Deliverable Phase 1 – Climate risk assessment

Climaax Risk Assessments Methodology Implementation for the Region Şanlıurfa (CRAS)

Türkiye, Southeastern Anatolia Region / Şanlıurfa Metropolitan Municipality

Version 3.0 | March 2025

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

Funded by the European Union

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

1. Document Information

Deliverable Title	Phase 1 – Climate risk assessment
Brief Description	The first deliverable of the CRAS project presents the implementation of the CLIMAAX methodology for multi-risk climate assessment in Şanlıurfa. It includes the analysis of heatwave, relative drought, and agricultural drought risks to support regional adaptation planning, without detailed analysis using regional data.
Project name	Climaax Risk Assessments Methodology Implementation for the Region Şanlıurfa (CRAS)
Country	Türkiye
Region/Municipality	Southeastern Anatolia Region/Şanlıurfa Metropolitan Municipality
Leading Institution	Şanlıurfa Metropolitan Municipality, Climate Change and Zero Waste Department
Supporting subcontracting Institutions	Atalay Climate Consulting
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Deliverable submission date	29/03/2025
Final version delivery date	31/03/2025
Nature of the Deliverable	R – Report
Dissemination Level	PU - Public

Version	Date	Change editors	Changes
1.0	25/02/2025	Şanlıurfa Metropolitan Municipality	First draft initiated
2.0	01/03/2025	Atalay Climate Consulting: Tamer Atalay-Soner Atalay	Part 3, 4, 5 and 6 added
3.0	27/03/2025	Şanlıurfa Metropolitan Municipality	Final Draft Review

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5. Abbreviations and acronyms

Abbreviation / acronym	Description
AFAD	Turkish Disaster and Emergency Management Authority
CCAP	Climate Change Action Plan
CDP	Carbon Disclosure Project
CDS	Copernicus Data Store
CLIMAAX	Climate Adaptation and Risk Assessment Methodology
CRAS	Climaax Risk Assessments Implementation for the Şanlıurfa Region
ÇŞİDB	Ministry of Environment, Urbanization, and Climate Change
DRMKC	Disaster Risk Management Knowledge Centre
ET_0	Reference Evapotranspiration
GAEZ	Global Agro-Ecological Zones
GAP	Southeastern Anatolia Project
GCM	Global Climate Model
GCoM	Global Covenant of Mayors for Climate and Energy
GIS	Geographic Information System
HDD/CDD	Heating Degree Days / Cooling Degree Days
LST	Land Surface Temperature
MGM	Turkish General Directorate of Meteorology
NUTS	Nomenclature of Territorial Units for Statistics
PMP	Project Management Professional
RCP	Representative Concentration Pathways
SECAP	Sustainable Energy and Climate Action Plan
SMM	Şanlıurfa Metropolitan Municipality
SPEI	Standard Precipitation Evaporatıon Index
SSP	Shared Socioeconomic Pathways
UTCI	Universal Thermal Comfort Index
WASP	Weighted Anomaly of Standardized Precipitation
WP	Work Package
WHO	World Health Organization

6. Executive summary

With a population exceeding 2.1 million and temperatures reaching a record 61°C, Şanlıurfa is one of the hottest and most climate-vulnerable regions in Türkiye. Covering approximately 19,000 km²—nearly half the size of the Netherlands—the province is located in the Southeastern Anatolia Region and hosts up to 350,000 refugees. The region faces compounding challenges from heatwaves, agricultural drought, and socioeconomic fragility. This deliverable summarizes the Phase 1 results of the CRAS project, which applied the CLIMAAX common methodology to assess these interconnected climate risks and identify priority areas for adaptation.

The assessment focused on three CLIMAAX workflows: (1) urban heatwaves, (2) relative drought, and (3) agricultural drought. These workflows provided a structured analysis of risk severity, exposure, and vulnerability despite limitations in regional data availability. Şanlıurfa's location outside the Euro-CORDEX domain required methodological adaptation using Mediterranean climate model data and localized crop coefficients. Although detailed site-specific analysis will follow in Phase 2, the current phase offers a solid foundation for understanding the region's climate risk profile.

Key findings include:

- Heatwaves: The Universal Thermal Climate Index (UTCI) exceeds 130 days/year, with projections indicating a rise in extreme heat events. Vulnerable neighborhoods were identified based on high land surface temperature and population density.
- Relative Drought: Şanlıurfa ranks among Türkiye's highest drought risk regions (risk score: 4/5), with no significant improvement projected under future climate scenarios (SSP1–2.6 and SSP5–8.5).
- Agricultural Drought: Irrigation-dependent crops face severe yield losses under water scarcity conditions: cotton (32–40%), maize (33–42%), wheat (10–25%), and pistachio (24–36%). Revenue losses due to irrigation deficits were mapped for future planning.

The assessment also identified key vulnerable groups: low-income households, elderly populations, refugees, farmers, and outdoor workers. Stakeholder engagement included two key events: a survey and briefing workshop held in October 2024 with municipal departments and local institutions and a regional stakeholder meeting in February 2025 involving over 150 participants, including public authorities, universities, NGOs, and international organizations. These events supported risk validation, encouraged knowledge sharing, and ensured alignment with Şanlıurfa's climate resilience priorities.

The CRAS project directly contributes to the goals of the CLIMAAX program and the EU Mission on Adaptation by delivering a transparent, high-resolution risk overview tailored to a high-priority region. Phase 1 establishes the technical and institutional foundation for Phase 2, which will refine the assessment using updated local datasets and modelling outputs. Phase 3 will focus on developing and integrating adaptation strategies into Şanlıurfa's local planning framework.

1 Introduction

1.1 Background

Şanlıurfa is near the Syrian border in the Southeastern Anatolia Region of Türkiye. Covering an area of approximately 19,000 km² (nearly half the size of the Netherlands), it has a population exceeding 2.1 million, including up to 350,000 Syrian refugees. Şanlıurfa is characterized by rapid population growth, low GDP per capita (€2,700), and limited access to technical and financial resources. These socioeconomic challenges heighten the region's vulnerability to climate risks, particularly heatwaves, drought, and sporadic floods.

The region's hot and dry desert climate (Köppen-Geiger climate classification Csa[1]) exacerbates its exposure to extreme weather events. Average summer temperatures often exceed 40°C. Annual HDD and CDD[2] values were realized as 1122 and 1383, respectively, in 2024. The region has the worst Universal Thermal Comfort Index[3] in Europe (High UTCI days is around 130 per year) (see Figure 1-1). Şanlıurfa region has a Relative Drought Risk of 4 over 5, which means the highest drought risk in Türkiye. SPEI12 Index[4] of Şanlıurfa indicates that the region has encountered several extreme drought seasons over the past two decades. Turkish General Directorate of Meteorology's (MGM) projections indicate that annual precipitation is expected to decrease by 26% (in RCP4.5) to 34% (in RCP8.5) by 2050-2060. Additionally, Şanlıurfa's agricultural sector, comprising 26% of its economy, is highly susceptible to climate variability, threatening food security, livelihoods and natural resources.

The Climaax Risk Assessments Methodology Implementation for the Region Şanlıurfa (CRAS) project aims to address these pressing challenges by applying the CLIMAAX common methodology framework. The project will focus on conducting a multi-risk climate assessment with a specific emphasis on the two most significant climate hazards for the region:

1. **Heatwaves:** Increasing temperatures severely threaten public health, agricultural productivity and urban infrastructure. Vulnerable groups, such as refugees, outside workers, low-income populations and elderly residents, are particularly at risk due to cooling energy poverty and limited green spaces (4.6 m² per capita, compared to the WHO's minimum recommendation of 9 m² per capita).
2. **Drought:** The region has experienced extreme drought conditions four times between 2008 and 2017, with a 13% reduction in rainfall compared to the GAP region average. Projections indicate a continued decline in annual precipitation, accelerating desertification, salinization of soils, and loss of agricultural land (16.6% reduction over the last decade).

In the CRAS project, **we will apply three specific workflows** within the CLIMAAX framework to address these critical climate hazards, ensuring that risk assessments are accurate, localized, and actionable. The **Heatwave** workflow will analyze expected heat wave occurrence, frequency and duration in future, vulnerable populations, and adaptation measures, while the **Relative Drought** and **Agricultural Drought** workflows will focus on expected future yield losses of several crops in case of artificial irrigation deficit. The results of workflows will provide quantitative data to develop sustainable water management for food security and resilient urban planning for public health. By implementing this approach, the CRAS project will enhance local climate resilience and provide a model for other municipalities in the Southeastern Anatolia Region, contributing to broader regional and national climate adaptation goals.

[1] Updated Köppen-Geiger climate map of the World (https://people.eng.unimelb.edu.au/mpeel/koppen.html)
[2] https://www.mgm.gov.tr/veridegerlendirme/gun-derece.aspx?g=yillik&m=06-00&y=2024&a=02#sfB
[3] https://climate-adapt.eea.europa.eu/en/metadata/indicators/high-utci-days
[4] https://www.mgm.gov.tr/iklim/indis.aspx

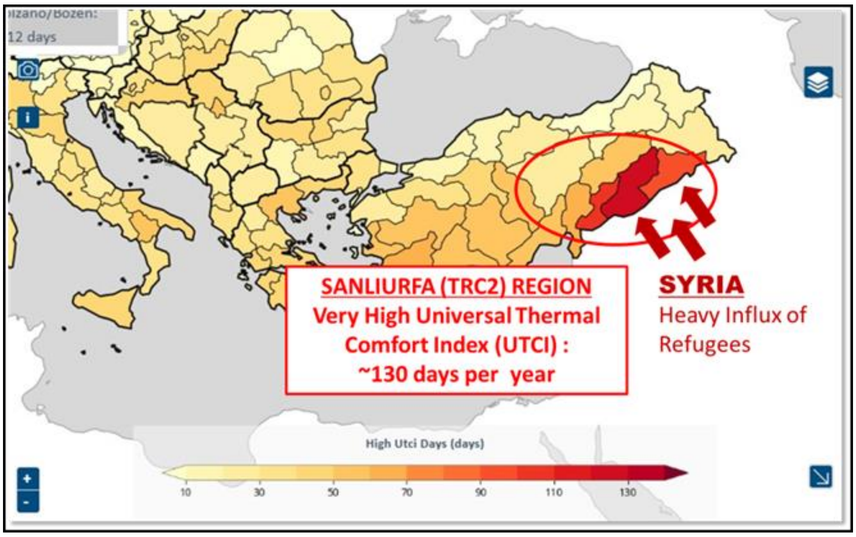

Figure 1-1 Geographic Location of Şanlıurfa

1.2 Main objectives of the project

The CRAS project aims to support the reduction of Şanlıurfa's climate vulnerability by providing a high-resolution, data-driven climate risk assessment using the CLIMAAX Handbook. The project equips local authorities and stakeholders with standardized, actionable information to guide future adaptation planning and decision-making by focusing on the region's two most critical hazards-heatwaves and drought.

