climate-health cluster

Uneven Ground:

Health inequalities in a changing climate

Blue Adapt | CATALYSE | CLIMOS | HIGH HORIZONS | IDAlert Infectious Disease decision-support tools and Alert systems | trigger

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Introduction:

Climate change poses an unprecedented threat to public and veterinary health and disproportionately harms individuals and communities who are already the most vulnerable. The health-related impacts from climate change, including rising temperatures, extreme weather events, deteriorating air quality, and the spread of infectious diseases—are not experienced equally.[1] Beyond these direct effects, climate change also drives wider social and economic impacts that further deepen inequalities. Indirect and delayed consequences—such as population displacement, increased migration pressures, disruptions to essential services, and heightened risks of conflict—tend to affect disadvantaged groups most, exacerbating existing vulnerabilities.[2]

Climate change increasingly jeopardises the performance and resilience of health systems. Health infrastructure is often not designed to withstand extreme heat, floods, or storms. Hospitals in urban heat islands without adequate cooling, or in flood-prone areas, face operational risks, while health personnel may experience heat stress alongside patients. Climate-related events can also trigger power outages, disrupt medical supply chains, and increase hospitalisations during extreme events, placing additional strain on already stretched services. These pressures risk deepening inequalities, as regions with fewer resources are less able to absorb and respond to shocks.

The elderly, pregnant women, children, low-income communities, migrants and people on the move, outdoor workers, and people with chronic illnesses or disabilities, face a double burden: they are more likely to experience adverse health outcomes and may have limited resources to respond to climate-related hazards.[3] There are also spatial inequalities across Europe: differences in resources, infrastructure, and adaptive capacity which influence how communities can prepare for, respond to, and recover from climate-related impacts.[4]

Against this backdrop, the European Climate-Health Cluster brings together six Horizon Europe projects with partners from across the Union and beyond. Together, they generate evidence on how climate impacts interact with social and regional inequalities. Each project also investigates specific climate-health challenges, in particular heat exposure, air pollution, or vector- and water-borne diseases, offering insights to support more equitable actions in facing climate change impacts.

