



Impacts, Adaptation and Vulnerability

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[Renan / Unsplash]



Climate Change 2022 Impacts, Adaptation and Vulnerability



The science is clear.

Any further delay in concerted global action will miss a brief and rapidly closing window to secure a liveable future.

This report offers solutions to the world.



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New understanding of interconnections



Climate change combines with unsustainable use of natural resources, habitat destruction, growing urbanization and inequity.

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The risk propeller shows that risk emerges from the overlap of:







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3.3 – 3.6 billion people live in hotspots of high vulnerability to climate change.

Overlapping challenges

- Limited access to water, sanitation and health services
- Climate-sensitive livelihoods
- High levels of poverty
- Weak leadership
- Lack of funding
- Lack of accountability and trust in government

[Denis Onyodi / KRCS CC BY-NC 2.0; Marco Dormino UN Photo CC BY-NC-ND 2.0; Markus Krisetya / Unsplash]

Simultaneous extreme events compound risks

Multiple extreme events that compound the risks are more difficult to manage



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Nature's crucial services at risk in a warming world



Pollination



Coastal protection



Tourism / recreation



Food source



Health



Water filtration



Clean air



Climate regulation

[Ocean Image Bank/ Shaun Wolfe, Dimitris Poursanidis; FAO/Kurt Arrigo, Unsplash, Axel Fassio/CIFOR CC BY-NC-ND

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Global and regional risks for increasing levels of global warming



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Future global climate risks



Heat stress

Exposure to heat waves will continue to increase with additional warming.

Water scarcity

At 2°C, regions relying on snowmelt could experience 20% decline in water availability for agriculture after 2050.



Food security

Climate change will increasingly undermine food security.



Flood risk

About a billion people in low-lying cities by the sea and on Small Islands at risk from sea level rise by midcentury.



Action on adaptation has increased but progress is uneven and we are not adapting fast enough.





Water management

Options on farms:

- Irrigation
- Rainwater storage, water-saving tech
- Moisture conservation in soils

Economic and ecological benefits; reduced vulnerability

Wider options:

- Securing drinking water
- Flood and drought risk management
- Working with nature, land-use planning

Effectiveness declines with increased warming

[Adam Öjdahl / IWMI CC BY-NC 2.0; Artem Beliaikin / Unsplash; rodjonesphotography.co.uk CC BY 2.0]

Improving food security

Effective options:

- Cultivar improvements
- Agroforestry
- Farm and landscape diversification
- Community-based adaptation
- Strengthening biodiversity

Wider benefits:

- Food security and nutrition
- Health and well-being
- Livelihoods



SUSTAINABLE DEVELOPMENT GOALS



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Transforming cities

By 2050 urban areas could be home to twothirds of the world's population.

Effective options

- Nature-based and engineering approaches together
- Establishing green and blue spaces
- Urban agriculture
- Social-safety nets for disaster management

Wider benefits

- Public health improvements
- Ecosystem conservation



[Chuttersnap, Jordan Brierley / Unsplash; SDOT Photos CC BY-NC 2.0]

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Maladaptation

Adaptation that results in unintended consequences



The most disadvantaged groups are most affected by maladaptation.

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There are limits to adaptation

- Even effective adaptation cannot prevent all losses and damages
- Above 1.5°C some natural solutions may no longer work.
- Above 1.5°C, lack of fresh water could mean that people living on small islands and those dependent on glaciers and snowmelt can no longer adapt.
- By 2°C it will be challenging to farm multiple staple crops in many current growing areas.

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Climate Resilient Development.

- Reduced climate risks adaptation
- Reduced greenhouse gas emissions mitigation
- Enhanced biodiversity
- Achieved the Sustainable Development Goals



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Climate Resilient Development: The Solutions Framework

- Is considered across government and all of civil society
- Involves everyone forming partnerships
- Draws on wide-ranging knowledge (scientific, Indigenous, local, practical)

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- Conserves and restores ecosystems
- Involves marginalized groups
- Prioritises equity and justice
- Reconciles different interests, values and world views
- Requires scaled-up investment and international cooperation



Climate resilient development is already challenging at current global warming levels.

The prospects will become further limited if warming exceeds 1.5°C and may not be possible if warming exceeds 2°C.





