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Extreme Weather

Challenge Definition - Summary

MCRIT

Mcrit Multicriteria Planning

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What is Extreme Weather?

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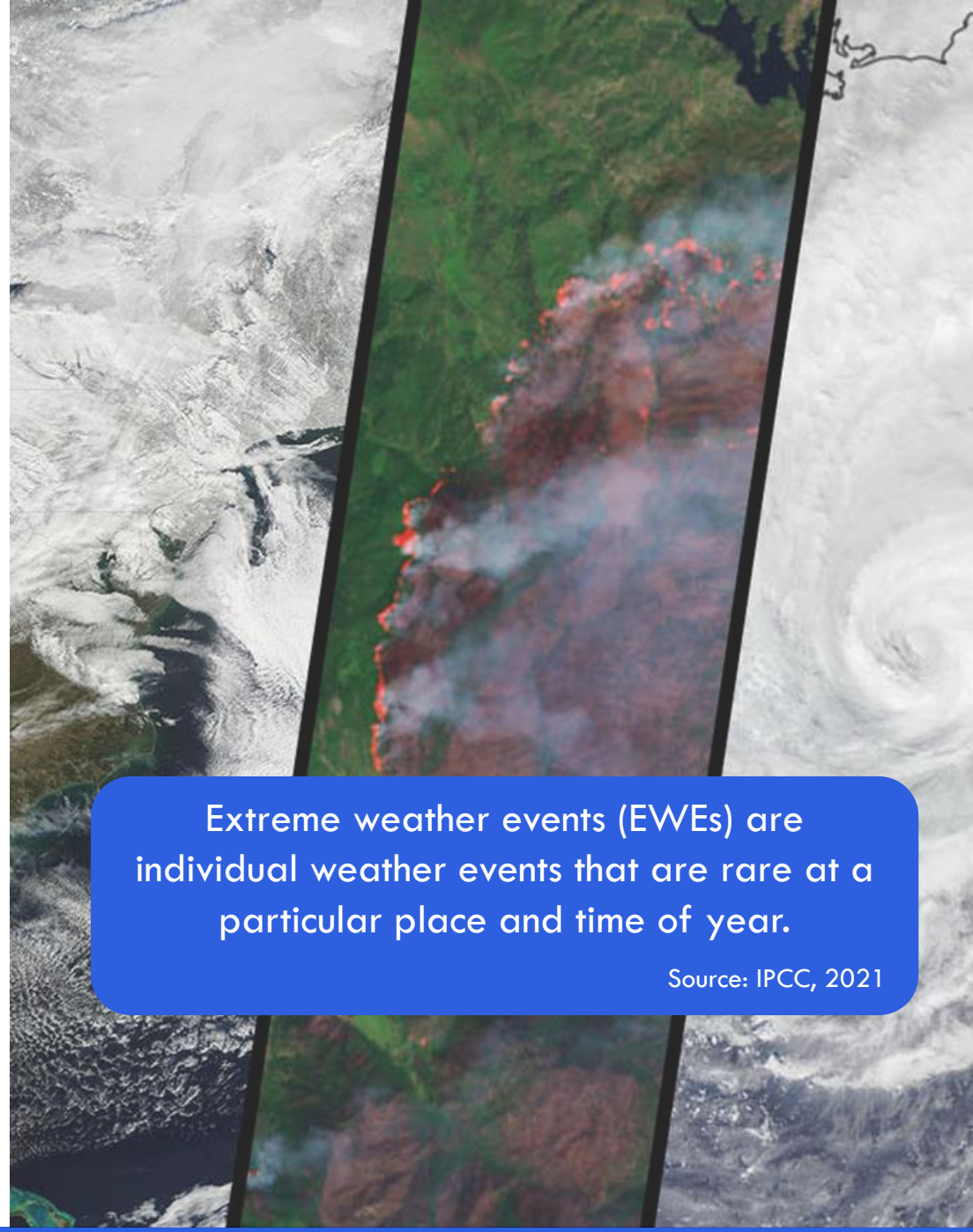
Definition of the Challenge

- The climate is constantly at flux, warming and cooling over the passage of millennia.
- In the past century, these changes have increased significantly, putting ecosystems, human health, and economies, at risk.
- In addition to a general increase in temperatures worldwide, the Earth has experienced **more frequent, more intense, and longer extreme weather events.**
- These incidences are natural, but the recent increase in frequency, duration, strength, and number of regions effected by them is primarily a **result of human influence** and **threatens our economy, infrastructure, agriculture, health, and security.**



Extreme weather events (EWEs) are individual weather events that are rare at a particular place and time of year.

Source: IPCC, 2021

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Types of EWEs

Heat Wave

A period of three or more days when a region experiences abnormally hot temperatures.

Heavy Precipitation

When the amount of rain or snow fall in a location substantially exceeds what is normal (EPA, 2021).

Wildfires

An unplanned fire that burns in a natural area such as a forest, grassland, or prairie (WHO, Wildfires).

Droughts

When a region experiences significantly low precipitation over a long period of time resulting in an imbalance in the water cycle.

Storms

A deep and active area of low pressure with associated strong winds and precipitation, including tropical cyclones, tornados, and hurricanes (Met Office).

Floods

Floods are the most frequent type of natural disaster and occur when an overflow of water submerges land that is usually dry (WHO, Floods).

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How are EWEs and Climate Change related?

Changes in extreme weather and climate events are the **primary way that most people experience Climate Change (CC)**

"Sadly, a tragic experience with an extreme weather event may be a citizen's most personal encounter with the consequences of CC, and what ultimately spurs collective action" (Marcia McNutt, President of the National Academy of Sciences).

Climate change can also **intensify food crises** resulting from floods and droughts

With the rise in sea level, also attributed to climate change, water contamination due to infiltration of salty or polluted water is more likely.

The increase in EWEs worldwide is largely influenced by the increase in global temperatures, which are a direct result of emissions produced by human activities

This change has resulted in an increase in sea level rise, temperature, weather extremes, biodiversity loss, etc.

It is crucial to note, however, that while climate change does influence EWEs, it is **not the sole cause of their occurrence**

Their increase in frequency and severity are a result of a combination of many factors, climate change being one of them.