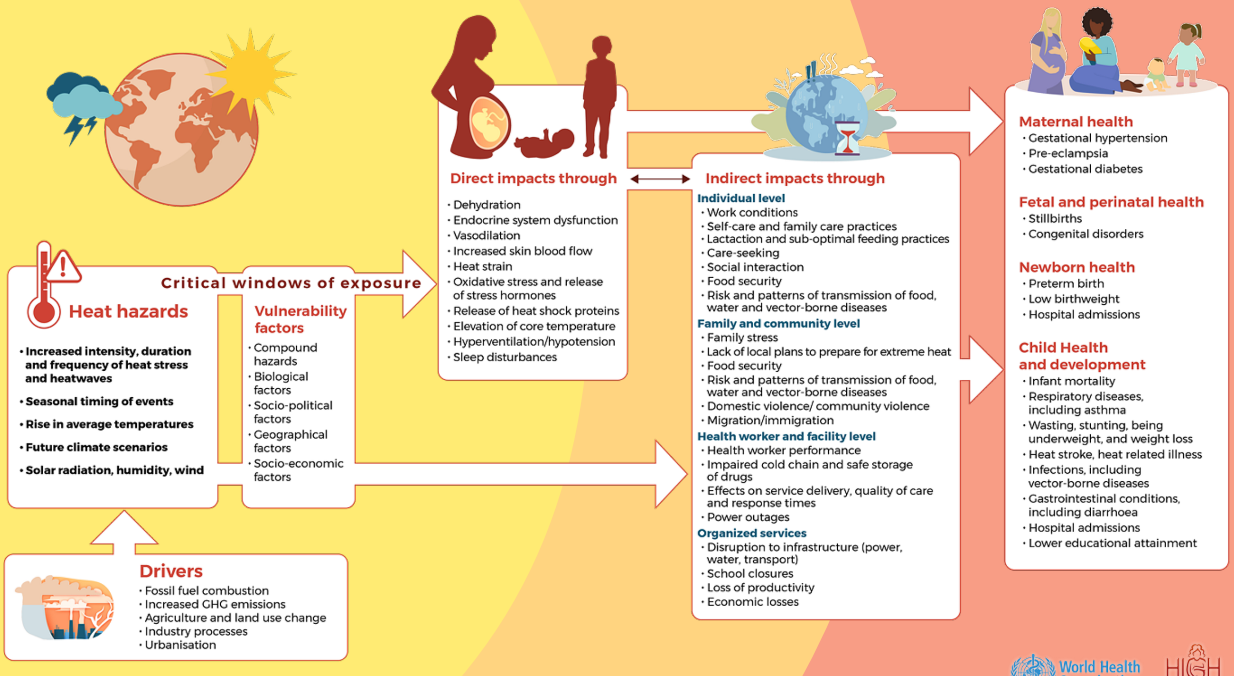
Heat exposure

Heat exposure exacerbates cardiovascular and respiratory conditions and can trigger acute episodes such as heatstroke or dehydration. Evidence from the European Climate and Health cluster projects shows that these impacts are unevenly distributed, influenced by factors such as physiological vulnerability, occupational status, socioeconomic circumstances, and access to protective infrastructure, including cooling systems, housing quality, and healthcare.

Heat exposure:
HIGH Horizons

Key findings: Research by HIGH Horizons shows that exposure to high ambient temperatures during pregnancy is associated with increased risks of preterm birth, stillbirth, congenital anomalies and maternal complications such as hypertensive disorders and gestational diabetes and may also be linked to long-term mental health and other health impacts in people exposed to heat in utero[5]. Women's experiences are also influenced by sociocultural norms, economic disparities, health service access and the built environment, all of which mediate the effects of climate change on health. These factors disproportionately affect the most vulnerable populations in low- and middle-income countries. For example, the impact of heat exposure on preterm birth risk varies by country income level, and the odds increase with 61% in low-income countries compared to 10% in upper–middle-income countries and 11% in high-income countries. These differences in vulnerability to heat exposure, including long-term effects beginning in utero, already contribute to unequal climate impacts and are likely to worsen inequalities in the future.[6] HIGH Horizons conducted multi-country analyses on the relationship between short-term and long-term heat exposure during pregnancy and perinatal health outcomes.[7] Findings from Belgium, Greece, Italy (Lazio Region) and Sweden suggest that the third trimester is the most critical window of vulnerability to heat exposure during pregnancy.[8]

Figure 1. **Conceptual framework**
Extreme heat and maternal, newborn and child health



Source: Conceptual framework – WHO & HIGH Horizons

HIGH Horizons also generated evidence of the impact of heat exposure on health workers, demonstrating that it reduces their well-being, endurance and productivity – especially in settings where heat-resilient infrastructure is lacking. The findings show indoor temperatures, especially in maternity and neonatal wards, frequently exceeded 30°C, sometimes remaining higher than outdoor readings for several hours. In Zimbabwe, 75% of healthcare workers were dehydrated during the hot season, and more than half of their counterparts in South Africa showed similar signs. These adverse health effects consequently affect the quality of care they provide to patients[9]. HIGH Horizons is working with health workers to develop simple, affordable interventions including nature-based, infrastructural and behavioural adaptation measures, to alleviate health workers' heat exposure[10].

Our actions:

> Awareness raising at global and country level about the adverse outcomes of heat exposure on maternal, newborn and child health. Together with the World Health Organization, HIGH Horizons developed a conceptual framework on heat impacts on women and children (above) and regularly convenes Expert Group meetings to select heat health indicators, which will result in a joint UN agencies' guidance, to monitor impacts of heat on maternal, newborn and child health. We also established country dialogues on integration of these indicators at country level in Greece, South Africa and Zimbabwe.