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Impacts, Adaptation and Vulnerability

The AR6 Climate impact, risk and adaptation assessment for Europe

Prof Daniela Schmidt Coordinating Lead Author WGII Chapter 13 Europe University of Bristol and Cabot Institute

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Climate impacts drivers and socio-ecological vulnerabilities





Our current 1.1°C warmer world is already affecting natural and human systems in Europe

As impacts vary both across and within European regions, sectors, and societal groups, inequalities have deepened.

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 The number of deaths and people at risk of heat stress will increase twoto threefold at 3°C compared with 1.5°C GWL

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- Warming will decrease suitable habitat space for current terrestrial and marine ecosystems and irreversibly change their composition, increasing in severity above 2°C GWL
- Due to a combination of heat and drought, substantive agricultural production losses are projected for most European areas over the 21st century, which will not be offset by gains in Northern Europe

[AR6-WGII, Figure 13.28]

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 Risk of water scarcity will become high at 1.5°C and very high at 3°C GWL in Southern Europe and increase from moderate to high in Western Central Europe.

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 Due to warming, changes in precipitation and sea level rise (SLR), risks to people and infrastructures from coastal, riverine and pluvial flooding will increase in Europe.

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Projected heat stress risks for people in Europe (2040–2060)









Heat stress risk for people under different warming and population increase

Risk will become severe more rapidly in Southern and Western Central Europe and urban areas

Thermal comfort hours during summer will decrease significantly, by as much as 74% in Southern Europe at 3°C GWL.

> 3°C GWL, limits to the adaptation of people and existing health systems, particularly in Southern Europe, Eastern Europe INTERGOVERNMENTAL PANEL ON Climate chanee WMO

BE & adaptation pathways: Risks to human health from heat



Global warming level

Low

i. Heat proof land development takes time to become effective (....) and is bundled with other measures to achieve high adaptation as warming increases (•••).

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- ii. Air conditioning alone is not enough and is combined with behaviour changes and/or building interventions (**) and
- iii. For high warming heat proof land development might still be needed (...).
- iv. Building interventions have low to medium effectiveness and need to be combined with other measures at higher warming (...).

(c) Pathway to achieve high adaptation to heat stresss, mortality and morbidity in Southern Europe

Medium

Hiah

- i. Measures are to be implemented and combined earlier in Southern Europe due to higher risk (••).
- ii. There is less that can be achieved with behaviour change because there is already extensive culture of heat in Southern Europe
- iii. Building interventions are crucial to be combined with other measures earlier since they have low to medium effectiveness (**).
- iv. Heat proof land development is needed for high warming levels (•••).

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Impacts and risk for terrestrial ecosystems

Fire-prone areas are projected to expand across Europe, threatening biodiversity and carbon sinks.

> Confidence level: Observations

Confidence level: Projections Low

Low

Medium H

High

Medium

Major terrestrial ecosystem impacts and risks Observed and projected for two different warming levels: 1.5°C and 3.0°C

of		act / Risk from Interacting	on / to Affected systems		Di	rection of	change by	regions	
Effect	Climatic hazards	non-climatic hazards	and processes		Europe	SEU	WCE	EEU	NEU
Reduction in	Warming, Land-use change,	Rare, cold-adapted,	Observed				•	٠	
habitat availability of cold-adapted	heatwaves, drought	habitat fragmentation	endemic species, low dispersal capacity groups	Proj. +1.5°C				•	•
groups	arought			Proj. +3.0°C				•	•
Reduction in	Warming,	Land-use change,	species, endemic species,	e Observed				•	•
biodiversity of cold-adapted	heatwaves, drought	habitat fragmentation		Proj. +1.5°C				•	•
groups	diougni			Proj. +3.0°C				•	•
Range shifts	Warming,	Land-use change,	Northward shifts and altitudinal movements of species and populations.	Observed				•	•
	change in precipitation	habitat fragmentation		Proj. +1.5°C				•	•
	precipitation	precipitation species and populations	species and populations.	Proj. +3.0°C				•	•
Changes	Warming		Species and populations	Observed					
in phenology				Proj. +1.5°C					
				Proj. +3.0°C					
Decrease in	Warming,	Land-use change	Ecosystem productivity, and nutrient and carbon cycling	Observed	•	٠	•	٠	•
ecosystem production	heatwaves, drought			Proj. +1.5°C	•		•	•	•
production	alought			Proj. +3.0°C	•		•	•	•
Rising	Warming,	Land-use change,	Ecosystems	Observed	•	٠	•		•
incidence of fire	heatwaves, drought	management		Proj. +1.5°C					
	alought			Proj. +3.0°C					
Reduced	Warming,	Land-use change,	Pollination and crop yields	Observed	٠	٠	٠	•	٠
pollination services	heatwaves, drought	management		Proj. +1.5°C	•	•	•	•	•
	arought			Proj. +3.0°C	•	•	•	•	•
Increased	Warming,	Land-use change,	Soil erosion	Observed	٠	•	٠	•	٠
soil erosion	heatwaves, drought,	management		Proj. +1.5°C	•	•		na	
	precipitation			Proj. +3.0°C	•	•		na	

