intensity events.
- In many modeled scenarios, projected rainfall exceeds the current drainage system design thresholds, especially in older or informal settlements.

2.3.1.5 Risk assessment

The risk analysis integrates climate hazard projections with urban exposure data and vulnerability indicators to identify where **extreme precipitation could result in localised flooding**.

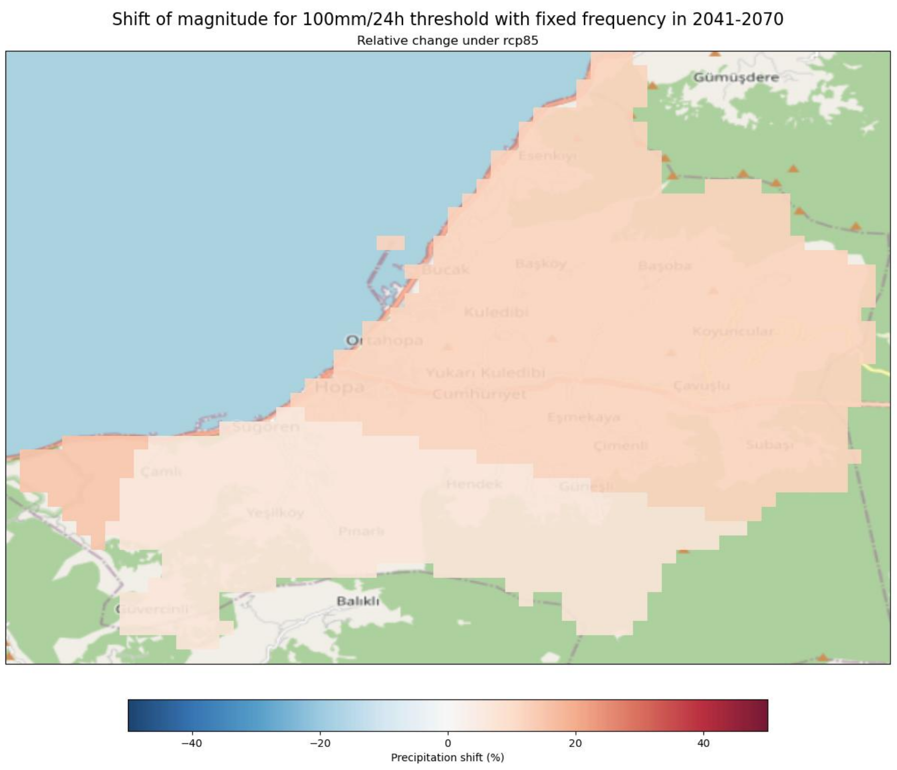

Figure 17: Shift of magnitude for 100mm/24h threshold with fixed frequency in 2041-2070