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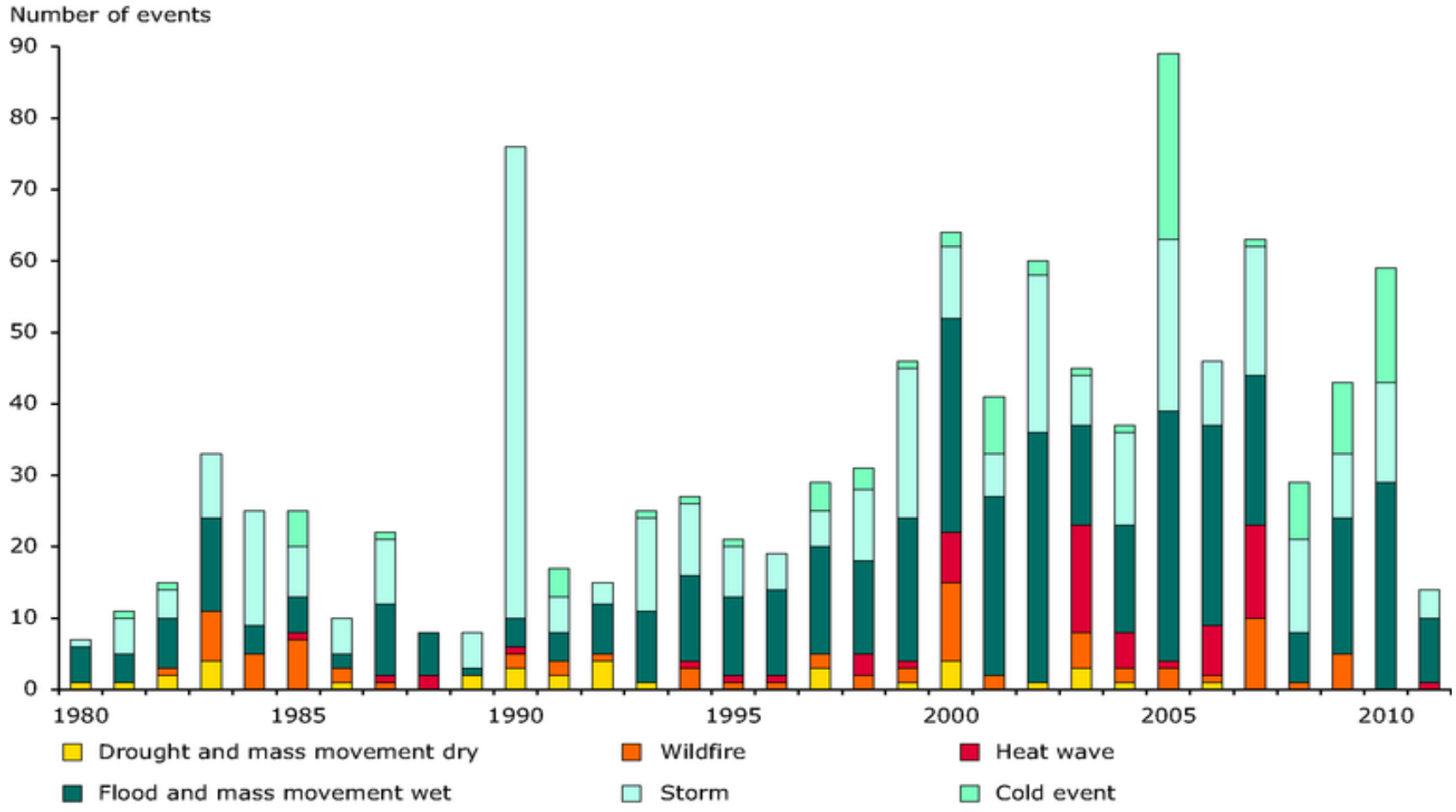
"Global warming has increased the intensity and probability of the hottest daily and monthly events in over 80% of the territory studied"

(PNAS, 2017).

"Of 152 heat events analysed, **93% were more severe due to influences from climate change"**

(Carbon Brief, 2022).



Number of reported extreme weather events and wildfire. 1980-2012. Source: EEA, 2016.

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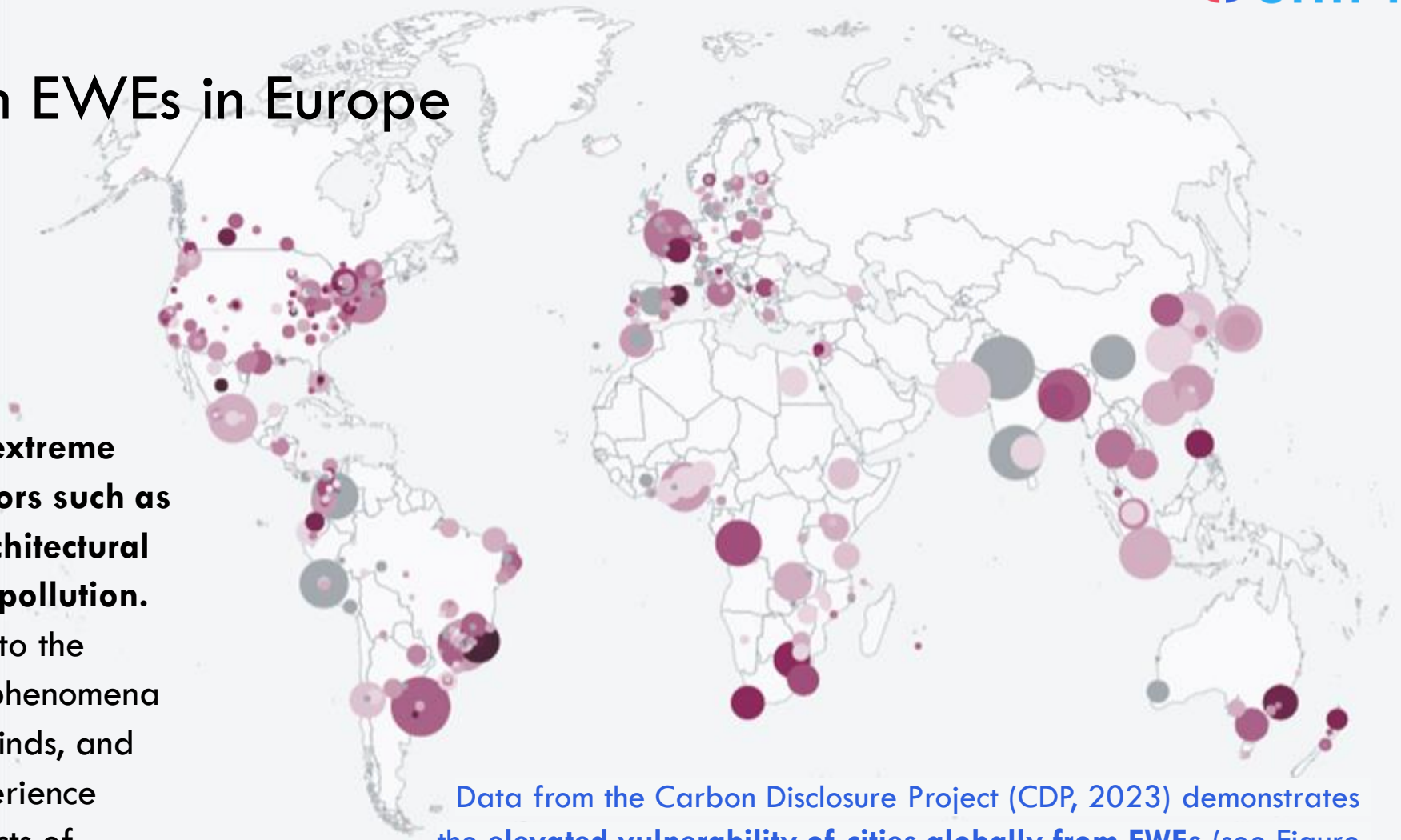
An Urban Focus on EWEs in Europe



Cities face increased risks during extreme weather events (EWEs) due to factors such as high population density, urban architectural design, and elevated levels of air pollution. These characteristics can contribute to the amplification of EWEs, resulting in phenomena like hotter temperatures, stronger winds, and larger hail. Urban areas often experience more severe and concentrated effects of extreme weather events compared to rural areas.