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Impacts and risk for terrestrial ecosystems



i. Northern Europe (NEU) ii. Eastern Europe (EEU) iii. Western and Central Europe (WCE) iv. Southern Europe (SEU)

iv.

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Coverage of Marine Protected Area (MPA)

Protection needs coordination and stewardship

Current protection status of Marine Protected Areas (MPA) across European seas Together, the three marine sub-regions encompass an approximate total 11 million km²



Adaptation actions habitat restoration protection, fire and forest management agroecology increase the resilience of ecosystems and their services.

Trade-offs between adaptation and mitigation options will result in risks for the integrity and function of ecosystems. Working Group II – Impacts, Adaptation and Vulnerability

Projected yield changes with climate change, altered crop management and associated water demand Yield changes for current Yield increase with Irrigated yield increases Water demand for production systems from new varieties crop irrigation Wheat (winter Relative yield change (%) Irrigation water use (km3 ha -100 % -50 % 50 % 100 %

Yield losses for maize up to 50% at 3°C GWL, especially in SEU. Yields of some crops (e.g., wheat) may increase in NEU > 2°C. Irrigation is an effective adaptation option for agriculture Ability to adapt using irrigation will be increasingly limited by water availability, especially $> 3^{\circ}C$

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Feasibility of adaptation options for key sectors

Effectiveness and feasibility of adaptation options						Feasibility							
for food system to climate impacts and risk in Europe								D	Con	fidence			
Impact type	Adaptation option	Effectiveness	- Economic	- Technological	 Institutional 	- Socio-cultural	- Ecological	- Geophysical	Evidence	- Agreement			
	Irrigation					•	•	•					
Heat stress	Change of sowing/harvest date				na								
	Change of cultivars	•			na								
	Irrigation						•	•					
Drought	Change of sowing/harvest date				na								
broagin	Change of cultivars	•			na								
	Soil management								•				
	Change of sowing/harvest date	•	•		na			•	•				
	Plant and livestock breeding, including GMO			•	•								
Flooding	Mixed use - agroecology and agroforestry				•	•							
Compound and extreme weather	Agricultural policy changes								•				
	Training and information	•		na					•				
	Crop selection changes				na	•	•	•	•	•			
	Land cover change, including agricultural land abandonment	•				•	•	•	•	•			
Disease pathogen and vectors	Plant and livestock breeding, including GMO	na	na	•	•	•	na	na	•	na			
	Management, including high frequency rotations	na	na	na	na	na	na	na	•	na			
Combined impacts on productivity	International trade changes				•		•		•				
Combined impacts on productivity	Consumer shifts in consumption	na		na	na	٠	na	na	•				

irrigation, vegetation cover, changes in farming practices, crop and animal species, and shifting planting (KR2: agriculture);

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Key Risk Sea level rise

Risk and national adaptation planning to sea level rise in Europe

(a) Amount of sea level rise used in national level planning per country and population at risk by amount of sea level rise per country



SLR poses risks to people and infrastructures from coastal, riverine and pluvial flooding will increase in Europe

inundation and extreme flooding will increase

- 3°C GWL, damage costs and people affected by precipitation and river flooding may double
- Coastal flood damage is projected to increase at least tenfold by the end of the 21st century, and even more or earlier with current adaptation and mitigation
- SLR an existential threat for coastal communities and their cultural heritage, particularly beyond 2100

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Low Medium High

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Confidence

Feasibility

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Effectiveness and feasibility of main adaptation options to climate impacts and risk for cities, settlements and key infrastructure in Europe