To achieve this, the project applies the CLIMAAX methodology through three targeted workflows:

1. **Heatwaves** – Assessing temperature trends, vulnerable populations, and potential adaptation measures.
2. **Relative Drought** – Evaluating current and projected drought risk under different climate scenarios.
3. **Agricultural Drought** – Estimating yield losses for key crops (wheat, maize, cotton, pistachio) under irrigation deficit conditions.

The project also aims to:

- Identify vulnerable sectors and social groups, including low-income households, farmers, refugees, and the elderly.
- Disseminate findings through training sessions and stakeholder engagement activities.
- Provide reliable data to support the development of local adaptation strategies and integration into municipal policies.

The application of the CLIMAAX Handbook brings several key benefits to Şanlıurfa. It enables a standardized and high-resolution climate risk assessment, ensuring adaptation strategies are based on consistent and comparable data. By connecting with the wider CLIMAAX community, the project gains access to best practices and methodological support, strengthening the quality of local assessments. It also promotes sustainable data management and public engagement, encouraging long-term capacity building. Ultimately, this approach positions Şanlıurfa as a pioneer municipality in Türkiye's climate adaptation landscape, offering a replicable model for other regions.

1.3 Project team

The CRAS project team is composed of a multi-disciplinary group of professionals, combining local expertise, technical skills, and project management capabilities. The team structure ensures a holistic approach to climate risk assessment and adaptation, supported by CLIMAAX mentors for methodological alignment.

Key Team Members and Roles:

1. **Şanlıurfa Metropolitan Municipality (SMM)** leads the project through its Climate Change and Zero Waste Department, involving environmental experts, IT and GIS specialists responsible for data collection, risk assessment, and integration of CLIMAAX tools.
2. **Atalay Climate Consulting** provides project management and technical support, including workflow implementation, stakeholder coordination, and reporting, led by a PMP-certified project manager.

Local institutions such as **Harran University**, the **Karacadağ Development Agency**, and various **municipal departments** have been **informed and invited to contribute** to the project through knowledge-sharing and feedback opportunities. While formal partnerships are not established, their potential support is considered valuable for aligning the project with regional priorities. More than **150 stakeholders**—including local authorities, NGOs, and representatives of vulnerable communities—have been **engaged through information-sharing events and workshops** to encourage participation and future collaboration.

1.4 Outline of the document's structure

This deliverable follows the structure defined in the CLIMAAX Handbook and template, presenting the Phase 1 climate risk assessment results for Şanlıurfa.

- **Introduction** provides background information on Şanlıurfa, outlines the project's objectives, describes the project team, and introduces the document structure.
- **Climate Risk Assessment – Phase 1** details the implementation of selected workflows (Urban Heatwave, Relative Drought, Agricultural Drought). It covers scoping, risk exploration, risk analysis, and preliminary findings, including severity, urgency, and adaptive capacity.
- **Conclusions** summarize the main outcomes of Phase 1 and the implications for Şanlıurfa's climate resilience efforts.
- **Progress Evaluation and Contribution to Future Phases** reviews the progress against Key Performance Indicators (KPIs) and outlines next steps for Phase 2 and Phase 3.
- **Supporting Documentation** lists relevant background studies, visual materials, and datasets that support the findings and ensure transparency.

2 Climate risk assessment – phase 1

2.1 Scoping

The scoping process in Şanlıurfa is focused on:

- Addressing the most significant climate hazards, specifically heatwaves and drought.
- Defining the governance and policy context that will influence risk management strategies.
- Engaging local authorities, community representatives, NGOs, and vulnerable groups to foster a collaborative approach to climate adaptation.

2.1.1 Objectives

Şanlıurfa Metropolitan Municipality (SMM) has set an overall target to become "climate neutral" and "climate resilient" city by 2050. To achieve this target, SMM has started to implement, review and update the Sustainable Energy and Climate Action Planning (SECAP)[5] process, which has three main pillars "mitigation, " adaptation " and "energy poverty".

Since 2022, initial qualitative assessments of climate hazards have been conducted. However, these lacked sufficient spatial and temporal resolution to support robust adaptation planning. The CRAS project addresses this gap by applying the CLIMAAX methodology to deliver a localized, quantitative climate risk assessment focused on heatwaves and drought—Şanlıurfa's most critical hazards.

Objective, Purpose, and Expected Outcome

- Objective: To apply the CLIMAAX common methodology for multi-risk assessment at the NUTS3 level, supporting Şanlıurfa's long-term adaptation and resilience goals.
- Purpose: To generate high-resolution, evidence-based insights into climate risks, enabling informed decision-making and funding applications at national and international levels.
- Expected Outcomes: i) Enhanced understanding of climate risks, particularly regarding heatwaves and drought. ii) Identification of vulnerable groups, including elderly >65 years old, children < 5 years, low-income communities, farmers, and refugees. iii) Informed policy development, enabling the integration of risk assessment data into local adaptation strategies and risk management plans. iv) Improved stakeholder engagement through training sessions and dissemination activities.

Contribution to Policy and Decision Making

The CRAS project's findings will directly support policy and decision-making processes by:

- Providing local authorities with spatial and temporal risk assessment data to shape urban planning, water management, and public health strategies.
- Enabling the integration of CLIMAAX tools into existing policies, ensuring sustainability and continuous improvement.
- Supporting the Şanlıurfa Metropolitan Municipality's (SMM) Climate Change and Zero Waste Department in aligning with national and EU climate objectives, including the Global Covenant of Mayors for Climate and Energy[6], which Şanlıurfa joined in 2022.

Limitations and Boundaries of the Climate Risk Assessment

While the CRAS project aims to provide a thorough risk assessment, there are several limitations and boundaries to consider:

1. Data Availability:

- Challenges: Şanliufa (TRC2) region is out of the Euro-Cordex domain. The current "crop-table" doesn't include two other main crops of our Region: cotton and pistachio
- Countermeasure 1: This challenge was solved by modifying the repositories and applying the "Mediterranean" domain's Global and Regional Climate Models for Heatwave-Xclime and Agricultural Drought workflows. However, applying the Heatwave-Euroheat workflow was impossible as it requires only the Euro-Cordex domains' data set.
- Countermeasure 2: The Regional Crop_Table was prepared based on local crop coefficients. SMM has also reported an essential bug to CLIMAAX in Agricultural Drought to prevent incorrect results. The workflow was revised, and all users were informed.

2. Stakeholder Involvement:

[5] https://www.sanliurfa.bel.tr/files/1/iklim_degisikligi.pdf
[6] https://www.globalcovenantofmayors.org/

- Challenges: Ensuring the engagement of all relevant stakeholders, including vulnerable communities and private sector representatives.
- Countermeasures: Conducting three targeted training sessions involving 150 stakeholders and ensuring transparent communication throughout the project phases.

3. Resource Constraints:
   - Challenges: Limited technical and financial resources within the Şanlıurfa Metropolitan Municipality, impacting data collection and analysis capacity.
   - Adaptation Strategy: Collaboration with Atalay Climate Consulting and leveraging CLIMAAX mentorship for methodological support.
4. External Influences:
   - Challenges: Regional geopolitical factors, including proximity to Syria, may influence data collection and stakeholder engagement.
   - Countermeasures: Establishing flexible project management practices and maintaining strong communication channels with international organizations operating in the region.

2.1.2 Context

Assessment and Management of Climate Hazards in Şanlıurfa
Şanlıurfa has long faced climate hazards—particularly heatwaves and drought—due to its hot, dry climate and water-stressed agricultural economy. In 2022, the Şanlıurfa Metropolitan Municipality (SMM) published a Climate Change Risk and Vulnerability Assessment Report, which included qualitative surveys and historical climate event analysis. However, these efforts lacked sufficient spatial and temporal resolution and did not fully integrate stakeholder input or quantitative risk analysis. The CRAS project builds upon this foundation using the CLIMAAX methodology to provide a proactive, standardized, and localized climate risk assessment, enabling better-informed adaptation strategies.

Problem Statement and Broader Development Context
Şanlıurfa's increasing climate vulnerability stems from the interplay of environmental and socioeconomic factors: rapid population growth, the highest birth rate in Türkiye, limited infrastructure, hosting approximately 350,000 refugees, and a low GDP per capita (€2,700). These dynamics amplify the region's sensitivity to extreme heat and chronic water scarcity.
The province is also part of the Southeastern Anatolia Project (GAP), which has enhanced agricultural productivity and significantly increased water demand, intensifying drought risks. At the national level, Türkiye's evolving climate policies—including alignment with the EU Green Deal and Horizon Europe frameworks—emphasize integrated risk assessment and local adaptation, positioning Şanlıurfa's efforts as highly relevant to broader regional and national resilience goals.