Data from the Carbon Disclosure Project (CDP, 2023) demonstrates the **elevated vulnerability of cities globally from EWEs** (see Figure behind). Flash/surface flooding, heat waves, rainstorms, and droughts are said to be the most common EWEs in cities.

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Causes

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Causes

(1) Natural Causes

- Currents, Wind Patterns, and Pressure Systems
- The Four Seasons
- Topography
- Variations in Climate Patterns

(2) Anthropogenic[1] Causes

- Climate Change
- Land Use
- Land Management
- Urban Planning
- Human Negligence

[1]Influenced by people, either directly or indirectly.

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(1) Natural Causes

Currents, Wind Patterns, and Pressure Systems

Storms are naturally more likely to occur in regions where a cold front meets a hotter environment, when a high-pressure system meets and low-pressure system, and in other areas where conflicting environmental circumstances meet.

Topography

Changes in altitude, proximity to the coasts, presence of lakes, and other geographical features can impact the type of EWEs experienced in a region.

The Four Seasons

Each season comes with its own set of meteorological challenges: the summer brings the heat; fall, the storms; spring, the rain; and winter, the cold. The impacts of these trends vary depending on the region.

Variations in Climate Patterns

Volcanic eruptions can cause oddities in climate patterns, which can in turn impact the development of EWEs. Some variations in climate patterns are patterns themselves, meaning their occurrence is expected and they interrupt normal weather trends (e.g., El Niño Southern Oscillation)

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(2) Anthropogenic[1] Causes

[1]Influenced by people, either directly or indirectly.

Climate Change

Climate change significantly affects extreme weather events (EWEs) related to temperature and moisture, increasing the likelihood of heatwaves, droughts, heavy rainfall, and flooding.

Land Management

Between the surplus of dry wood (due to forest mismanagement, climate change and natural processes) and the other contributing factors such as higher temperatures, drier atmosphere, and water deficiencies, wildfires are bound to ignite.

Human Negligence

75% of wildfires are human caused (e.g., from burning rubbish and debris, industrial accidents, agricultural overspill) (WWF, BCG).

Land Use

Human land use, including urbanization, agricultural development, deforestation, river channelling, and urbanization, further increase the likelihood of extreme weather occurrences.

City Placement

Poor urban planning that places cities in harm's way of natural hazards, especially near wildfire prone areas or by the coast, is another issue that increases the severity of EWEs.

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Effects: Why does this matter to us?

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Effects: Why does this matter to us?

Physical aspects

Health Problems
- Decrease in human comfort, lack of night-time relief (heat wave)
- Respiratory problems (heat wave)
- Sunstroke, dehydration, tiredness (heat wave)
- Malnutrition & dehydration (droughts)
- Respiratory infections & chronic illness (wildfires, dust storms)
- Drowning, heart attacks, injuries, infections, and exposure to chemical hazards (flooding, storms)
- Stress, depression & other mental illnesses (all)
- Even increase in mortality rates (all)

High Impacts on Biodiversity
- Destruction of habitats and disruption of the lives of native organisms of the region impacted (i.e., storms may disrupt migration, mating, and flight patterns of birds)
- Increased likelihood of wildfire, erosion of shorelines, insect infestations, and establishment of invasive species caused by EWEs decrease biodiversity
- Marine heat waves can also have detrimental effects on marine biodiversity, causing the mortality of many marine species

EWEs

Increased Energy Use for Cooling
- Increase in the demand for energy to power air-conditioning units

Economic Losses
- Infrastructure damages, cost of emergency aid services, drop in labour productivity.
- Cost of living may increase as housing supply decreases and food and water become more expensive.
- Certain industries (i.e., tourism and agriculture) particularly vulnerable to the impacts of EWEs.

Cultural and Heritage Losses
- The destruction of habitats by storms or floods may mean the loss of a sacred space, cemetery, or other area of cultural importance

Unequal effect on territories and society, depending on their degree of vulnerability

Socio-economic aspects

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The Challenge in Europe

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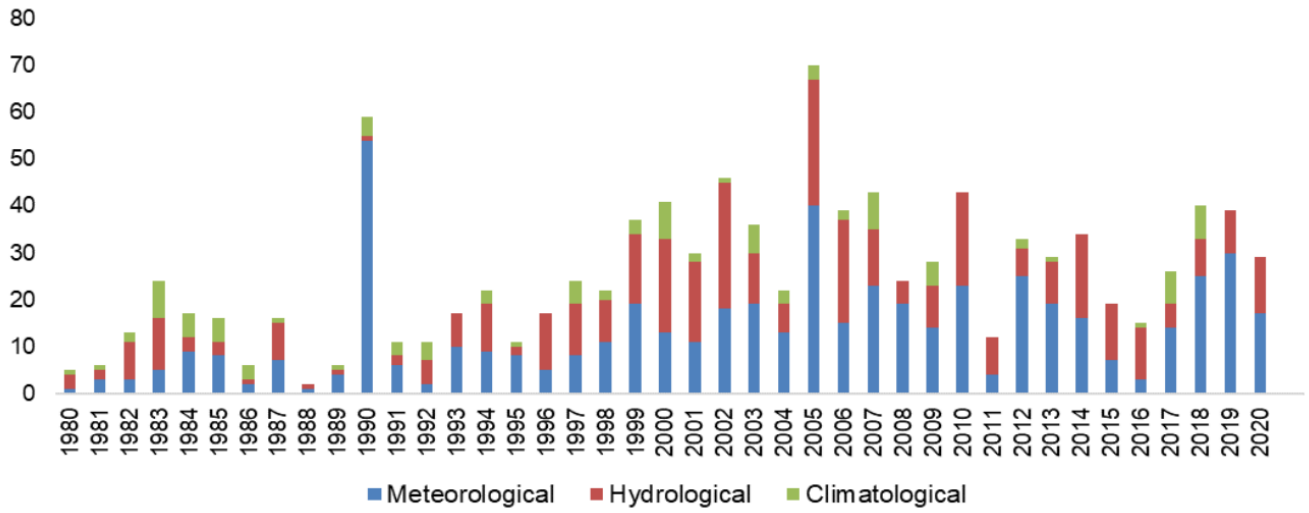
The Challenge in Europe

- **Meteorological events are the most common** (e.g., temperature extremes and storms), consisting of 543 total disasters over the forty-year period (1970-2019).
- Hydrological (389) (e.g., floods) and climatological (e.g., droughts and wildfires) (108) disasters follow in turn (WMO, 2021).



Disasters reported in Europe from 1970 to 2019 (WMO, 2021)

1.672 disasters

€441,9 billion (economic losses)

159.438 deaths

Extreme temperatures accounted for the most deaths (45%)

38% Floods

32% Storms

18% Temperature extremes

13% Others

Wildfires 8%
Droughts 3%
Landslides 2%

Number of weather- and climate-related events in the EU, by disaster subgroup. 1980-2020.