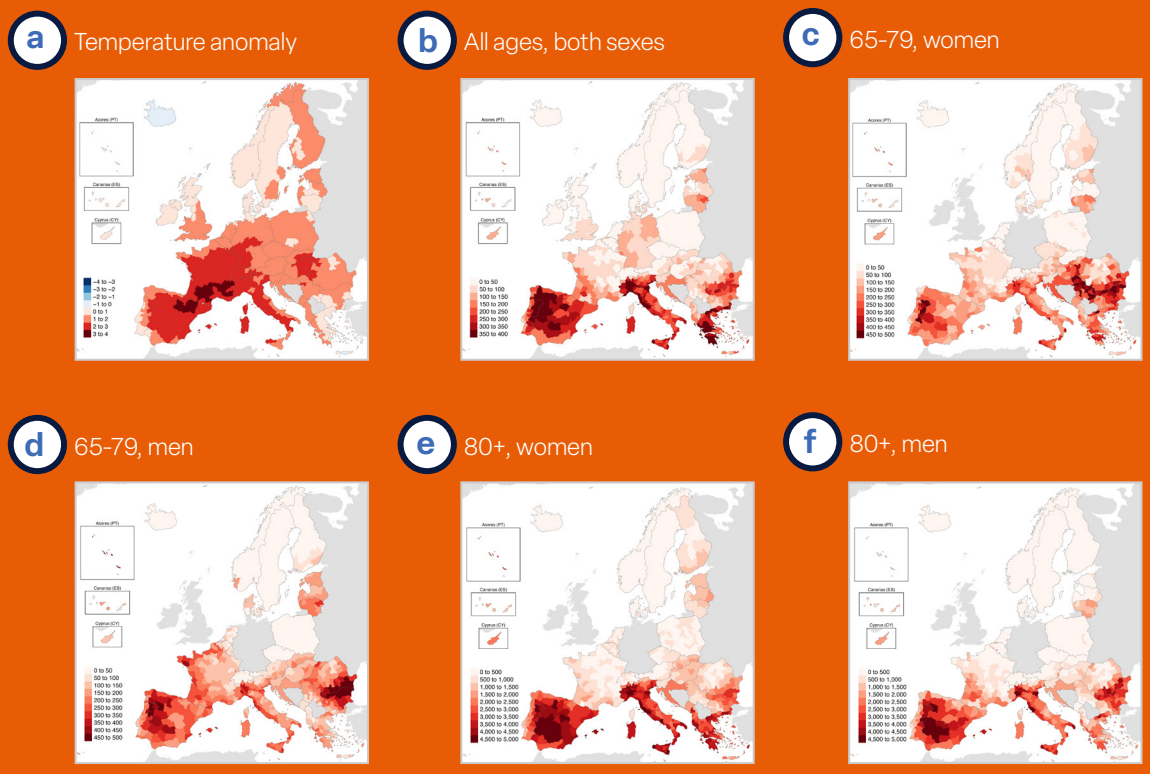
> Promote the integration of low-cost heat adaptation measures into health facilities to reduce indoor temperatures, ensuring safe environments for patients and staff.

Heat exposure:
CATALYSE

Key findings: Catalyse work highlights factors such as age, gender, preexisting cardiovascular and respiratory diseases, social isolation or socioeconomic and occupational status influence individuals' exposure and their ability to cope with extreme heat (Figure 2).[11]

Occupational exposure further amplifies heat-related health risks, particularly in sectors where outdoor, labour-intensive work is common. A scoping review highlights that migrant and ethnic minorities in the agricultural and construction sectors experience severe and persistent heat stress. This is often linked to limited training on heat-related illnesses, low risk perception, and adverse incentives such as piece-rate pay and fear of supervisors. These risks are further exacerbated by barriers to heat-prevention measures and, in some cases, restricted access to healthcare.

Figure 2. Regional temperature anomaly and heat-related mortality rate during the summer of 2022



a, **b–f**, Regional heat-related mortality rate (summer deaths per million) aggregated over the summer for the whole population (**b**), women aged 65–79 years (**c**), men aged 65–79 years (**d**), women aged 80+ years (**e**) and men aged 80+ years (**f**). Summer refers to the 14-week period between 30 May and 4 September 2022 (weeks 22–35). Source:

https://www.nature.com/articles/s41591-023-02419-z#Abs1

Our actions:

> **Early warning systems:** CATALYSE is developing impact-based early warning systems that integrate socio-demographic and sex-disaggregated data with small-area exposure–response modelling and high-resolution weather forecasting. These tools support alerts tailored to vulnerable groups and are being co-designed with meteorological and public health agencies for integration into heat-health action plans. One example is a system currently under adaptation in Catalonia that combines epidemiological models with high-resolution forecasts to deliver locally relevant heat-health warnings.