Governance Context
SMM established a Climate Change and Zero Waste Department in 2022, supported by 10 technical staff and guided by a Climate High Council and interdepartmental working group. Şanlıurfa is also a signatory of the Global Covenant of Mayors for Climate and Energy (GCoM) and actively implements its SECAP.

At the national level, climate adaptation in Türkiye is guided by:

- The National Climate Change Adaptation Strategy and Action Plan (2024–2030) encourages integrated risk assessments and the development of local adaptation strategies.
- The Climate Law of Türkiye provides the legal foundation for municipalities to implement climate action.
- The Integrated Disaster Risk Reduction Plan (IRAP) developed by the Disaster and Emergency Management Authority (AFAD) aims to enhance preparedness and response to natural hazards, including those induced by climate change.

- EU Integration: The CRAS project aligns with the CLIMAAX methodology, contributing to EU climate resilience initiatives, such as the Pathways2Resilience[7] (P2R) project.
-

Relevant Sectors and Potential Impacts of Climate Change

The most climate-relevant sectors in Şanlıurfa include **agriculture**, **water supply**, **health**, **infrastructure**, and **energy**. A sectoral vulnerability analysis conducted via surveys revealed that agriculture and water supply are highly sensitive to heatwaves and droughts, particularly due to the region's dependence on irrigation. Public health is also at risk, especially among vulnerable groups during extreme heat events. Infrastructure and energy services face challenges from increased cooling demand, water scarcity, and potential damage from extreme weather.

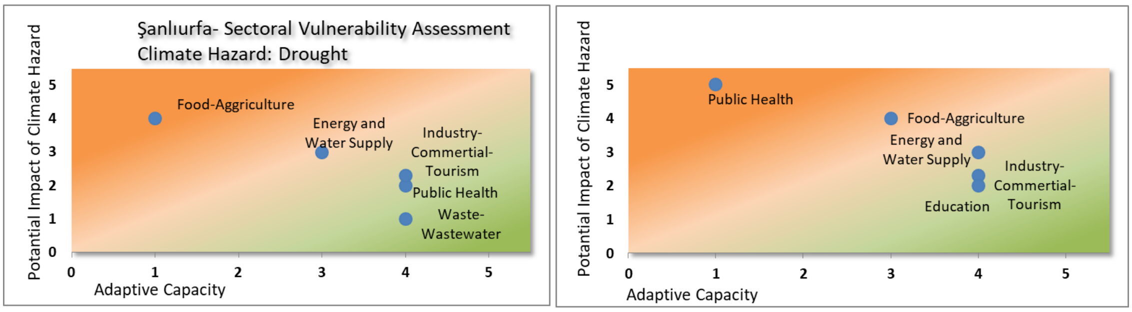

Figure 2-1 Sectoral Vulnerability Analysis in Şanlıurfa

External Influences on Climate Risks

Several external influences may impact Şanlıurfa's climate resilience efforts, including:

- The Southeastern Anatolia Project (GAP): While GAP promotes economic growth, it also increases water demand, potentially exacerbating drought risks.
- Regional Conflicts: The proximity to Syria introduces geopolitical challenges, influencing resource allocation, population dynamics, and stakeholder engagement.
- EU and International Projects: Collaboration with EU-funded projects like Pathways2Resilience (P2R) and Horizon Europe initiatives provides opportunities for capacity building, data sharing, and methodological alignment.

Potential Adaptation Interventions

The CRAS project supports and complements adaptation priorities outlined in Şanlıurfa's Climate Change Action Plan by promoting actions aligned with the CLIMAAX Handbook.

These include:

1. Water Management Strategies
   - Adoption of efficient irrigation techniques and structural transition to modern irrigation systems.
   - Reduction of water losses and promotion of demand management solutions.
   - Development of rainwater harvesting, reuse systems, and preventive measures to protect water resources.
2. Urban Heat Mitigation and Resilient Urban Planning
   - Expansion of urban green areas to meet international standards.
   - Climate-resilient settlement planning and enforcement of infrastructure to support population pressures.
   - Establishment of shaded public spaces and cooling infrastructure to address extreme heat.
3. Capacity Building and Community Resilience

[7] https://www.pathways2resilience.eu/get-involved#

- Emergency preparedness and proactive systems to manage surface floods and extreme events.
- Training and awareness-raising activities for communities and municipal staff.
- Programs to protect vulnerable groups from climate impacts.

4. Sustainable Agriculture and Food Systems
   - Research and rehabilitation to prevent soil salinization and desertification.
   - Promotion of sustainable, organic agriculture and localized food systems.
5. Mainstreaming CLIMAAX Tools
   - Integration of CLIMAAX workflows into municipal planning and decision-making processes to support long-term resilience and scalable adaptation planning.

2.1.3 Participation and risk ownership

The CRAS project prioritizes a comprehensive stakeholder engagement strategy, ensuring diverse groups are actively involved in the climate risk assessment process.

First Steps in Stakeholder Involvement
Initial stakeholder mapping identified actors from local government, academia, NGOs, the private sector, and community groups. The engagement strategy included:

- An **internal workshop** in October 2024 with municipal departments and technical staff to review preliminary findings.
- A **large-scale regional stakeholder meeting** in February 2025 with over 150 participants from public institutions, NGOs, universities, and international organizations.
- Ongoing communication channels, including training sessions, social media updates, and newsletters.

Relevant Stakeholders for the CRAS Project
The CRAS project engages a broad spectrum of stakeholders, categorized as follows:

Table 2-1 Relevant Stakeholders for the CRAS Project

Stakeholder Group	*Role and Contribution*
Government Institutions	Şanlıurfa Metropolitan Municipality, Provincial Directorates of Environment, Agriculture, Health, Education, Social Services, State Hydraulic Works (DSI). Institution of South Anatolian Project Agricultural Research and Training Center (GAPTAEM), Disaster and Emergency Management Authority (AFAD), General Directorate of Meteorology (MGM), Karacadağ Regional Development Agency, Şanlıurfa Water and Wastewater Works (ŞUSKİ)
Non-Governmental Organizations	Local and regional NGOs, including the Chamber of Environmental Engineers, Chamber of Agricultural Engineers, Chamber of Urban Planners, Regional Irrigation Unions, Foundation of Combating Erosion (TEMA), other environmental groups and community associations.
Academia	Harran University, contributing research expertise, student involvement, and data analysis support.
Private Sector	Local businesses, particularly in agriculture, water management, and urban development: Chamber of Şanlıurfa Industry and Commerce,
Community Representatives	Engagement with vulnerable groups, including low-income families, farmers, and refugee communities.
International Organizations	Collaboration with EU-funded projects, such as Pathways2Resilience (P2R), to share best practices and enhance capacity building.

Priority Groups and Vulnerable Areas
The CRAS project focuses on priority groups and vulnerable areas, including:

- Low-Income Communities: Particularly those affected by heatwaves, living in urban areas with limited green spaces.
- Farmers and Agricultural Workers: Exposed to heatwaves and drought risks due to high dependence on irrigation and variable rainfall patterns.
- Refugee Populations: Approximately 350,000-400,000 Syrian refugees who may have limited access to resources and infrastructure resilience.
- Elderly>65, Children>5 and Health-Vulnerable Individuals: At higher risk during heatwaves, requiring targeted public health measures.

Risk Ownership Regulation

Risk ownership within the CRAS project is clearly defined to ensure accountability and efficient management, following the CLIMAAX Handbook's guidelines:

- Şanlıurfa Metropolitan Municipality (SMM): Leads the overall project management, policy integration, and risk communication. Şanlıurfa Metropolitan Municipality (SMM) has established "The Climate Change and Zero Waste Department" to effectively manage climate change related issues by decision number 683 dated 15/12/2022.
- Provincial Directorates: Take ownership of sector-specific risks, such as environment and climate change, health, agriculture, education, tourism and water management.
- Local NGOs and Community Leaders: Act as intermediaries, helping to communicate risks to vulnerable populations and gather feedback.
- Private Sector: Engages in adaptation strategies, particularly in agriculture and urban development.

This structured risk ownership model aligns with local governance frameworks, enhancing the implementation of adaptation measures and ensuring sustainability.

Figure 2-2 Stakeholder Engagement Meetings realized in CRAS Project

Acceptable Risk Levels for the Community

During initial stakeholder consultations, a preliminary risk tolerance assessment was conducted, revealing:

- Heatwaves: The community accepts the risk of short-term heatwaves but prioritizes reducing impacts on vulnerable groups, such as elderly and refugees.
- Drought: High concern among farmers and water management authorities, indicating a low tolerance for prolonged drought periods and a strong demand for proactive measures.

Communication Strategy for Results Dissemination

Results are communicated through:

- Training workshops and stakeholder events.
- Visual reports and media coverage.
- Digital platforms, including the Şanlıurfa Metropolitan Municipality's official website, LinkedIn, and X (formerly Twitter)—which is widely used in Türkiye, especially by local stakeholders who may not be active on LinkedIn. This multi-channel approach promotes shared understanding and lays the groundwork for future co-designed adaptation actions.

2.2 Risk Exploration

The risk exploration phase systematically assesses climate-related hazards, focusing on their underlying risks, exposure, and vulnerabilities within the Şanlıurfa region.

2.2.1 Screen risks (selection of main hazards)

For risk exploration, a qualitative hazard identification, climate risk and vulnerability assessment process was performed according to the methodology defined in **The Global Covenant of Mayors for Climate and Energy (GCoM) Common Reporting Framework[8].** GCoM is the world's largest city and local government alliance, supporting voluntary actions for a low-emission, climate-resilient future. Şanlıurfa Metropolitan Municipality Sustainable Energy and Climate Action (SECAP) Working Group has conducted three Qualitative Analysis Surveys to assess potential climate hazards, current and future climate risks, and sectoral impacts. Surveys were shared with internal and external stakeholders via Google Forms. Results were first reviewed internally and then presented during the public Şanlıurfa Stakeholder Engagement Meeting in February 2025.