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Even if all countries are subject to EWEs, **the distribution of these events is quite uneven.**

Also, while all countries are experiencing an increase in number of disasters, many Central-Eastern European countries (particularly Croatia, Czechia, Latvia, Slovakia, Bulgaria, Romania, and Hungary) **have had a particularly significant rise in EWEs over the past 20 years.** Some Southern European countries (i.e., Italy, Greece, and Portugal) have also noted the same trend (European Commission, 2022).

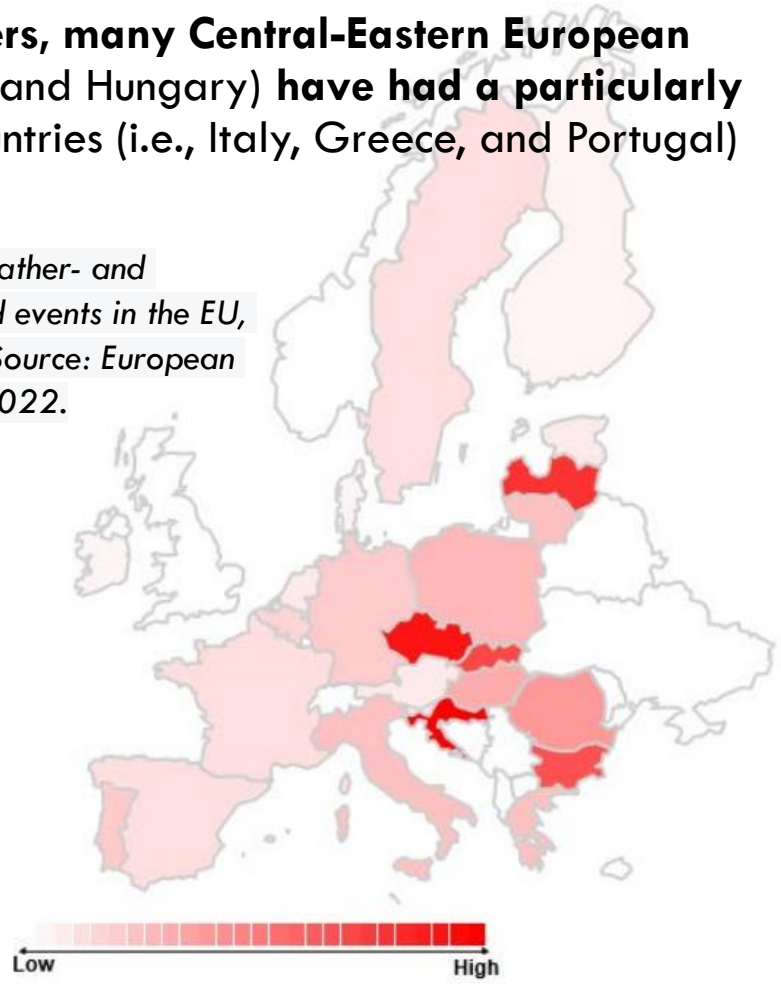
Countries with most reported events

15%	France
9,3%	Italy
8,7%	Spain

Countries with least reported events

0,2%	Finland
0,4%	Estonia
0,9%	Slovenia

Number of weather- and climate-related events in the EU, 2000-2020. Source: European Commission, 2022.



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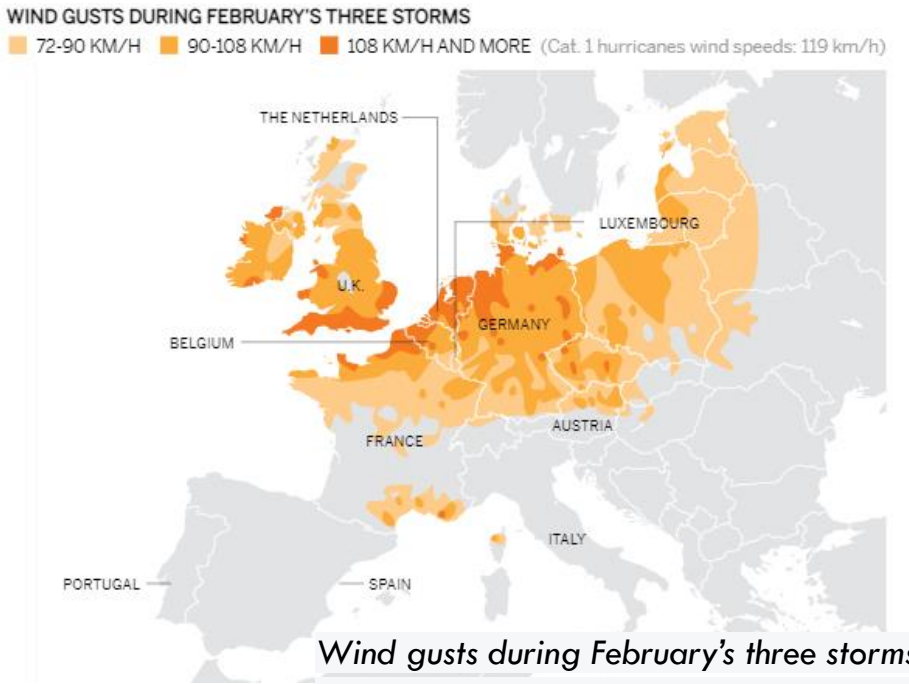
Storms

Coastal regions in Europe are at high risk of storms due to milder winters. Since storms often come in from the ocean, the regions proximity makes it a perfect target for storms.

While some animals may be able to evolve to the increase in storms and other environmental changes, others will not be able to keep up with the fast-changing world, likely resulting in another mass extinction event if efforts are not taken to mitigate these impacts.



Wind gusts during February's three storms, 2022. Source: EU Copernicus Programme, 2022.

Floods

Rainfalls, river, and ocean floods are all expected to increase in frequency in Europe. Northern and Eastern Europe is expected to experience a 35% increase in heavy precipitation causing flash floods, while low lying cities throughout Europe are projected to have a rise in coastal and river floods.

The Ahr River in Insul, Germany, on July 15, 2021, after heavy rainfall. Source: CNN, 2021

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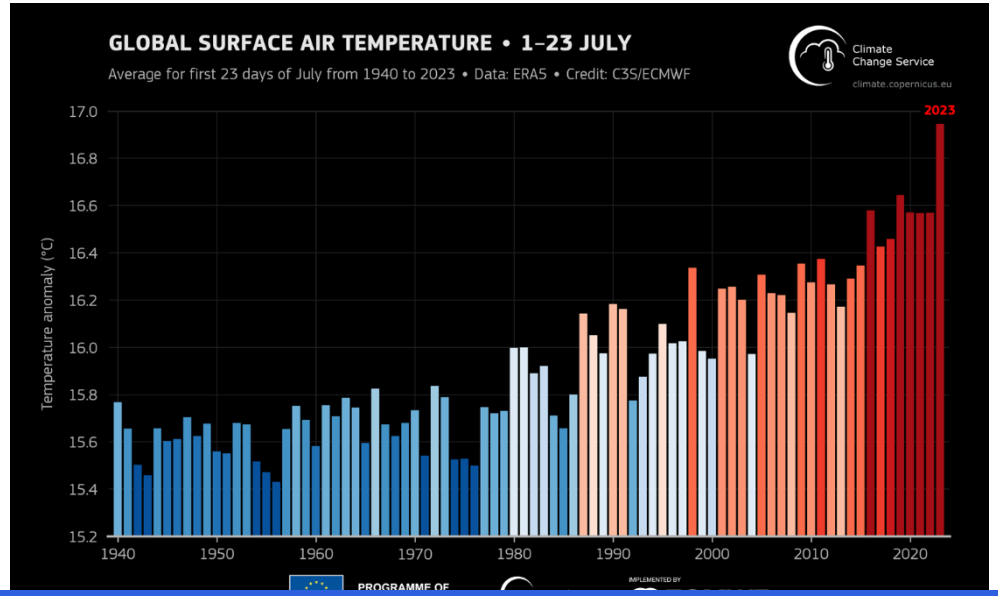
Heat Waves

The summer of 2023 was Europe's hottest in history. These temperatures have been related to heatwaves in large parts of North America, Asia and Europe, which along with wildfires have had major impacts on people's health, the environment and economies.