> **Field studies and local engagement:**[12] CATALYSE conducts field studies to understand local contexts, identify intersecting vulnerabilities and assess how project results can be applied in practice. These field studies enable engagement with NGOs, healthcare workers, labour unions and other stakeholders, helping tailor recommendations to community needs. Field studies were conducted in Spain, Italy and Austria on heat perception and adaptation among migrant farmworkers provided insights on the perception of heat stress, working conditions, current response measures in place, and access to health care. Among the over 700 migrant agricultural workers interviewed, 40% reported experiencing three or more heat-related illnesses (HRI) over the last season, the most common symptoms where headache, dizziness, dehydration and muscle cramps.

Heat exposure - Call to action:

- Prioritise adaptation interventions during heat exposure such as implementing intensive cooling and hydration initiatives, behaviour change awareness campaigns and enhanced surveillance — especially for vulnerable groups such as pregnant women and newborns.
- Develop and enforce sector-specific heat-risk adaptation guidelines, mandatory training and protective measures for outdoor workers, particularly migrant and seasonal workers, but also for indoor workers in hot settings.
- Develop heat-based early warning systems that combine weather forecasts, health data and epidemiological models to predict heat-related risks at small-area level, and expand these to other climate-sensitive conditions.

Air pollution

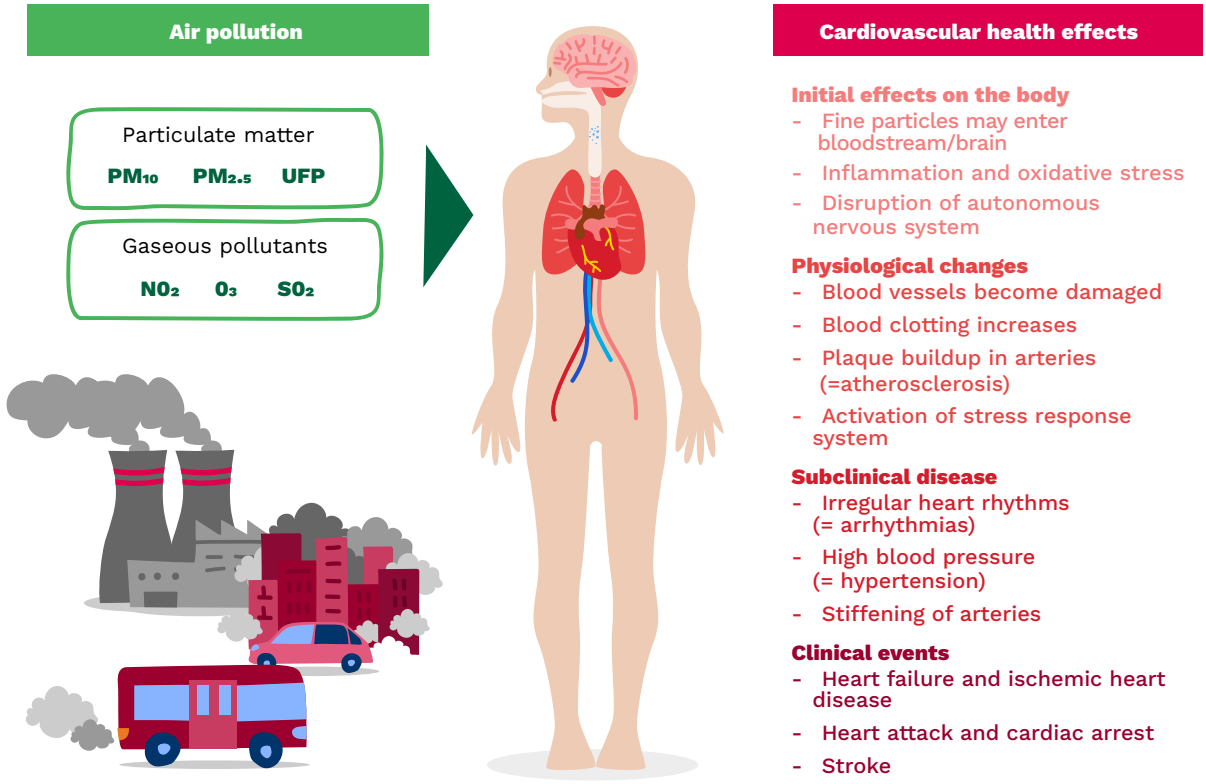
Air pollution and climate change are closely interconnected, as activities that pollute the air often also drive climate change through greenhouse gas emissions. In turn, rising temperatures, changing weather patterns and more frequent wildfires under climate change can increase ground-level ozone and fine particulate matter, both of which worsen pre-existing cardiorespiratory conditions and increase hospital admissions. Evidence from Climate and Health Cluster projects shows that these impacts are unevenly distributed, with higher risks in densely populated areas and in socioeconomically disadvantaged communities where exposure to fossil-fuel–related pollution is greatest.