The survey studies have aimed at the following objectives:

- **Survey 1:** Identify current and future climate hazards for Şanlıurfa
- **Survey 2:** Assess negative impacts of climate hazards on urban service sectors and vulnerable community groups.
- **Survey 3:** Evaluate climate hazards' effects on service sectors, current adaptive capacity, and sectoral vulnerabilities.

Key Climate Hazards Evaluated:
Excluding events like sea level rise, monsoon rains, Avalanches, and typhoons, which are irrelevant for Şanlıurfa, the following hazards were assessed: Heavy Rainfall – Floods, Hailstorms, Storms – Tornadoes, Fog, Severe Winter Conditions – Cold Waves, Heatwaves – Urban Heat Islands, Drought, Wild Fires, Soil Salinization – Degradation, Landslides, Waterborne and Airborne Diseases, Vector-Borne Diseases and Pest Invasions.

Sectors and Services Evaluated:
Energy and Water Supply, Transportation and Communication, Food – Agriculture – Forestry, Waste and Wastewater Management, Industry – Commerce – Tourism, Housing – Residential Areas, Education, Health Systems – Public Health and Emergency Response Management

Vulnerable Population Groups Evaluated:
Elderly (>65 years), Chronically Patients, Disabled Individuals, Youth/Students, Children <5 years, Women, Refugees, Rural/Small Producers, Outdoor/Agricultural Workers, Low-Income Households

Current Situation: Hazard Occurrence and Impact

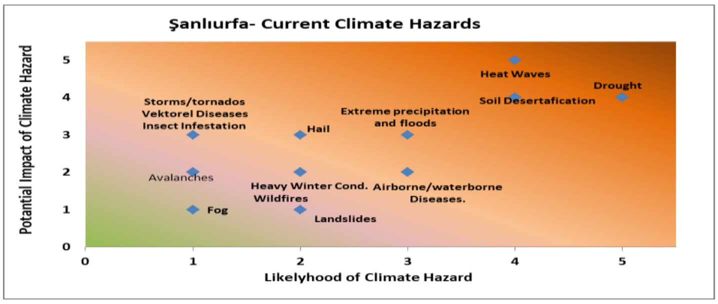

Figure 2-3 Climate Risk Exploration Analysis

Based on surveys, past events, and stakeholder engagement meetings, drought, heat waves, soil degradation/salinization, and floods have been identified as the most significant climate hazards with high potential magnitude and likelihood.

[8] https://www.globalcovenantofmayors.org/faq/hat-is-the-gcom-common-reporting-framework-crf/

The results of the surveys and the risk and vulnerability analysis were reported to GCoM using Carbon Disclosure Project (CDP-cities)/ ICLEI-Track 2024 Response[9]. See details of assessment in Şanlıurfa MM Climate Change Risk and Vulnerability Assessment Report-English [1]:
https://www.Şanlıurfa.bel.tr/uploads/2024/20240925064813-36184-90200.pdf
Climate Change Risk and Vulnerability Analysis can also be seen in Şanlıurfa MM Climate Change Action Plan-Turkish [2] in pages 67-78 (Chapter 3).
https://www.Şanlıurfa.bel.tr/files/1/iklim_degisikligi.pdf

Climate-, Hazards and Potential Risks in Şanlıurfa
Risk and vulnerability screening surveys indicate that the major climate hazards of the region are Drought, Heatwaves, Soil Degradation and Floods.

Table 2-2 Main Climate-Related Hazards and Potential Risks in Şanlıurfa

Climate Hazards	*Impact Description*	*Most Exposed Sectors*	*Vulnerable Population Groups Most Exposed*
Extreme Heatwave / Heat Stress	Vital danger for chronic patients, elderly, and outdoor workers due to extreme heat. İncrease in Forest fire risk. Decrease in agricultural and livestock production	Food-Agriculture-Forestry, Public Health, Energy and Water Supply, Industry-Trade-Tourism	Elderly>65 /children < 5 years old, Small-scale producers, Outdoor workers/farmers, Low-income households, Refugees
Drought	Decrease in agricultural production and soil salinization due to excessive irrigation. Decrease in energy production and water reserves	Food-Agriculture-Forestry, Energy and Water Supply, Public Health, Industry	Elderly, Vulnerable health groups, Small-scale producers, Low-income households

Hazards Covered in This Risk Assessment

- Heatwaves: Focusing on heatwave index, frequency and duration, vulnerable areas
- Drought: Relative and Agricultural drought. Drought risk, yield loss due to irrigation deficit

Existing Data, Knowledge, and Gaps

Table 2-3 Existing Data, Knowledge and Gaps

Hazard	*Available Data*	*Data Gaps and Needs*
Heatwaves	Daily Temperatures, Population Density, Land Surface Temperatures, Regional Climate Projections	Spatial distribution of vulnerable populations
Drought	Daily Precipitation, Temperature in 2 mt, Relative Humidity, Elevation, Solar Radiation, Wind Speed, Soil Available Capacity, Regional Crop Coefficients, irrigation patterns, Crop Productions, MED-Cordex Domain's data-sets , RCP4.5 and RCP 8.5 Projections.	Euro-Cordex domain's data-sets, Current regional irrigation patterns, current regional crop production data.

[9] https://myportal.cdp.net/guidance/questionnaire?tags=&outputType=REPORTING&type=CSTAR&locale=en

2.2.2 Workflow selection

The CRAS project applies the CLIMAAX framework using three targeted workflows to assess the most pressing climate hazards in Şanlıurfa: heatwaves and drought (relative and agricultural). Each workflow includes specific methodologies, datasets, and target groups.

2.2.2.1 Workflow #1: Heatwaves

Objective: To assess the impacts of heatwaves on public health, urban infrastructure, and community well-being, with a focus on vulnerable populations.
Methodology: To assess the heatwave hazard, EURO-CORDEX climate model data was analyzed using the xclim package to calculate heatwave frequency and total duration. Regional thresholds were defined using the 90th percentile of daily maximum and minimum temperatures (Tmax = 33°C, Tmin = 18°C), with a minimum event duration of two consecutive days. The analysis was conducted at a 12×12 km resolution. Exposure was mapped using high-resolution (30 m) Land Surface Temperature data from Landsat 8, highlighting urban heat island effects. Vulnerability was assessed using WorldPop datasets focusing on children under 5 and elderly populations over 65. These components were integrated using a 10×10 exposure-vulnerability matrix to produce spatial heatwave risk maps.
Vulnerable Groups: Elderly populations >65 years old, who are more susceptible to heat-related illnesses; children <5 years old, Refugees particularly those living in crowded urban settings with limited access to cooling infrastructure; low-income households, often residing in high-density areas with reduced green spaces, outdoor workers particularly seasonal agricultural workers.
Exposed Areas:

- Urban areas with high Land Surface Temperature, limited vegetation, and significant heat island effects, primarily in central Şanlıurfa.

Key Actions in the Workflow:

1. Data Collection: Definitions of temperature thresholds based on 90 percentile of regional daily temperatures
2. Hazard Assessment: Calculation and graphical representation of heatwave days, heatwave frequency (per year) and total length of heatwave projections according to RCP 4.5-RCP 8.5
3. Risk Assessment: Spatial distribution mapping of land surface temperatures, population density and heatwave risk map of vulnerable populations.

2.2.2.2 Workflow #2: Relative Drought

Objective: This workflow aims to visualize and explore the relative drought risk in the TRC2 Region. It includes maps of relative drought risk at the NUTS3 level in Türkiye.
Methodology: The workflow contains precalculated results, which can be explored in the visualization workflow. Relative drought hazard for the TRC2 Region was estimated as the probability of exceedance of the median of regional (EU level) severe precipitation deficits for a historical reference period (1981-2015) and for a future projection period (SSP1-2.6, SSP3-7.0, SSP5-8.5 for 2050 and 2080). Regional drought risk scores are on a scale of 0 to 5, with 0 representing the lowest risk and 5 the highest. The workflows take each risk determinant (i.e. hazard, exposure and vulnerability) and normalize it taking into account its maximum and minimum values across all sub-national administrative regions.
Vulnerable Groups: Farmers and agricultural workers dependent on irrigation systems and natural water cycles; Rural communities, whose livelihoods are closely tied to agricultural productivity; Low-income groups, who may struggle with food security during extended drought periods.
Exposed Areas: Agricultural zones of TRC2 are reliant on irrigation, particularly in the Harran Plain, where water availability is crucial for crop yields.
Key Actions in the Workflow:

1. Data Collection: Analyzed monthly precipitation patterns

2. Hazard Assessment: Drought hazard for a given region is estimated as the probability of exceeding the median of EU-level regional severe precipitation deficits for a historical reference period and for a future projection period
3. Risk Assessment: The relative drought risk was quantified as the product of drought hazard, exposure and vulnerability. The result of this workflow is a risk map showing the relative drought risk of Turkish NUTS3 regions so that we can compare our TRC2 region with other administrative areas in historic and future projections.

Workflow#3: Agricultural Drought

Objective: The aim is to estimate the potential loss in yield for a given crop without an artificial irrigation system compensating for precipitation scarcity.
Methodology: This workflow evaluates potential income losses due to reduced crop yields from precipitation scarcity in the absence of irrigation. Hazard is quantified as the shortfall in evapotranspiration, while exposure is measured through total crop production and revenue. Vulnerability is represented by the spatial distribution of existing irrigation systems. The analysis uses high-resolution (~10 km) climate data from the EU Copernicus Data Store, including variables such as precipitation, temperature, humidity, solar radiation, and soil water capacity. The assessment focused on four regionally significant crops: cotton, maize, wheat, and pistachio. Results include risk maps displaying potential yield losses and associated revenue impacts, offering practical resource allocation and climate-resilient planning guidance.
Vulnerable Groups: Farmers and agricultural workers, dependent on irrigation systems and natural water cycles; Rural communities, whose livelihoods are closely tied to agricultural productivity; Low-income groups, who may struggle with food security during extended drought periods.
Exposed Areas: Agricultural zones of TRC2 are reliant on irrigation, where water availability is crucial for crop yields.