Europe is becoming ever more vulnerable to heat waves a result of having drier springs and consequently drier soil. Since drier land conditions can lead to higher atmospheric water content, heavy rainfall is likely to follow periods of heat waves and drought, causing floods, like those experienced in Germany in 2021.



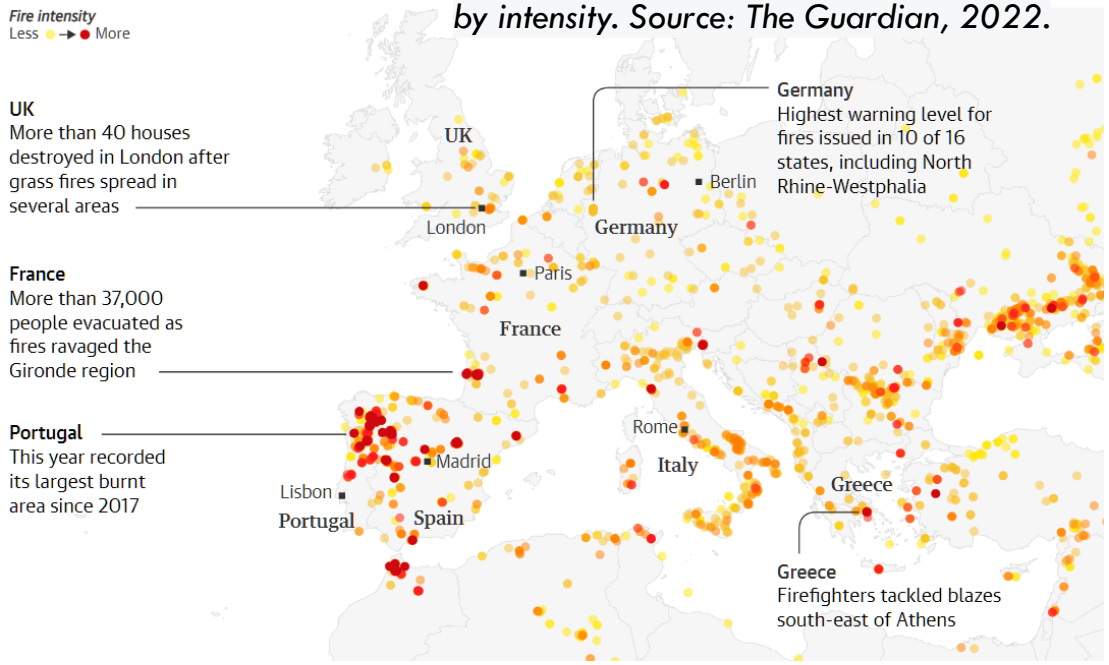
Globally averaged surface air temperature for July for all months of July from 1940 to 2023. Source: WMO, 2023.

Wildfires

With the increase in drought and extreme heat, Europe has become more susceptible to wildfires. In 2022, wildfires raged Europe, impacting 26 out of the 27 EU countries. Spain, Portugal, France, Italy, and Greece were hit the worst, making 2022 Europe's second worst fire season since 2000.

A World Bank study explained that with every €1 invested in wildfire prevention, another €10 are saved in damages.

Map of European fires in 2022, categorized by intensity. Source: The Guardian, 2022.



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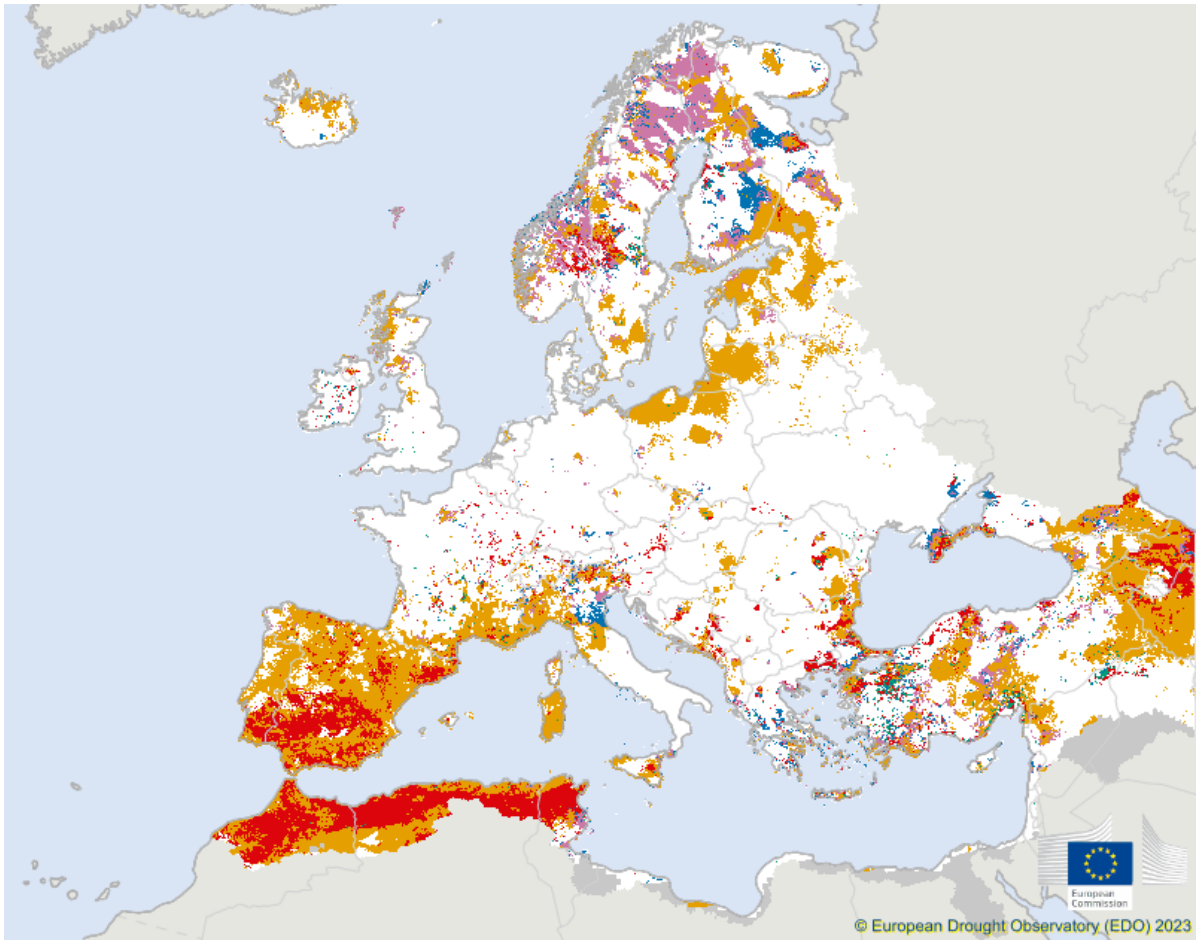
Drought

In 2022, Europe faced its worst drought in 500 years, resulting in EUR 19 billion in insured losses. Two-thirds of the continent received drought warnings in August. Climate change is accelerating these extreme events, making them occur roughly every 20 years, instead of every 400 years.