Air pollution: TRIGGER

Key findings: Through its work, TRIGGER explores how climate change and air pollution affect health and contribute to health inequalities. The project examines cardiovascular, respiratory and mental health impacts, focusing on how environmental stressors interact with socio-economic and demographic vulnerabilities.

TRIGGER highlights that exposure to pollutants such as $PM_{2.5}$, NO_2 and ozone, especially when combined with temperature extremes, can aggravate cardiovascular and respiratory conditions. Children, older people, women, pregnant women, outdoor workers, people with disabilities, people with pre-existing cardiorespiratory conditions and people with lower socioeconomic status are identified as particularly affected (Figure 3).

Figure 3. How air pollution affects cardiovascular health (based on Bonet er al., 2022)[11]



The project also explores how air pollution, prolonged heat, extreme weather and degraded environments influence mental health. These pressures can heighten anxiety, stress and other mental health problems, especially among young people, older adults, people with disabilities and those living in poverty, who may have fewer coping resources and face higher exposure to environmental hazards.[14]

TRIGGER uncovers key gaps in climate-related EU policies, noting limited attention to mental health and insufficient consideration of how social determinants—such as income, employment, education and access to healthcare—shape vulnerability to climate-related hazards. It highlights inadequate identification of vulnerable groups, constraining the design of equitable policies.[15]

Our actions:

- **Deployment of the Climate-Health Connection (CHC) Labs** in European cities (Augsburg, Bologna, Geneva, Heraklion, Oulu) to integrate environmental and clinical data, engage citizens and co-create tools to protect vulnerable groups.
- **Planned exploitable products** include low-cost wearable sensors and devices for vulnerable workers, early notification systems and training materials for the health sector, consulting services for key institutional stakeholders in climate-health adaptation, a holistic workshop approach to support mental health and resilience in the face of climate and social crisis and the TRIGGER dashboard, which delivers climate-health information and educational material. The dashboard will include a tool to identify workers, sectors, and regions most at risk of heat-related productivity loss.

Air pollution - Call to action:

- Enforce stricter EU-wide air quality regulations by aligning limits for key pollutants (e.g., $PM_{2.5}$, NO_2, ozone) with WHO guidelines. Establish an EU-wide Inequalities Register to monitor regional disparities in pollution-related diseases and support equitable access to mental-health and psychosocial-support services (MHPSS).
- Ensure health equity in the design and implementation of interventions that deliver co-benefits for air quality, public health and climate change mitigation, including the promotion of clean energy, energy-efficient buildings, urban greening, and sustainable transport and diets.
- Prioritise investments in low-income and high-pollution urban areas and actively involve socio-economically disadvantaged groups through community-based projects.