Key Actions in the Workflow:

1. Data Collection: The evaluation is based on climate projections and global agricultural datasets that allow for predicting potential losses at approximately 10 km resolution. The data sets are downloaded from the EU Copernicus Data Store: Daily average precipitation flow; Maximum and minimum temperature;2-meter relative humidity; Surface solar radiation; 10-meter wind speed; Soil available water capacity; Elevation; Thermal climate zone.
2. Hazard Assessment: The hazard assessment was performed for the 4 main crops of TRC2 region (Cotton, Maize, Wheat and Pistachio) parameterized in the regional crop coefficients. The assessment is performed using climate data averaged inter-annually to show the impact of precipitation scarcity on yield for an average growing season in the selected period.
3. Risk Assessment: In this workflow, we have visualized the revenue losses deriving from the reduction in crop yield due to precipitation scarcity and the absence of irrigation. Data on total crop production [ton] and revenue [EUR] is combined with the yield loss reduction calculated in the hazard workflow to derive a map of the revenue loss from the absence of irrigation. Revenue loss is expressed here as the 'lost opportunity cost' of not using irrigation. The maps also show the distribution of existing irrigation systems, which are used as a proxy of vulnerability to precipitation scarcity.

2.2.3 Choose Scenario

Şanlıurfa Metropolitan Municipality (SMM) has set an overall target to become a "climate neutral" and "climate resilient" city by 2050. The CRAS project applies hybrid-medium and pessimistic scenarios to model potential climate impacts under different conditions. The selected scenarios and temporal period include:

- Medium-Term (20-30 Years): Analyze socio-economic impacts of heatwave and prolonged drought and population growth by 2050
- Medium Scenario: SSI2 - RCP4.5
- Pessimistic Scenario: SSI5 - RCP8.5

2.3 Risk Analysis

This section presents how the selected CLIMAAX risk workflows were applied in Şanlıurfa. For each workflow, we summarize the methodology and datasets used for hazard, exposure, and vulnerability assessment, leading to spatial risk outputs.

2.3.1 Workflow #1: Heatwaves

Table 2-4 Data overview in workflow #1 Heatwaves

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Daily Temperatures, Tmax, Tmin thresholds, Regional Climate Projections, Heatwave Index, Heatwave Frequency, Heatwave Duration	Population Density	Land Surface Temperatures	Heatwave Index, Heatwave Frequency, Heatwave Duration, Heatwave Risk Map to Vulnerable Population

2.3.1.1 Hazard assessment

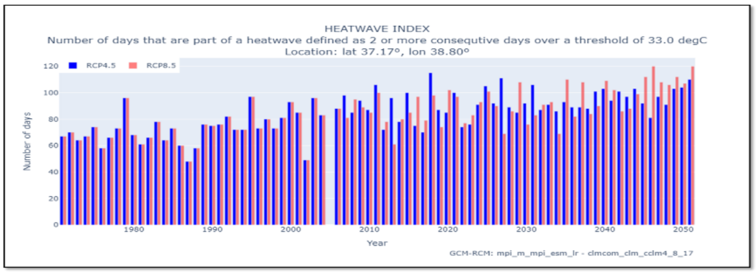

Figure 2-4 Heatwave Index Projections (RCP4.5-RCP8.5)

Heatwave hazards were assessed using the Xclim package, which calculates heatwave index, frequency and duration. Regional thresholds were defined using the 90th percentile of daily maximum (33°C) and minimum (18°C) temperatures. Results were generated at 12×12 km resolution for both RCP4.5 and RCP8.5 scenarios.

2.3.1.2 Risk assessment

Overheated city center of Şanlıurfa map below (about 20 km x 20 km) represents high to very high land surface temperature (around 50-55 C). Also, population density in the same geographic location is shown in Figure 2-5 below.

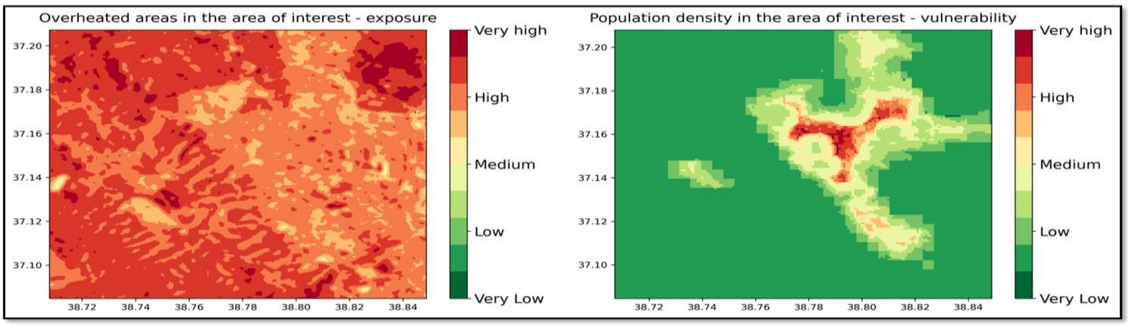

Figure 2-5 Overheated Surface Area and Population Density Maps in Şanlıurfa

The product of exposure and vulnerability data is the Heatwave risk map of Şanlıurfa City Center, as shown in Figure 2-6 below.
The geographic location of neighborhoods which will be exposed to Major Heatwave Risk and high priority for adaptation actions are determined as follows: Kamberiye, Bahçelievler, Ulubatlı, Haliliye, Veysel Karani, Eyyubiye, Hacı Bayram, Hayati Hayrani

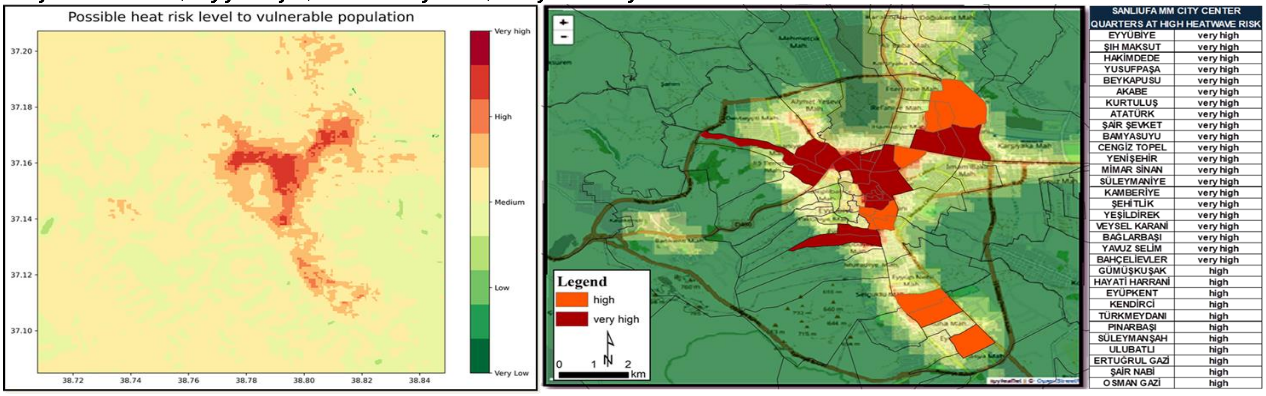

Figure 2-6 Possible Heatwave Risk Level to Vulnerable Population in Şanlıurfa City Center

2.3.2 Workflow #2: Relative Drought

Table 2-5 Data overview in workflow #2 Drought

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Monthly precipitation (1981–2015) and projections under SSP1-2.6, SSP3-7.0, SSP5-8.5, averaged from five CMIP6 models at 0.5° resolution	Rural population share, GDP per capita (from drought_vulnerability.csv)	Cropland, livestock, population, water stress (from drought_exposure.csv)	Relative drought risk classes (1–5), based on the combined hazard, exposure, and vulnerability

2.3.2.1 Hazard assessment

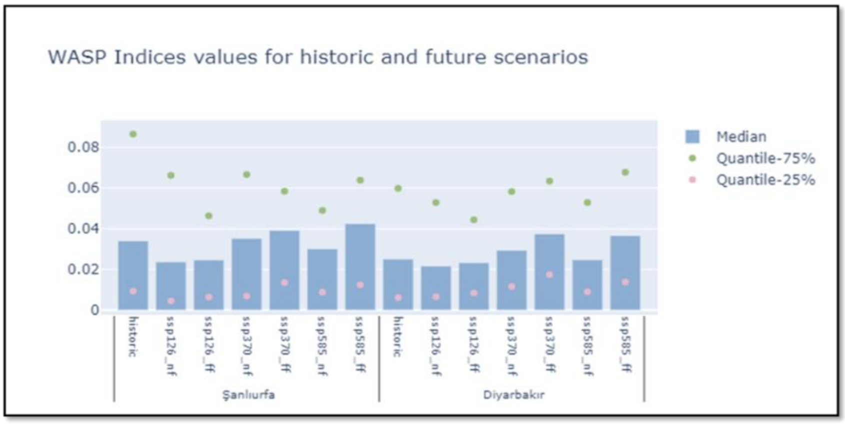

Figure 2-7 The weighted anomaly of standardized precipitation (WASP) index in TRC2 Region

The hazard component for relative drought was analyzed using the Weighted Anomaly Standardized Precipitation (WASP) index, which captures precipitation deficits while accounting for seasonal variation. Figure 2-7 illustrates the WASP index values for Şanlıurfa and Diyarbakır across the historical baseline and three future scenarios: SSP1-2.6, SSP3-7.0, and SSP5-8.5, for near-future (nf) and far-future (ff) periods. The results show a projected increase in precipitation anomalies under SSP5-8.5, indicating heightened drought risk by 2050 and 2080. Median values, as well as the 25th and 75th percentiles, are displayed to reflect the spread and uncertainty across model outputs.