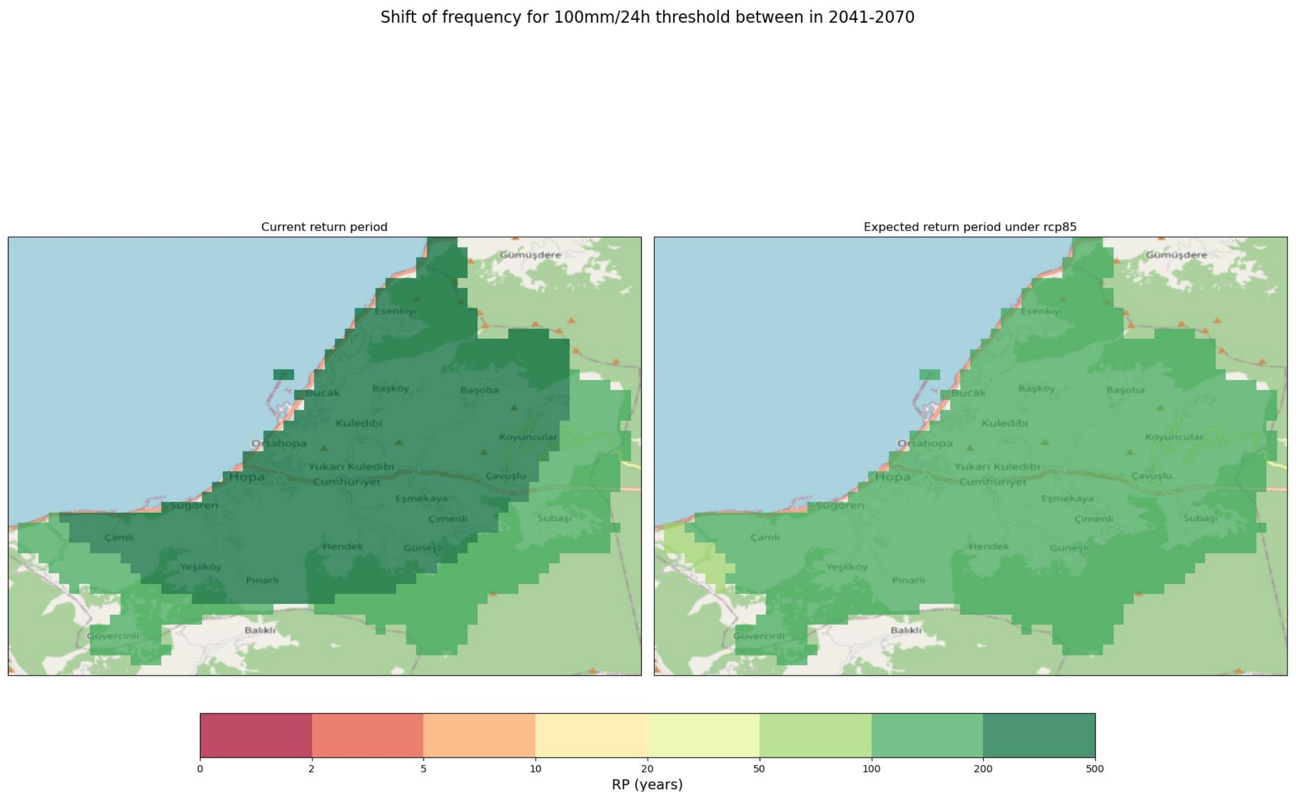

Figure 18: Shift of frequency for 100mm/24h threshold between in 2041-2070

Key observations:

- Under the RCP8.5 scenario, the 100 mm/24h threshold is projected to increase in intensity by 11% if the return period remains fixed, or occur more frequently—shifting from a 5-year to a 4-year return period—if the magnitude remains constant.
- Urban areas with high impervious surfaces and aging drainage systems face heightened pluvial flood risk, particularly during late summer, when intense rainfall events are projected to cluster.
- In many locations, projected rainfall exceeds the design capacity of existing drainage infrastructure, highlighting the need to revise planning standards.
- Areas of highest risk are concentrated in coastal and peri-urban zones, where exposure, vulnerability, and extreme rainfall converge.
- Findings underscore the need for proactive flood risk management, including infrastructure upgrades, nature-based solutions, and early warning systems.

2.4 Preliminary Key Risk Assessment Findings

2.4.1 Severity

Hopa is located in a geography where natural disasters such as floods, flash floods, and landslides triggered by heavy rainfall frequently occur. As the region with the highest precipitation levels in Türkiye, Hopa faces significant climate-related risks, primarily due to extreme rainfall and the associated natural hazards. With climate change, these risks are expected to increase further, as both the intensity and frequency of extreme rainfall events are rising as a result of global warming. Hazard and risk analyses conducted for floods and heavy rainfall demonstrate that Hopa will continue to be exposed to climate-related hazards such as intense rainfall and floods in the future. These hazards pose significant threats to Hopa, leading to loss of life, infrastructure damage, and economic losses.

The greatest threat to the region is excessive rainfall, which triggers floods and landslides. Extreme precipitation events and secondary disasters such as landslides are expected to cause fatalities, degrade the natural environment (particularly agricultural and forested areas), and inflict severe damage on infrastructure. As experienced during the disaster of August 2015, floods and landslides can result in loss of life. Landslides triggered by heavy rainfall can also damage fertile agricultural land, particularly tea plantations, leading to crop losses. Furthermore, heavy rainfall and landslides may disrupt forest ecosystems, causing biodiversity loss.