Vector-borne and Water-borne Threats

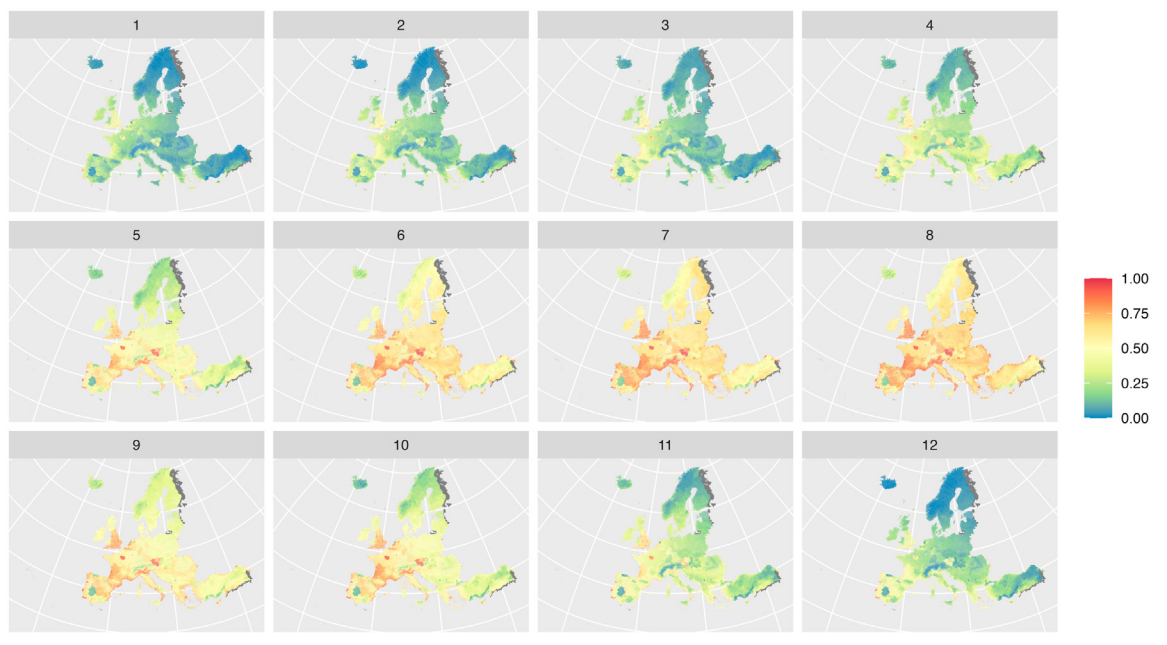
The emergence, transmission, and geographic expansion of infectious diseases are shaped by global environmental changes including shifting climate conditions, land-use transformation, populations on the move, and broader socio-political factors.[16] Infectious diseases already account for roughly one-third of global morbidity and mortality, and nearly two-thirds of deaths in children under five. Around 80% of human pathogens are environmentally mediated, including vector-borne, water borne, and zoonotic diseases, many of which are highly sensitive to changes in temperature, precipitation, and humidity. Climate change is altering the distribution, seasonality and intensity of these diseases, from mosquito and sand fly-borne diseases and waterborne diarrhoeal illnesses to respiratory infections influenced by humidity and temperature. These shifts pose growing challenges for public health systems and disproportionately increase risks for populations already facing social and environmental disadvantage.[17]

Vector-borne Diseases

IDAlert

Key findings: Evidence from IDAlert shows that climate change is accelerating the spread of climate-sensitive vector-borne diseases. It is shifting their geographic range and increasing the likelihood of outbreaks across Europe. Climate suitability for various climate-sensitive disease pathogens and vectors (including Vibrio, West Nile virus, dengue, chikungunya, Zika, malaria, leishmaniasis, ticks that spread Lyme disease, and other tick-borne diseases) is increasing in Europe, and population groups may be affected differently.IDAlert findings have further established that mosquito vectors, such as Aedes albopictus (Tiger mosquito), that cause infectious diseases such as dengue and chikungunya, are expanding northwards in Europe at a rate of around 60 km per year, whilst these infectious diseases are expanding northwards at 120 km per year, putting an additional 5 million people at risk each year.

Figure 4. Estimated probabilities of at least one mosquito bite report being sent from each GADM-4 unit by month during 2022



Southern Europe tends to be more affected by mosquito-borne diseases and leishmaniasis, whereas northern Europe is equally or more affected by Vibrio and ticks. More generally, negative climate-related impacts of infectious diseases are not equally distributed within Europe (or across the globe), which in part highlights socio-economic inequalities and marginalisation of at-risk groups.[18]

Countries with higher health expenditure are associated with a higher chance of detecting and reporting cases of chikungunya and dengue; while the data also suggest there is under reporting and identification of arbovirus cases in countries with lower health expenditure.

IDAlert is also examining how exposure varies across occupational groups, with particular attention paid to workers who spend more time outdoors and therefore may be at higher risk of contact with vectors.

Our actions:

- **Led the health risk assessment for EUCRA-1:** IDAlert researchers led the risk assessment for the first European Climate Risk Assessment (EUCRA). In the Storyline chapter on infectious diseases, we identified strengthening the capacity of vector surveillance systems and pathogen identification as the key actions needed to address the climate change induced expansion of vector and water-borne pathogens in Europe.