2.3.2.2 Risk assessment

Using the CLIMAAX Relative Drought workflow, risk scores were derived as the product of hazard, exposure, and vulnerability, each normalized across NUTS3 regions. For Şanlıurfa (TRC2 region), the risk was calculated using the WASP index (hazard), exposure indicators (cropland, population, water stress), and vulnerability data (rural population share, GDP per capita). Current and future relative drought risks are demonstrated in the figures below. The relative drought risk score in the Şanlıurfa Region remains at 4 (high) out of 5 under both the SSP1 (sustainability – RCP2.6) and SSP5 (fossil-fueled development – RCP8.5) scenarios by 2050.

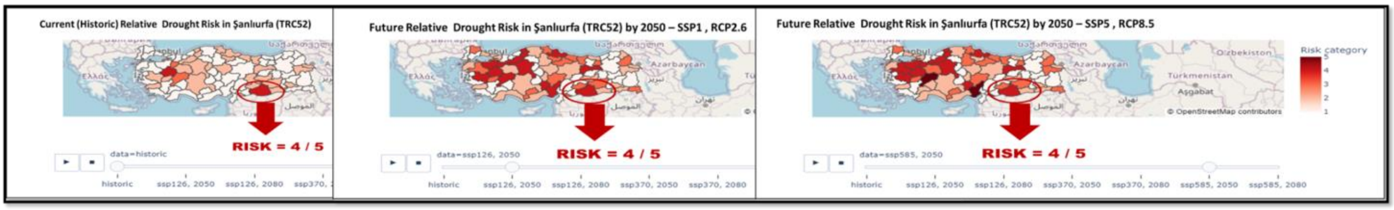

Figure 2-8 Current and Future Relative Drought Risk Level in Şanlıurfa

2.3.3 Workflow #3: Agricultural Drought

Table 2-6 Data overview in workflow #3 Agricultural Drought

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Daily precipitation, max/min temperature, 2m humidity, solar radiation, wind speed, soil water capacity, elevation, thermal zone; crop coefficients and growing season length for cotton, maize, wheat, and pistachio	Irrigation availability (GAEZ)	Crop production (MapSPAM 2010); Crop values (FAO GAEZ)	Maps showing crop yield loss and revenue loss due to irrigation deficit; vulnerability based on irrigation system coverage

The hazard assessment was performed for the four main crops of TRC2 region (Cotton, Maize, Wheat and Pistachio) parameterized in the regional crop coefficients as shown in Table 2-7 below:

Table 2-7 Regional Crop Table used in Agricultural Drought Hazard Assessment[10]

FAO Code	Crop	Clim	Kc_in	Kc_mid	Kc_end	lgp_f1	lgp_f2	lgp_f3	lgp_f4	Season start	Season End	RD1	RD2	DF	Type	Ky
111	wheat	Regional	0.66	1.14	0.26	0.137	0.522	0.183	0.137	286	139	0.2	1.25	0.55	1	1
112	maize	Regional	0.29	1.25	0.37	0.177	0.25	0.339	0.234	141	281	0.2	1	0.55	1	1.25
9211	Cotton	Regional	0.32	1.25	0.62	0.166	0.274	0.31	0.25	120	301	0.2	1.35	0.65	1	0.85
365	Pistachio	Regional	0.4	1.1	0.45	0.089	0.292	0.354	0.266	71	297	1.25	1.25	0.4	0	0.85

2.3.3.1 Hazard assessment

The agricultural drought hazard was assessed using climate projection datasets from the EU Copernicus Data Store for the RCP4.5 scenario covering the period 2041–2045. The analysis focused on cumulative seasonal precipitation, available soil water capacity, and standard

[10] https://www.tarimorman.gov.tr/TAGEM/Belgeler/yayin/Tu%CC%88rkiyede%20Sulanan%20Bitkilerin%20Bitki%20Su%20Tu%CC%88ketimleri.pdf

evapotranspiration to evaluate the water balance affecting crop productivity in the Şanlıurfa and Diyarbakır regions.

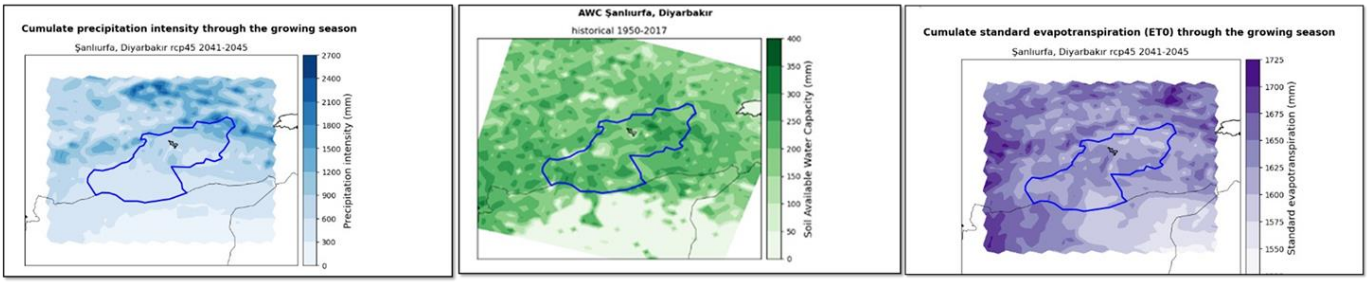

Figure 2-8 Maps of Annual Precipitation, Water Available Capacity and Standard Evapotranspiration in TRC2 Region.

The potential yield losses due to precipitation deficits (in the absence of irrigation) were calculated using crop-specific parameters for cotton, maize, wheat, and pistachio.

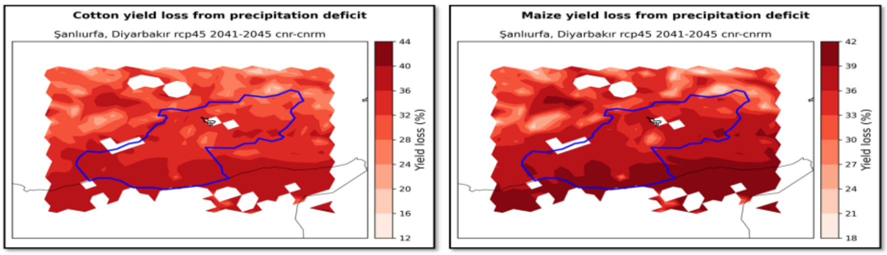

Figure 2-9 Maps of Yield Loss in Main Crops (Cotton and Maize) because of İrrigation Deficit.

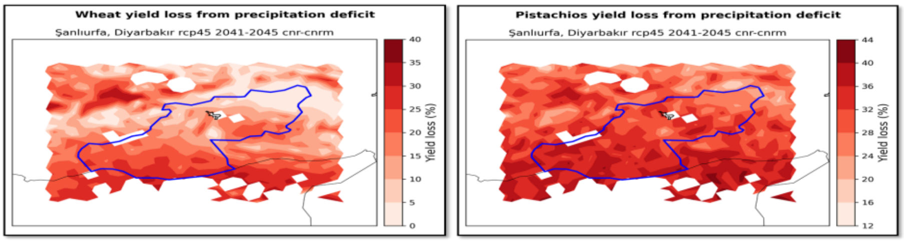

Figure 2-10 Maps of Yield Loss in Main Crops (Wheat and Pistachio) because of Irrigation Deficit.

2.3.3.2 Risk assessment

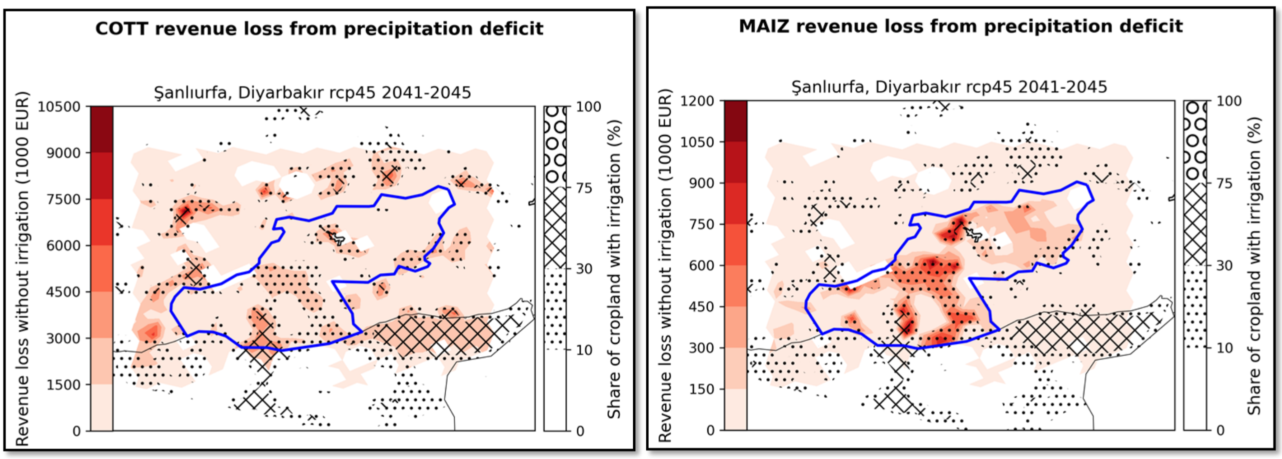

Figure 2-11 Maps of Revenue Loss in Main Crops (Cotton and Maize) because of İrrigation Deficit.