As observed in the August 2015 disaster, floods and landslides can severely damage urban infrastructure and disrupt transportation, with long-term adverse effects on the regional economy. Misguided land-use decisions, such as construction in riverbeds, are expected to further exacerbate these impacts in the region. In conclusion, climate-related risks in Hopa are severe both in the present and in the future.

2.4.2 Urgency

In Hopa, compared to other hazards, extreme rainfall requires urgent short- and medium-term adaptation measures, as both the frequency and intensity of such events are increasing with climate change and are projected to worsen in the future. Without the implementation of necessary risk reduction measures, climate-induced natural disasters will cause loss of life and property in the region almost every year. Proactive measures such as strengthening infrastructure, improving drainage systems, clearing riverbeds, establishing flood and flash flood early warning systems, monitoring landslide-prone areas, constructing retaining walls on high-risk slopes, and most importantly, raising public awareness about disasters are of critical importance for reducing risks and must be implemented urgently.

Extreme rainfall constitutes the primary climate challenge for Hopa, and without immediate and robust adaptation measures, it poses a severe threat of disruption to health, the economy, and infrastructure. Therefore, short-, medium-, and long-term adaptation plans must be developed to promote disaster-resilient urbanization; natural disaster insurance should be expanded to mitigate economic losses; and local and national-level partnerships should be established to formulate action plans for risk reduction, response, and recovery.

2.4.3 Capacity

In Hopa, although still insufficient, some measures aimed at reducing climate risks have already been initiated. In October 2024, Hopa Municipality, in collaboration with universities and both local and national stakeholders, prepared a “Disaster Action Plan,” marking an important first step towards strengthening its institutional capacity. The Disaster Action Plan, prepared to reduce flood and landslide risks triggered by extreme rainfall, includes a wide range of activities that contribute to climate risk reduction.

Multiple activities have been planned to ensure that the residents of Hopa are adequately informed about climate risks, to raise awareness levels, and to foster a resilient community capable of withstanding disasters. Additionally, the necessary planning has been carried out to create disaster-resilient and sustainable living spaces in Hopa. However, the implementation of the Action Plan requires increased financial resources.

Hopa has also taken a second important step to further enhance its capacity for climate risk management by engaging with global initiatives such as the CLIMAAX project. In conclusion, while the existing measures in Hopa have had partial effectiveness, there is a need for a more comprehensive, proactive, and financially supported strategy to tackle climate change. The CLIMAAX project will make a significant contribution to the formulation and implementation of such a strategy.

2.5 Preliminary Monitoring and Evaluation

In the first phase of the climate risk assessment, the analysis identified river flooding and heavy rainfall as the most pressing hazards for Hopa. River flooding was prioritized due to its recurring and widespread impacts on agriculture, infrastructure, and community well-being, while heavy rainfall was recognized as a key driver intensifying these risks. Current observations show increasing precipitation frequency and intensity, particularly in coastal zones, leading to soil saturation, erosion, and recurrent flooding. Vulnerable groups include small-scale farmers, low-income households, and socially disadvantaged populations residing in high-risk areas.

The main challenge encountered was limited access to localized data, particularly historical disaster records and socio-economic vulnerability statistics. While climatological and hazard datasets were available, the absence of detailed local information restricted the ability to capture long-term vulnerability trends and fully calibrate risk models. Overall, the first phase successfully narrowed the focus to the most critical hazards but highlighted the urgent need to close data gaps for more robust future assessments and adaptation planning.

The first phase of SAFE-HOPA enabled the concretization of the nature and scale of climate-induced risks in Hopa. It confirmed that river flooding and severe/prolonged rainfall are the primary risk drivers in the urban center and hillside settlements, with particularly high recurrence potential along the Ortahopa–Sundura corridor. The spatial reconstruction of the 24 August 2015 event revealed the critical intersections between flood propagation and existing settlements and infrastructure. During this analysis, it was identified that Hopa State Hospital is located within a high-exposure (orange) zone and that AFAD's current assembly/shelter lists are outdated.