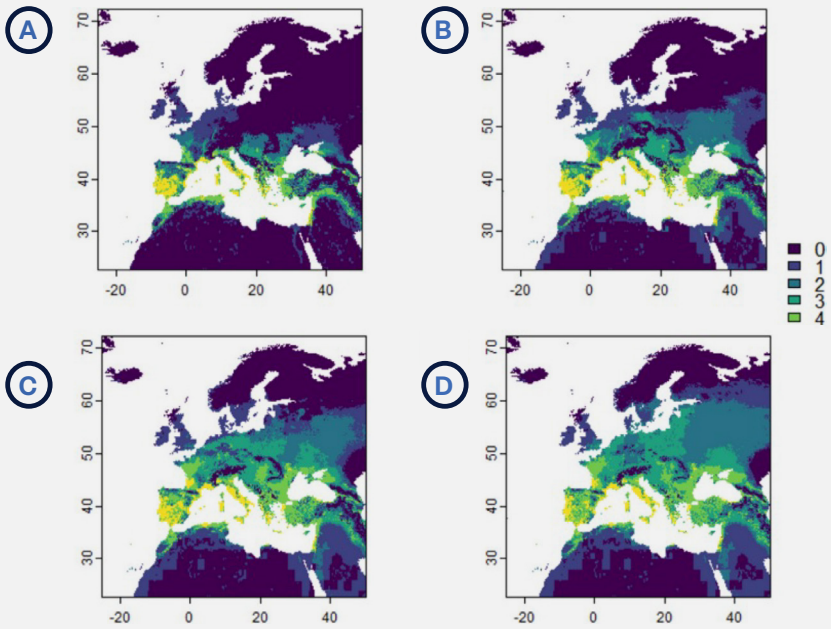
- **Mosquito Alert:** IDAlert collaborates with Mosquito Alert, a data collection app, to analyse how social factors such as poverty, inequality and occupational exposure, influence patterns of mosquito presence and human–vector contact, supporting more equitable prevention strategies.

- **Improving data for fair decision-making:** IDAlert works on harmonising multisource data to inform vector-borne disease risk management, helping to ensure that climate, environmental, and social data are combined in ways that support equitable policy and public-health responses.

Sand Fly-borne Diseases:
CLIMOS

Key findings: CLIMOS research shows that sand fly-borne disease risks intersect with socio-economic vulnerability. Evidence from the project indicates that Leishmaniasis is strongly associated with poverty, inadequate housing, and limited access to healthcare, leading to higher exposure and delayed detection among disadvantaged groups[19]. Modelling developed within CLIMOS also shows that climatic suitability for sand fly vectors is expanding unevenly across Europe. Regions such as southwest Iberia, the south and southwest coasts of France, coastal regions in Italy and in the Balkans, and west and central Turkey (see Figure 5) are projected to become increasingly favourable for vector establishment, with implications for areas that have weaker surveillance infrastructure and diagnostic capacity.[20]

Figure 5. Understanding and predicting the geographic distributions of phlebotomine sand flies in and around Europe



Suitable habitats, now (A) and in the future under SSP3-7.0 (2040 (B), 2070 (C), 2100 (D)), associated with vector species richness for those sand flies that can transmit L. infantum.

Source: https://link.springer.com/article/10.1007/s10584-025-04009-z/figures/5

Our actions:

- **Scenarios report** with documentation, executive summaries and infographics - mentioning vulnerable groups.
- Vector Surveillance and **Trapping sites:** Piloting harmonized sand fly-borne disease surveillance and integrated climate–health data sets across 13 European and Mediterranean countries, including vulnerable communities.
- **Co-creation with health ministries:** Co-coordinating actions with three national health ministries, to produce effective recommendations and assist better health systems preparedness for the emergence of sand fly borne diseases that still overwhelmingly burden otherwise vulnerable populations and communities.
- **Protection guidelines:** Explanatory guidelines for general public and the vulnerable groups, on how to identify a sand fly and what actions to take to protect yourself and others, including the animals in your surroundings.