Revenue losses were calculated by combining modeled yield loss percentages with crop-specific production and economic value data. While the outputs provide valuable insights, it is important to note that the dataset used in this workflow does **not fully reflect the current irrigation patterns or**

productivity levels in Şanlıurfa. Therefore, some results may differ from observed site-specific data.

Table 2-8 Regional Comparison of Revenue Losses between current regional data and workflow outputs.

Crop	Average Yield		Average Revenue		Yield Loss (Workflow)	Revenue loss - Region	Revenue loss - Workflow
	kg/1000m2	kg/grid	EUR/1000 m2	EUR/grid	%	EUR/grid	EUR/grid
Cotton (fiber)	194	27,879,070	290	41,818,605	40	**16,727,442**	**3,000,000**
Maize	900	129,600,000	180	25,920,000	40	**10,368,000**	**750,000**
Wheat	260	37,440,000	91	13,104,000	20	**2,620,800**	**150,000**
Pistaccio	67	9,648,000	315	45,345,600	30	**13,603,680**	**No data**

2.4 Preliminary Key Risk Assessment Findings

The preliminary key risk assessment findings provide an in-depth evaluation of the severity, urgency, and capacity aspects of the identified climate risks for Şanlıurfa, focusing on heatwaves and drought. These findings are critical for shaping adaptation strategies and prioritizing risk management actions.

2.4.1 Severity

Key Results from the Heatwave Risk Analysis

- Şanlıurfa experiences ~130 UTCI days per year—among the highest in Europe.
- The Heatwave Index (≥2 consecutive days >33°C) is currently ~80 days, projected to reach 100 days by 2050.
- Heatwave frequency (≥2 days with Tmax >33°C and Tmin >18°C) is currently 8–10 events annually and will likely remain stable.
- Total annual heatwave days may increase from ~80 to 100 by 2050.
- Urban areas with high land surface temperatures and dense populations face serious public health risks.
- High-risk neighborhoods—such as Kamberiye, Bahçelievler, and Eyyubiye—have been identified and prioritized for adaptation.

Key Results from the Relative and Agricultural Drought Risk Analysis

- Şanlıurfa has a relative drought risk score of 4/5, the highest in Türkiye, consistent across SSP1–2.6 and SSP5–8.5 scenarios.
- WASP index confirms significant long-term precipitation deficits.
- The region receives ~350 mm of seasonal rainfall but faces evapotranspiration rates of ~1650 mm, indicating heavy reliance on irrigation.
- Modeled yield losses without irrigation: Cotton (32–40%), Maize (33–42%), Wheat (10–25%), Pistachio (24–36%).
- Revenue loss estimates diverge from current local productivity data, highlighting the need for refinement using actual irrigation patterns and crop yields in the next project phase.

Severity of the Identified Risks

Heatwaves: With a very high Universal Thermal Climate Index (UTCI), frequent and prolonged heatwaves, and extreme Land Surface Temperatures (LST), heatwaves pose a severe risk—especially in densely populated urban areas. High-risk neighborhoods have been identified and prioritized for adaptation actions.

Drought: Şanlıurfa has one of the highest relative drought risk scores in Türkiye. This is expected to persist under both optimistic and pessimistic climate scenarios. Extremely low annual precipitation combined with high evapotranspiration will continue to drive significant crop yield losses—up to 42% without sufficient irrigation.

2.4.2 Urgency

Timing and Impact of Risks
Heatwaves: Represent an immediate threat, especially during summer months when temperatures surpass 40°C. Urgent adaptation is needed—particularly increasing green space in high-risk urban areas.
Drought: A gradual but persistent hazard with significant projected impacts by 2050. Proactive action on water conservation and irrigation efficiency is essential to prevent major yield and revenue losses.

Onset of Hazards and Urgency Evaluation
Heatwaves: Sudden-onset hazard requiring rapid-response systems and emergency preparedness.
Drought: Despite being gradual in appearance, it can escalate quickly—necessitating early planning and sustained mitigation efforts.

2.4.3 Capacity

Current Climate Risk Management Measures
The CRAS project assessed Şanlıurfa's capacity across financial, social, human, physical, and natural dimensions:

- **Institutional Commitment**: Şanlıurfa has committed to the Global Covenant of Mayors (GCoM) and implemented its SECAP in 2022, aiming for climate neutrality and resilience by 2050.
- **Financial**: While municipal resources are limited, Şanlıurfa has strong potential to leverage EU funding via Pathways2Resilience (P2R) and Horizon Europe.
- **Social**: Active civil society and local NGOs contribute to awareness-raising and community engagement.
- **Human**: The Climate Change and Zero Waste Department includes 9 environmental experts, supported by Atalay Climate Consulting for technical capacity.
- **Physical**: Infrastructure gaps remain, particularly in water management and urban cooling systems.
- **Natural**: Agricultural lands and water resources are under stress but present opportunities for improved sustainable management.

Opportunities from Addressing Risks

- **Financial**: Unlocking access to national and EU climate funds.
- **Social**: Building community resilience through inclusive education and participation.
- **Economic**: Enhancing local food security via climate-smart agriculture and efficient water use.
- **Environmental**: Potential for ecosystem restoration, especially in soil health and water conservation.

2.5 Preliminary Monitoring and Evaluation

Lessons Learned from Phase 1
The first phase of CRAS highlighted both the strengths and limitations of current climate risk assessment practices. One of the main challenges was data integration. Since Şanlıurfa lies outside the Euro-CORDEX domain, regional datasets had to be adapted for use in CLIMAAX workflows. For agricultural drought analysis, regional crop coefficients were successfully applied and the crop table was expanded to include key crops like cotton and pistachio. However, the outdated MapSPAM dataset led to discrepancies between workflow outputs and actual field conditions. Future assessments will include updated yield/revenue data and current irrigation maps for more accurate results.
Stakeholder engagement proved effective overall, with high participation during workshops and training events. However, the involvement of private sector actors remained limited and will need

to be strengthened in the next phase. Methodologically, while the CLIMAAX approach was useful, it requires further adaptation to better address local complexities, particularly around drought risk.

Stakeholder Feedback

Feedback from local authorities and community groups was generally positive. Stakeholders appreciated the data-driven risk maps and the transparency of the project. Still, several emphasized the need for more frequent updates and broader outreach, including additional training sessions.

New Data and Further Needs

New high-resolution regional climate projections from the Turkish State Meteorological Service, updated crop yield and revenue data, and detailed irrigated land maps are now available and will be integrated into future work. Additional research is also needed on urban heat vulnerability and improved agricultural impact data, along with continued capacity-building to support long-term climate risk monitoring.

3 Conclusions Phase 1- Climate risk assessment

The CRAS project's Phase 1 has successfully laid a data-driven foundation for climate risk management in Şanlıurfa, with a focus on two critical hazards: **heatwaves** and **drought**. Applying the CLIMAAX methodology, the project generated localized insights into hazard severity, exposure, and vulnerability—enabling more targeted adaptation planning.

Key Findings

- Heatwaves and drought are the most pressing risks.
- Urban areas show very high heat stress due to elevated Land Surface Temperatures (LST) and population density.
- The Heatwave Index based on 33°C (determined as 90-percentile of regional data-set) is currently 80 days and is projected to increase to 100 days by 2050. Heatwave frequency based on the thresholds of day: 33 C and night: 18 C with 2 consecutive days is currently 8-10 and will remain the same by 2050. Total number of heatwave days is currently 80 days and has a tendency to increase up to 100 days by 2050.
- The geographic location of neighbourhoods which will be exposed to "very high" and "high" Heatwave Risk and will have high priority for adaptation actions are determined and visualised by a heatwave vulnerability map.
- Şanlıurfa also has one of the highest relative drought risk scores (4/5) in Türkiye. WASP index analysis confirms ongoing severe precipitation deficits, compounded by very low growing season rainfall (~350 mm) and high evapotranspiration (~1650 mm).
- Agricultural drought analysis shows significant yield losses in case of irrigation deficit: Cotton (32–40%), Maize (33–42%), Wheat (10–25%), and Pistachio (24–36%).
- Vulnerable groups face disproportionate risks.
  Urban heat islands affect the elderly, children, low-income communities, and refugees. In rural areas, small-scale farmers dependent on irrigation are at high risk of drought-induced income loss.
- Risk mapping enabled evidence-based adaptation planning.
  By combining regional climate models (RegCM4.3.4), stakeholder input, and geospatial datasets, the project produced detailed risk maps to guide future municipal action.

Challenges Addressed

- Integration of multiple data sources, including climate models and stakeholder insights.
- High levels of stakeholder engagement through training sessions and workshops.
- Successful adaptation of CLIMAAX workflows to fit Şanlıurfa's regional context.

Challenges Remaining

- **Limited high-resolution local data** (e.g., irrigation maps, crop yield records) constrained model accuracy in some areas.
- **Insufficient private sector engagement**, especially in agriculture and urban development.
- **Need for continued capacity building** among municipal staff and technical stakeholders.

Next Steps – Phases 2 and 3

- **Phase 2: Refinement of Risk Analysis**
  Integration of updated datasets (e.g., local irrigation maps and yield records), improved model calibration, and comparative trend analysis.
- **Phase 3: Development of Adaptation Strategies**
  Use of risk results to shape city-level adaptation plans. Launch of pilot actions (urban greening, water conservation), and development of policy recommendations aligned with national/EU goals.

4 Progress evaluation and contribution to future phases

The Phase 1 deliverable of the CRAS project forms a strong analytical foundation for Şanlıurfa's climate resilience planning. This phase focused on assessing the climate risks posed by heatwaves and drought, applying the CLIMAAX methodology through three tailored workflows. The results of this phase will inform deeper local-scale analysis in Phase 2 and the co-design of adaptation strategies in Phase 3.