Droughts pose as a particular threat in Southern and Central Europe due to the expected drier and warmer winters, which would reduce snow accumulation.

These trends would result in a reduction in long-term water storage (e.g., snow, ice, and glacial ice), a reduction in agricultural productivity, and a decrease in food accessibility.

Situation of Combined Drought Indicator in Europe - 3rd ten-day period of May 2023. Source: JRC, 2023.



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Future Trends

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Future Trends

Increases in EWEs are highly likely to occur across Europe regardless of the level of global warming reached in the coming years.

▲ **Temperatures** will continue to rise in all of Europe at rates exceeding global mean temperature changes

Southern Europe is likely to experience the most heat waves.

▼ **Cold periods and frost waves** are predicted to decrease in frequency.

▲ **Precipitation events** are overall likely to increase. These predictions, however, still vary depending on the region and season.

In Northern Europe, precipitation patterns are projected to increase drastically in the winter, while they are said to decrease at similar rates during the summer from the Mediterranean to Northern Europe. This expected rise in precipitation events is likely to result in an equivalent increase in landslides.

▲ **Extreme precipitation and pluvial floods** are expected to increase if global warming increases 1.5°C from pre-industrial levels.

If levels reach 2°C, river floods in Northern Europe and Eastern Europe are expected to decrease, while in Western and Central are expected to continue to increase in frequency.

▲ **Sea level** in all of Europe except for the Baltic Sea is expected to rise at rates above the global mean

▲ **Droughts and wildfires** are also likely to increase in frequency in Southern Europe

▲ **Cities** will continue to be targeted by EWEs

They will experience exacerbated urban heat islands, amplification of heat waves, extreme weather volatility, floods, droughts, and coastal inundation

Source: IPCC, 2021

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Strategies for EWEs Adaptation and Mitigation

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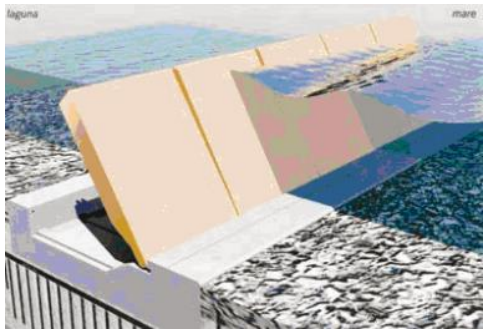
Federal Commitments and Urban Projects to EWEs Adaptation and Mitigation

- **Many countries in Europe have realized the importance of acting against EWEs and have developed plans and strategies** to properly address these challenges, focusing on aiding the most impacted communities.

(1) Investment in EWEs resistant infrastructure

- Many countries are **constructing and installing infrastructure that prevents damage from EWE** as a means of mitigating damages.
- Portugal, which suffers from many coastal floods, is putting up seawalls and gryones to physically impede flood waters from damaging the city.
- In Riba-Roja de Túria, Spain, the city is constructing green firebreaks (i.e., strips of low-flammable vegetation) to halter fire spread).



Smart barriers to shield La Serenissima from freak tide

(2) Improved ecosystem management

- **Strengthening the ecosystem of a region** is another way to reduce damages from EWEs.
- France is strengthening their forests by installing and regenerating, practicing wider spacing and strong and early thinning, and using wood-based heating for energy. These actions can increase biodiversity and reduce vulnerability to strong winds, storms, and droughts.

(3) Greenifying neighbourhoods: tree planting and construction of water features

- Some actions include the implementation of tree planting and **construction and restoration of water features** in areas designated as vulnerable to mitigate the impacts of heat waves in a residential area of Trnava and Košice, Slovakia.
- The **Vienna environmental department - MA 22,** had been dealing with the topic "heat in the city" for more than 15 years. This included a climate assessment and map based on thermal images and the implementation of measures, such as green space networking, roof greening, façade greening and rainwater management. This led to the creation of an ecosystem-based adaptation solution; the greening of the building 'façade' or front wall.
- In Paris, Flemish Brabant, Belgium, Germany, and Sweden, programs were developed to **green disadvantaged schools and neighbourhoods**
- Amsterdam and Malmö focus on **mitigating flood impacts by installing green roofs** that can store excess stormwater or constructing sustainable drainage systems.

Urban stormwater management in Augustenborg, Malmö

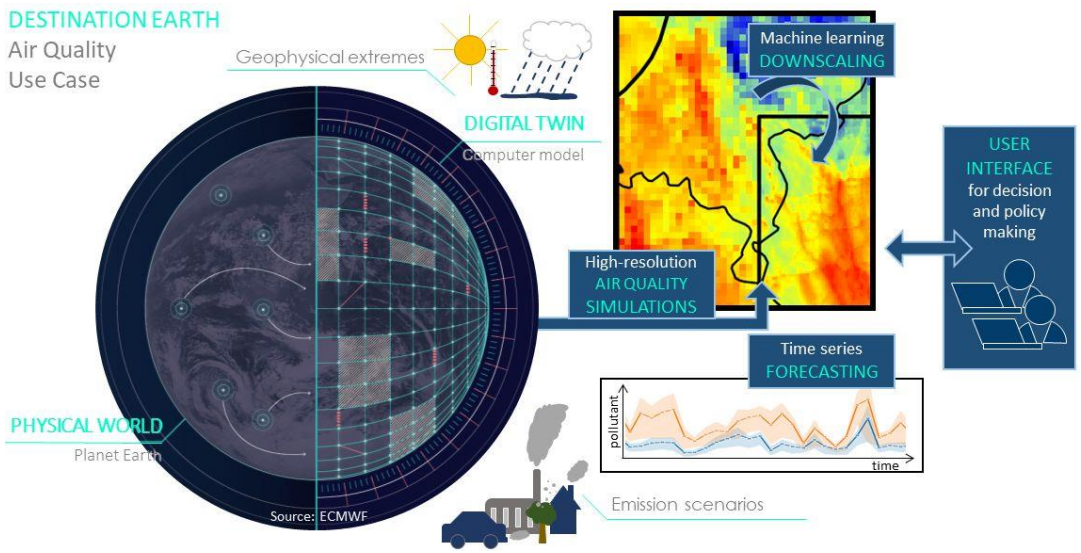
(4) Hands-on warnings, rescues, and post-disaster care

- Some regions have focused on **providing aid to disadvantaged communities during and after EWEs**.
- In Bologna, Italy volunteers can assist vulnerable citizens make their way to safety during an EWE.
- Another program in Kassel, Germany provides free calls to warn people of coming heat waves.
- In Lisbon, the municipality care department aids homeless people during times of crisis.
- In Finland, three NGOs provide mental healthcare to youth suffering from climate anxiety and other similar stressors (EEA, 2022).