Cross-project collaboration: leishmaniasis

A modelling study conducted in cooperation between IDAlert and CLIMOS shows that leishmaniasis infections are more prevalent in poorer communities and socially disadvantaged groups, where malnutrition, inadequate housing, and limited access to health services increase exposure and worsen outcomes. These conditions heighten susceptibility and reduce people's capacity to cope with health threats. As a result, vulnerable populations face disproportionate risks as climatic suitability for disease transmission expands.

Vector-borne Diseases

BlueAdapt

Key findings: BlueAdapt research has taken a systemic approach to analyse how climate change, pollution, and social context interact to amplify health risks related to coastal pathogens. In this context, BlueAdapt has constructed a One Health conceptual framework, which identifies pathways through which these pressures increase health inequalities, moving beyond isolated risk factors to consider their combined and reinforcing effects. Building on this approach, health is defined as an emergent property of socio-ecological systems, where environmental pressures interact with social and economic inequalities, generating context-specific risk cascades.[21] In the project's context, focused on infectious diseases, vulnerability is analysed in terms of susceptibility, the predisposition to develop disease after pathogen exposure, and is shaped by factors such as socio-economic status, access to public services, infrastructure, and host characteristics (demographics, physiology). Applications of this framework provide insight into Vibrio (a coastal bacterial pathogen) infection dynamics, showing that exposure and host susceptibility depend on social and structural factors, highlighting how inequalities lead to unequal health outcomes.[22]

Within the Baltic Proper coast, BlueAdapt is testing how different risk-information formats about coastal pathogens influence bathing-site choices and willingness to pay for safer water, explicitly accounting for vulnerability indicators (income, self-reported health status and age).

Our actions:

> **BlueAdapt One Health conceptual framework.** This framework takes a systemic approach to analyse how climate change, pollution, and social context interact to amplify health risks related to coastal pathogens. Importantly, it identifies pathways through which these pressures increase health inequalities, moving beyond isolated risk factors to consider their combined and reinforcing effects.

> Equity-sensitive valuation and distributional analysis to inform cost–benefit assessment of coastal pathogen monitoring and warning options, explicitly comparing impacts across income, age and health-status groups.

Vector-borne and water-borne threats - Call to action:

- Integrate citizen-science tools such as MosquitoAlert and traditional vector and diseases surveillance with socioeconomic data to analyse how poverty, inequality, and occupational exposure shape vector presence and human–vector contact, thereby supporting more equitable prevention strategies.
- Design community-engagement strategies that account for geography, socio-economic status, education levels and gender to strengthen surveillance and vector-control practices in underserved populations.
- Strengthen surveillance and diagnostic systems in regions projected to become newly suitable for sand-fly establishment, particularly those with weaker health-system capacity.
- Target prevention and control measures toward vulnerable populations who face higher exposure to sand-fly-borne diseases because of poor housing conditions and limited access to healthcare.

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Recommendations

1. Strengthen the systematic identification and monitoring of climate-related health inequalities, focusing on vulnerable groups, which are often underrepresented in research, through disaggregated data (for example, by social and economic conditions, age, gender, disability, and geographic exposure) to ensure health equity and climate justice in the design of climate adaptation and mitigation measures. Targeted and sustained funding should support data collection, longitudinal analysis, and evidence-based actions to assess how impacts vary across social groups and target interventions to reduce inequalities.

2. Ensure that climate-related EU policies promote social interventions to empower local governments and communities to protect health against climate-related hazards. To address health disparities, it is crucial to identify vulnerable groups and tailor interventions to their needs, recognising social determinants of health such as income, employment, housing, and education.

3. Integrate Health Impact Assessments systematically into EU policy-evaluation processes, ensuring that, beyond physical health indicators, they also include social and mental-health metrics.

4. Strengthen early-warning systems, prevention plans, and long-term adaptation strategies, to better protect vulnerable populations from health risks related to heat exposure, infectious diseases, air pollution, and their interconnected impacts.

5. Promote the integration of multidimensional decision support tools that combine climate, environmental, animal-health and human-health data to enhance preparedness for outbreaks and other climate-linked health threats.

6. Strengthen advocacy among policymakers, stakeholders, media, and affected communities to drive climate action that accelerates mitigation and adaptation, protects human health and wellbeing, and actively reduces social and health inequalities.

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