Connection to Future Phases

Phase 2 – Refined Local Analysis (Months 7–16):

- Building on Phase 1 outputs, Phase 2 will integrate high-resolution local datasets (e.g. updated crop yield data, local irrigation patterns, high-resolution population maps).
- The CLIMAAX Toolbox will be further customized to better reflect local conditions and data availability.
- A comparative analysis will validate Phase 1 findings and enhance their spatial and sectoral precision.

Phase 3 – Adaptation Strategy Development (Months 17–22):

- Informed by risk analysis, this phase will co-develop local adaptation measures with stakeholders.
- Expanded engagement with decision-makers and communities will support uptake and implementation.
- Outputs will include a local climate adaptation roadmap, aligned with national and EU-level strategies.

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
Risk assessment of 2 climate hazards (**heatwaves** and drought) at NUTS3 level.	3 Workflow (Urban Heatwave, Relative Drought and Agricultural Drought) were Successfully completed using CLIMAAX methodology.
Identification of 4 vulnerable sectors/populations.	Vulnerable groups identified: elderly>65 / Children<5 years old , low-income households, refugees, and outdoor workers/farmers.
Engagement of stakeholders through dissemination/training.	Two stakeholder engagement meetings were completed. Two more planned for later phases.
Provision of risk assessment data to 6 decision-making institutions.	Reports shared with Harran University, Provincial Directorate of Environment, and others.
Execution of 8 communication actions to inform stakeholders.	Three actions completed: stakeholder meeting, media article, and workshop.
Engagement of 5 municipalities in dissemination efforts.	Initial outreach completed- Neighbourhood municipalities- Mardin, Diyarbakır and Adıyaman were participated to 2nd Stakeholder Engagement Meeting. Full engagement planned in Phase 3.

Table 4-2 Overview milestones

Milestones	*Progress*
M1: Document review and initial data collection completed.	Achieved (M1)
M2: Initial risk assessment completed and first deliverable submitted	Achieved (M6).
M3: High-resolution local data integrated into the project.	Ongoing; will be expanded in Phase 2.
M4: Refined risk assessment completed and second deliverable submitted.	Planned for Phase 2 (M16).
M5: Adaptation strategies identified and proposed	Planned for Phase 3 (M20).
M6: Final deliverable prepared and project results disseminated.	Scheduled for M22.

Phase 1 has successfully achieved its objectives—producing a robust, stakeholder-informed climate risk baseline for Şanlıurfa. The findings directly feed into Phases 2 and 3, where more granular data will be incorporated, and locally tailored adaptation strategies will be co-developed. This ensures that Şanlıurfa's climate action remains both scientifically grounded and locally owned.

5 Supporting documentation

This section summarizes the key outputs produced during Phase 1 of the CRAS project. All materials are (or will be) uploaded to the Zenodo repository, ensuring accessibility, transparency, and alignment with CLIMAAX requirements.

5.1 Classification of Outputs

Outputs from this phase are organized into four categories:

Main Report

- **CRAS Phase 1 Climate Risk Assessment Report** (PDF/Word): Comprehensive documentation of methodology, analysis, findings, and conclusions.

Visual Outputs

- **Heatwave visual outputs:**

1_1_SANLIURFA_HEATWAVE_hazard_assessment_xclim.ipynb
1_2_SANLIURFA_HEATWAVE_risk_assessment.ipynb
1_3_SANLIURFA_HEATWAVE_heatwave_index.png
1_4_SANLIURFA_HEATWAVE_heatwave_frequency.png
1_5_SANLIURFA_HEATWAVE_heatwave_duration.png
1_6_SANLIURFA_HEATWAVE_LST_meanvalues.png
1_7_SANLIURFA_HEATWAVE_overheated_areas.png
1_8_SANLIURFA_HEATWAVE_roi_vulnerable_pop_density.png
1_9_SANLIURFA_HEATWAVE_possible_heat_risk_vulnerable_pop.png
1_10_SANLIURFA_HEATWAVE_City_Neighbourhoods_Borders_Under_Very_High_Risk.jpg

- **Relative Drought visual outputs:**

2_1_SANLIURFA_RELATIVE_DROUGHT_Hazard_assessment.ipynb
2_2_SANLIURFA_RELATIVE_DROUGHT_Risk_assessment.ipynb
2_3_SANLIURFA_RELATIVE_DROUGHT_Risk_visualization.ipynb
2_4_SANLIURFA_RELATIVE_DROUGHT_WASP_TR_ssp585_nf.xlsx

- **Agricultural Drought visual outputs:**

3_1_SANLIURFA_AGRICULTURAL_DROUGHT_Hazard-Med.ipynb
3_2_SANLIURFA_AGRICULTURAL_DROUGHT_Risk_Assessment.ipynb
3_3_SANLIURFA_AGRICULTURAL_DROUGHT_AWC.png
3_4_SANLIURFA_AGRICULTURAL_DROUGHT_Cumulate_Precipitation.jpeg
3_5_SANLIURFA_AGRICULTURAL_DROUGHT_Evapotranspiration_ET0.jpeg
3_6_SANLIURFA_AGRICULTURAL_DROUGHT_crop_table_regional.xlsx
3_7_SANLIURFA_AGRICULTURAL_DROUGHT_Yield_Loss_Spreadsheet.xlsx
3_8_SANLIURFA_AGRICULTURAL_DROUGHT_wheat_yield_loss.png
3_9_SANLIURFA_AGRICULTURAL_DROUGHT_maize_yield_loss.png
3_10_SANLIURFA_AGRICULTURAL_DROUGHT_Cotton_yield_loss.png
3_11_SANLIURFA_AGRICULTURAL_DROUGHT_Pistachios_yield_loss.png
3_12_SANLIURFA_AGRICULTURAL_DROUGHT_Wheat_revenue_loss_EUR.png
3_13_SANLIURFA_AGRICULTURAL_DROUGHT_Maize_revenue_loss_EUR.png
3_14_SANLIURFA_AGRICULTURAL_DROUGHT_Cotton_revenue_loss_EUR.png

Communication Outputs

4_1_SANLIURFA_GENERAL_21Feb_StakeholderMeeting_Climaax_Presentation.pdf
4_2_SANLIURFA_GENERAL_Regional_Climate_Data_MGM_Formal_Letter.pdf

4_3_SANLIURFA_Communication_Outputs_Phase1.xlsx
4_4_SANLIURFA_Stakeholder_Workshop_Report.pdf

During Phase 1 of the CRAS project, extensive communication and outreach activities were carried out across multiple platforms to raise awareness and engage stakeholders. 19 media and social media outputs were documented between October 2024 and February 2025.
These included:

- 4 press and web announcements about Şanlıurfa and EU climate funding.
- Multiple Twitter, Instagram, Facebook, and LinkedIn posts by Şanlıurfa Metropolitan Municipality and EU partners (EU4EnergyTR, CLIMAAX), sharing workshop updates, and key findings.
- A highlight video of the stakeholder workshop was published on YouTube.
- Notable posts included statements from Mayor Mehmet Kasım Gülpınar, public dissemination of 2050 climate risk results, and announcements celebrating the city's achievements in the CLIMAAX and Pathways2Resilience projects.

All communication outputs, including direct links, titles, and publication dates, are documented in the file 4_3_SANLIURFA_Communication_Outputs_Phase1.xlsx, which is also uploaded to the Zenodo repository as part of this deliverable.

Datasets Collected

5_1_SANLIURFA_20250123387B-Daily Sunshine Duration (hours).xlsx
5_2_SANLIURFA_20250123387B-Daily Maximum Wind Speed (ms).xlsx
5_3_SANLIURFA_20250123387B-Daily Total Global Solar Radiation (kWhm²).xlsx
5_4_SANLIURFA_20250123387B-Daily Total Solar Irradiance (calcm²).xlsx
5_5_SANLIURFA_20250123387B-Daily Total Global Solar Irradiance (Wm²).xlsx
5_6_SANLIURFA_20250123387B-Daily Total Precipitation (mmkgm²) – Automatic Station.xlsx
5_7_SANLIURFA_20250123387B-Daily Total Precipitation (mmkgm²) – Manual Station.xlsx

These 7 datasets were provided by the Republic of Türkiye Ministry of Environment, Urbanization and Climate Change – General Directorate of Meteorology. The data were transmitted via the following formal correspondence:

- Official Reference Number: E-95579059-107-434253
- Subject: Meteorological Observation Data Request
- Date: 23.01.2025
- Related Request Document: E-72341945-045.99-338317, Belgenet No: 127733
- Institution Addressed: Şanlıurfa Metropolitan Municipality, Climate Change and Zero Waste Department

5.2 Zenodo Repository Uploads

All Phase 1 outputs are structured in the Zenodo repository as follows, and have been uploaded in **ZIP format** for clarity, accessibility, and ease of reuse:

1. **Main Report**
2. **Visual Outputs** – Maps, charts, and Jupyter notebooks related to heatwave and drought risk assessment
3. **Communication Materials** – Press releases, stakeholder presentations, and social media documentation
4. **Datasets** – Climate data (Excel format)

All Phase 1 outputs, including the **final report**, are uploaded in ZIP format to the Zenodo repository and are accessible via the CLIMAAX community at:

🔗 **https://doi.org/10.5281/zenodo.15106529**

6 References

1. Şanlıurfa Metropolitan Municipality (2022). Climate Change Risk and Vulnerability Assessment Report. Climate Change and Zero Waste Department, Şanlıurfa Metropolitan Municipality. Climate Change and Zero Waste Department, Şanlıurfa Metropolitan Municipality.
2. Şanlıurfa Metropolitan Municipality (2022). Sustainable Energy and Climate Action Plan Report.
3. CLIMAAX Consortium (2024). CLIMAAX D1.4: Climate Risk Assessment Framework. Horizon Europe Project. Available at: https://climaax.eu/
4. Turkish State Meteorological Service (TSMS) (2023). Regional Climate Data for South-eastern Anatolia. TSMS Publications, Ankara, Türkiye.