(5) Better forecasting

- Many countries are investing in **increasing their ability to predict EWEs so that they can better respond when disaster strikes**.
- In Hungary, efforts to improve drought forecast are of particular importance. While they are working to better predict droughts, they have yet to develop a strategy for once drought hits.
- ENSEMBLES is a European project that aims to accurately predict EWEs and other climate change related occurrences. 66 partners from across the EU, Switzerland, Australia, and the USA are participating in this project.

Air Quality Forecast Example in Extreme Weather



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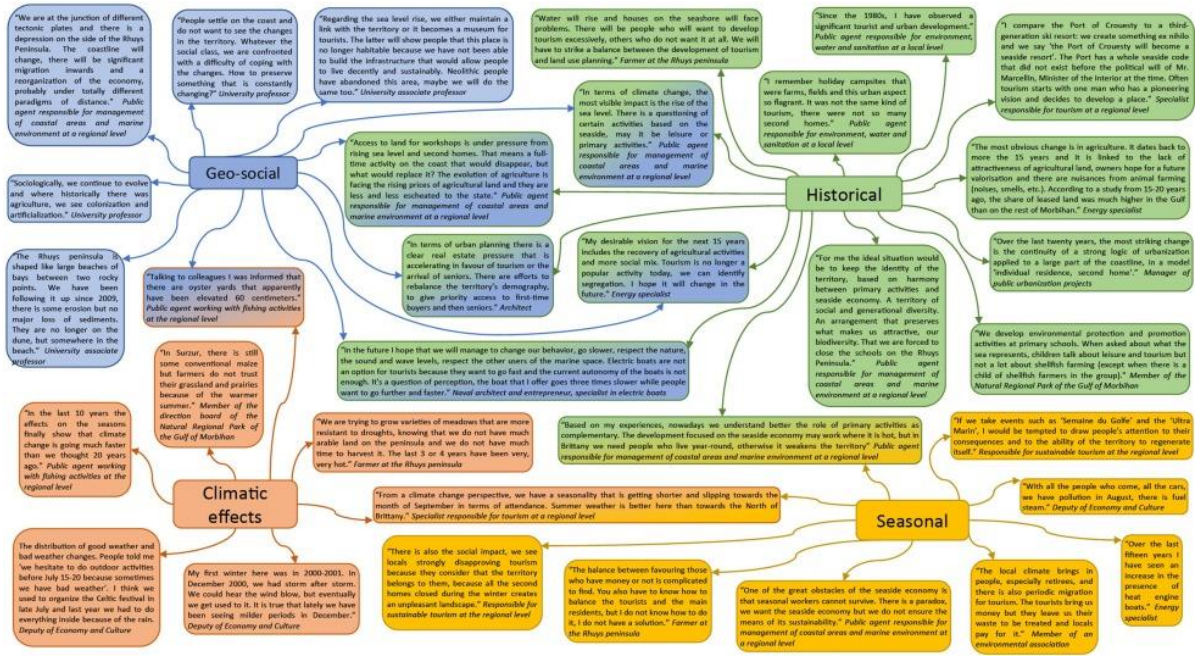
(6) Raising awareness

- In order to ensure that new climate policies are followed and to increase public understanding of climate change and EWEs, **countries are also working on improving public awareness of EWEs.**

(7) Involving the local community in problem-solving

- **The European Climate Pact and the European Mission on Adaptation have emphasized the importance of citizen engagement,** including vulnerable groups, in developing adaptation strategies.
- In France, the most vulnerable communities helped establish the second national adaptation plan and regional climate policies, while in Slovenia municipalities worked with disadvantaged populations to achieve the same result.
- In Prague, citizen engagement led to the installation of green roofs in bus shelters to increase comfort and ventilation.
- In Finland children, youth, the elderly, and the Sami indigenous people were consulted to develop strategies to address climate change.



Adaptation planning in France: Inputs from narratives of change in support of a community-led foresight process

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Case Studies: what will be needed in the future?

Start-ups

- **Many smaller companies and start-ups** have taken it into their own hands to develop technology and systems that help address EWEs.

DRONEHOPPER FIREFIGHTING DRONE

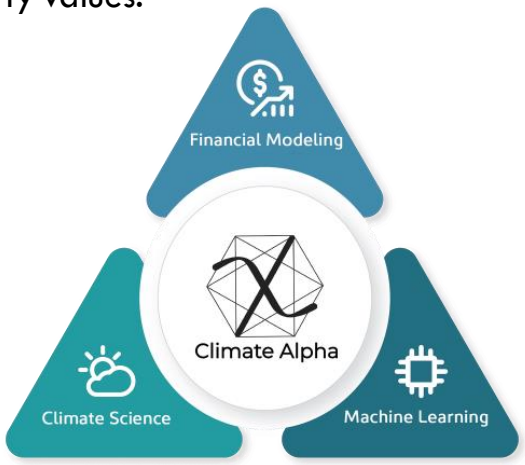
Drone Hopper

A company founded in Madrid, Spain produces heavy-duty drones that are designed to put out wildfires in urban and agricultural areas. Their drones can carry 600 litres of water and are built to fly under strong winds in 24/7 operations. They create firewalls and defence systems to protect communities and properties during fires.

Climate Alpha

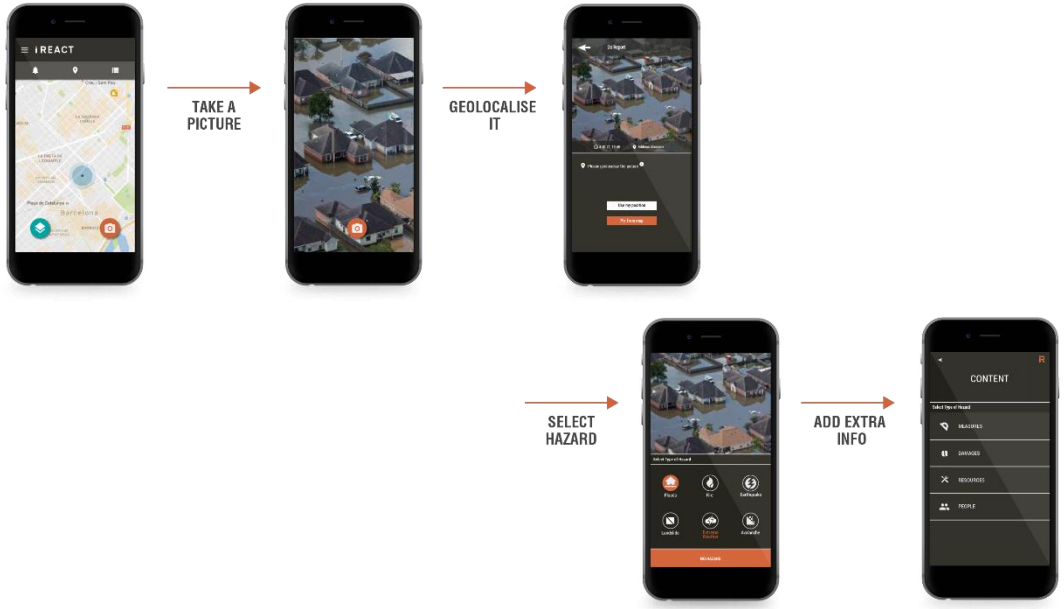
Climate Alpha

Developed in Singapore, Climate Alpha works to provide predictions on the best locations to invest in real estate. They use artificial intelligence to measure socioeconomic, demographic and market indicators and combine that data with information on EWE risks to determine future property values.



iREACT *iReact*

I-React, a company based in Turin, Italy that takes a different approach in monitoring EWEs by combining data from European monitoring systems, earth observations, historical information, weather forecasts, and civic reports collected on a mobile app and social media tool. This aggregation of information ensures a wider collection of information that can then be cross-checked. Individuals are also empowered by the ability to provide first-hand information to policymakers and first responders.