Within the vulnerability layer, address clusters of 202 people with disabilities and building-level points of the 65+ population were mapped. For the 0–6 age group, however, due to inter-institutional data restrictions at the address level, neighborhood totals from TÜİK ADNKS were used instead. Suitability analyses for temporary shelters identified approximately 11,900 m² of potential land across 10 municipally owned parcels, providing a solid basis for short-term implementable arrangements and "quick wins."

By the end of Phase 1, key layers such as flood propagation (2015 event), building-road-bridge networks, critical facilities (hospital, schools, mosques), municipal parcels, 202 disability addresses, 65+ building points, and neighborhood-level distribution of the 0–6 population were fully integrated.

2.6 Work plan

In the remaining phases of SAFE-HOPA, the work programme is designed to transform the findings from Phase 1 into high-resolution risk analyses and, based on these analyses, to produce adaptation options and enhanced risk management plans/maps, while also ensuring the integration of outputs into local policies. The plan follows the CLIMAAX sequence of "hazard – exposure – vulnerability – risk – adaptation."

Phase 2 (M7–M16): The focus of this phase is the more precise local-scale mapping of river flooding, heavy rainfall/flash flood, and rainfall-induced landslide hazards, thereby enabling the quantitative comparison of risks to infrastructure and population. Four subsequent activities will serve this objective:

i. Reviewing infrastructure and identifying alternative routes,
ii. Planning a Coordination Center for the disaster response team,
iii. Identifying suitable parking areas for equipment,
iv. Collecting meteorological data and conducting temporal analyses.

The outputs of Phase 2 will include: high-resolution hazard–exposure–risk maps, a short comparative note on “present–future” scenarios, a list of priority intervention areas, and a technical briefing for decision-makers.

Phase 3 (M17–M22): The Phase 2 risk results will be translated into feasible adaptation options and enhanced risk management plans. Activities will be grouped around the capacity–community component, including training for the municipal technical team and stakeholders, and awareness programmes in schools and neighborhoods. The expected outputs are: a portfolio of adaptation options, updated sections of the local risk management plan, a training/communication package, and policy recommendations.

3 Conclusions Phase 1- Climate risk assessment

Phase 1 of the SAFE-HOPA project has demonstrated that intense rainfall, river flooding, and rainfall-induced landslides are the primary climate hazards threatening Hopa. The reconstruction of the 24 August 2015 disaster and the analysis of recent 2024 events underline how extreme precipitation translates directly into destructive floods and slope failures, exposing both urban and hillside settlements. By applying the CLIMAAX framework, the municipality has for the first time combined hazard layers with exposure and vulnerability data, producing a coherent geospatial system that identifies high-risk floodplains, potential landslide zones, and critical intersections with infrastructure such as roads, bridges, and the State Hospital. Vulnerability mapping has added another dimension, highlighting elderly, disabled, and young populations most at risk, while temporary shelter suitability analysis provided ~11,900 m² of municipal parcels that could be rapidly mobilised for emergency use. These achievements mark a clear step forward: the main hazards have been prioritised, the affected areas and populations mapped, and practical entry points for short-term preparedness identified. Also these steps strengthen the municipality's operational readiness and provide direct inputs for plan updates (strategic/urban, disaster management). However, the limited access to micro-scale socio-economic data, the scarcity of long-term historical disaster records, and constrained financial capacity remain challenges that will need to be addressed in the next phases. Overall, Phase 1 has built a robust baseline that integrates rainfall, flood, and landslide dynamics with social vulnerability, offering a solid platform for adaptation planning.

Progress Evaluation and Contribution to Future Phases

The deliverable and its outputs connect directly to the planned activities in Phases 2 and 3. Having established the hazard–exposure–vulnerability backbone, the next stage will refine rainfall, flood, and landslide models using high-resolution local data and update infrastructure risk scenarios, including alternative routes and drainage capacity. Phase-2 activities—(1) reviewing infrastructure and identifying alternative routes, (2) planning a Disaster Response Coordination Center, (3) identifying equipment parking areas, and (4) collecting meteorological data and temporal analyses—are designed to convert the integrated layers into high-resolution hazard–exposure–risk maps, a present–future comparison note, a priority intervention list, and a technical briefing for decision-makers. In Phase 3, these findings will be translated into concrete adaptation measures, from infrastructure reinforcement and zoning updates to community awareness programmes and pilot interventions in Sundura neighbourhood, the most rainfall-affected area. These results into feasible adaptation options, enhanced risk management plans, and capacity & community programmes (training, school/neighbourhood awareness), with outputs including a portfolio of adaptation options, updated plan sections, a training/communication package, and policy recommendations.