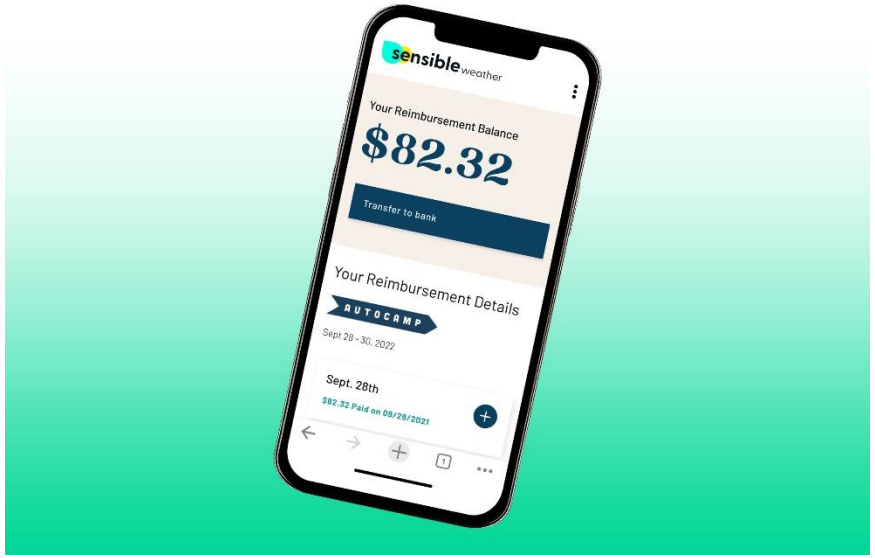


AQUIPOR *Aquipor*

A startup from Washington, United States, Aquipor, has developed porous cement that allows for stormwater to be absorbed into the ground. It is produced in a low emissions manner that makes it not only better climate adapted than concrete, but also less negatively impactful on the environment. FloodMap (Australia), BufferBlock (Holland), StormHarvester (UK), and Flood-Con (USA) are all startups working on mitigating the impacts of floods on the environment through better drainage systems and other initiatives.

Sensible Weather

Based in California, United States, Sensible Weather provides weather insurance for travellers. They monitor the weather conditions for the trip and if rain or another disaster is predicted, they will reimburse the client for their experience. For example, when booking a trip to an amusement park, one can purchase insurance through sensible weather and if the trip is cancelled due to poor weather conditions, the costumer will receive a reimbursement for the cost of the trip. Other similar companies include MeteoTech (France), Wetterheld (Germany), and New Paradigm Underwriters (USA).

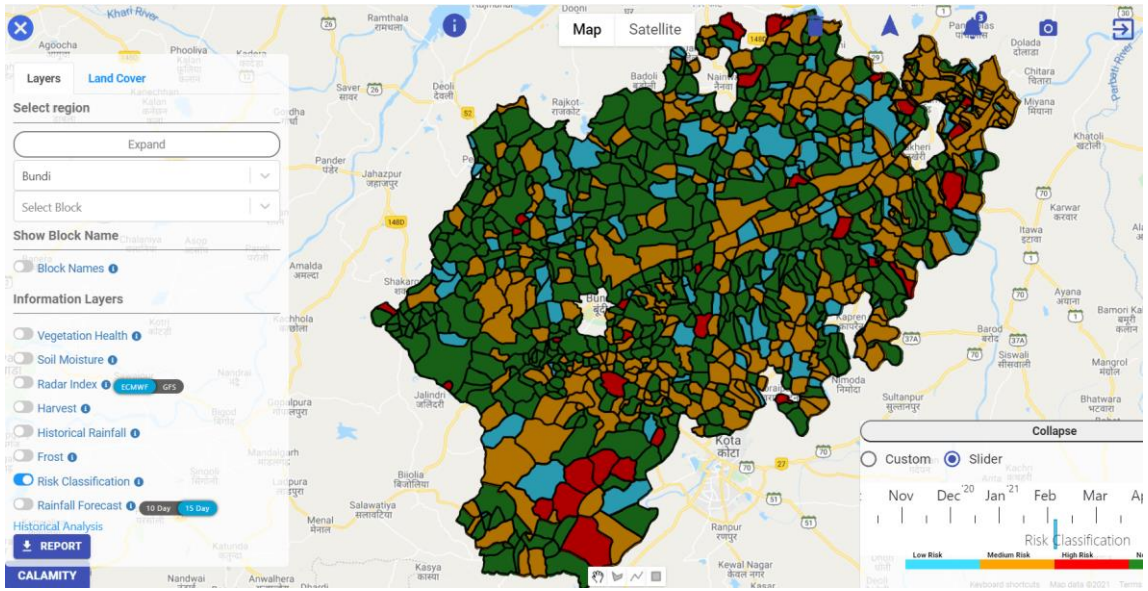


Tenevia

Founded in Grenoble, France and used across France and in two places in Germany, they use surveillance cameras along rivers to monitor flood risk and water movement during active floods. Since the cameras are not submerged in the water nor located on satellites in space, their lenses are less likely to experience interference from murky waters or clouds, making the system even more sound. Many other companies have developed technology to be able to monitor floods, wildfires, and other natural hazards, including Tesello (Portugal), Serinus (Germany), Vandersat (Netherlands).

Agtuall

Founded in The Netherlands, Agtuall helps building resilience to weather volatility. It provides affordable crop price risk management solutions for smallholder farmers across the world by assessing the frequency and intensity of natural calamities and their impacts on crop yields and price.



Ono Exponential Farming

Ono Exponential Farming is a vertical, indoor farming startup that grows herbs, fruits, and vegetables in Milan, Italy. Their products are local and pesticide free. By growing food indoors and under highly monitored conditions, they can regulate the climatic effects on their crops without experiencing the uncertainty and risks often felt in farms that can suffer from over sun-exposure and droughts during heat waves or fertilizer and pesticide runoff and overwatering during heavy precipitation and flooding. Interius Farms (Canada), Harvest London (UK), and Madar Farms (UAE) are similar startups.

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Urban Shift is a project Co-funded by the Erasmus+ Key Action 2 Partnerships For Innovation Alliances For Innovation 2021 Programme of the European Union.