With milestones such as multi-hazard risk assessment conducted using the CLIMAAX Toolbox, creating risk maps using CLIMAAX's hazard assessment methodologies, stakeholder meetings to define responsibilities, and collecting data and the integration of geospatial layers successfully completed.

Phase 1 has delivered on its objectives and paved the way for a deeper, more operational risk management approach in the following phases.

Table 6: Overview key performance indicators

Key performance indicators	*Progress*
1 Multi-hazard risk assessment conducted using the CLIMAAX Toolbox	Achieved
2 risk maps using CLIMAAX's hazard assessment methodologies	Achieved
1 Subcontracting process completed and technical assessments initiated	Achieved
10 Stakeholder meetings organized to define responsibilities and collect data	Achieved
5 Infrastructure resilience studies conducted	Phase 2
3 Refined local risk assessments completed with detailed local data	Phase 2
30 technical staff and stakeholders trained in climate risk assessment	Phase 3
3 policy recommendations formulated for disaster resilience	Phase 3
27 Community awareness and education sessions held	Phase 3
5 Scientific publications, media mentions, or policy briefs prepared	Phase 3

Table 7: Overview milestones

Milestones	Progress
Project kickoff meeting held, and task distribution completed	Achieved
Stakeholders identified, and responsibilities defined	Achieved
Barcelona workshop attended	Achieved
Multi-hazard risk assessment completed, and necessary data collected	Achieved
Temporary shelter areas identified, and priorities defined	Achieved
Infrastructure maps and alternative routes developed	Phase 2

Milestones	Progress
Necessary planning for the establishment of the Disaster Coordination Center and the data management system was completed	Phase 2
Necessary measures planned for risk areas	Phase 2
Obtained meteorological data and conducted temporal analysis	Phase 2
All processes presented to policymakers	Phase 3
Communities and stakeholders were trained and actively included in the plan and finalized adaptation strategies and risk management plans.	Phase 3
Visits to all 24 schools in Hopa were completed, and students were engaged in awareness activities regarding the CLIMAAX Toolbox and project outputs	Phase 3
Sustainability ensured through continued monitoring	Phase 3
Brussels workshop attended.	Phase 3

4 Supporting documentation

All outputs produced during Phase 1 of the SAFE-HOPA climate risk assessment are categorized and listed in this section using a clear, consistent format that corresponds to their planned release in the Zenodo repository.

All outputs produced during Phase 1 of the SAFE-HOPA climate risk assessment have been classified and listed below. The list follows the order in which the files are uploaded and made available in the Zenodo repository.

Main Report

- SAFE-HOPA Phase 1 Deliverable Report (PDF/Word) – Comprehensive documentation of the multi-hazard climate risk assessment conducted in Hopa, including methodology, results, and conclusions.

Visual Outputs (Infographics, Maps, Charts)

- Flood Propagation Map (24 August 2015 event, Ortahopa–Sundura corridor) – High-resolution map illustrating flood extent and critical points.
- Rainfall Intensity Map (Extreme precipitation events 2015–2024) – Visualisation of rainfall hotspots across Hopa district.
- Vulnerable Groups Distribution Map – Spatial representation of elderly (65+), and people with disabilities.
- Temporary Shelter Suitability Map – Identification of ~11,900 m² of municipal parcels suitable for emergency use.
- Critical Infrastructure and Road Network Map – Overlay of flood/landslide risk zones with roads, bridges, hospital, and public facilities.

Datasets Collected (PDF)

- Hazard Dataset – maximum observed rainfall values (mm) for standard durations and the return period analysis data (PDF).

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