Impact type	Adaptation option	Effectiveness	- Econom	- Technol	- Institutio	- Socio-ci	- Ecologic	- Geophy	- Evidenc	- Agreem
	Interventions in the building shell	•	•	•	•	•	na	•	•	•
	Ventilation (natural/mechanical, including night)					•	na	•		
	Air conditioning		•	na	na	•	na	•		
Reduction of thermal comfort due to increasing temperatures	Shading	•	•		•	•	na	•	•	•
and extreme heat	Green roofs, green walls	•			•	•			•	•
	Urban green spaces	•	•		•				•	
	Use of 'cool' paints and coatings	•		•	•	•	na		•	•
	Escape to nearby non-urban destinations	na	na	na	na	•	na	na	•	
	Improvements in cooling systems		•			na	na	•		0
	Shifting production to less water-intensive plants	•	•		•	na	na	na	•	
Loss of critical services	Regulatory measures	•	•	na	•	na	na	na	•	
due to heatwaves and drought	Management measures					na	•		•	•
and drought	Use of heat-resilient materials	•		•	•	•	na	na	•	
	Replace vulnerable infrastructure with resilient one	•	ŏ	na	na	na	na	na	•	

>2°C GWL widespread impacts on infrastructure and businesses

- increased risks for energy supply
- transport infrastructure,
- increases in air conditioning needs
- high water demand

European cities are hotspots for multiple risks of increasing temperatures and extreme heat, floods and droughts

na = no/limited evidence

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Climate risks from outside Europe are emerging due to a combination of the position of European countries in the global supply chain and shared

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There is emerging evidence that climate risks in Europe may also impact financial markets, food production and marine resources beyond Europe.

Climate resilient development

Adaptation is happening across Europe, but not at the scale, depth and speed to avoid the risks

Existing and planned adaptation measures not sufficient to avoid residual risk, $> 1.5^{\circ}C$ GWL

Residual risk: losses of habitat and ecosystem services, heat related deaths, crop failures, water rationing during droughts and loss of land

At > $3^{\circ}C$ GWL, a combination of many, maybe even all, adaptation options are needed,

Windows of opportunity to accelerate climate-resilient development (CRD) e.g., budget cycles, policy reforms and evaluations, infrastructure investment cycles; extreme events, COVID-19 recovery programmes.

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Ecosystems

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[Axel Fassio/CIFOR_Flickr_CC BY-NC-ND / Unsplash]

Observed Impacts (selected findings)

- It is very likely that many observed changes in ranges, phenology, physiology and morphology of terrestrial and freshwater species can be attributed to regional and global climate changes, particularly increases in frequency and severity of extreme events (very high confidence)
- Approximately half of species assessed globally have shifted their ranges to higher latitudes or elevations.
- Biome shifts and structural changes within ecosystems have been detected at an increasing number of locations.
- Global extinctions or near-extinctions have been linked to regional climate change in 3
 documented cases
- Climate-caused local population extinctions have been detected in 47% of 976 species examined and associated with increases in hottest yearly temperatures.

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Shifts in distribution of plant functional types

caused by climate change or combination of land use & climate change



Plant functional type changes

- Forest cover change
- ▲ Forest cover gain
- A Herbaceous cover gain
- ▲ Shrub / woodland cover gain
- ▼ Forest / woodland decline
- ▼ Herbaceous cover loss

Terrestrial biomes

- Tropical broadleaf forests Tropical coniferous forests Temperate broadleaf forests Temperate conifer forests Boreal forests
- Tropical grasslands / savannas / shrublands
- Temperate grasslands / savannas / shrublands Flooded grasslands Montane grasslands Tundra Mediterranean type ecosystems Deserts & xeric shrublands

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Biodiversity loss at different warming levels



Loss of biodiversity

0-25%	>25-50%	>50-75%	>75-100%

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Risks to ecosystems



Adaptation for ecosystems

• The resilience of biodiversity and ecosystem services can be increased by adaptation including ecosystem **protection and restoration** (*high confidence*)

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- There is new evidence that species can persist in **refugia** where conditions are locally cooler, when they are declining elsewhere (*high confidence*)
- Ecosystem restoration and resilience building cannot prevent all impacts of climate change, and **adaptation planning needs to manage inevitable changes** to species distributions, ecosystem structure and processes (*very high confidence*).
- Many adaptation plans and strategies have been developed but there is limited evidence of the extent to which adaptation is taking place and virtually no **evaluation** of the effectiveness of adaptation measures.

(A)

Ecosystem-based Adaptation (EbA) and Naturebased Solutions (NbS)

- EbA can deliver climate change adaptation for people with multiple additional benefits, including for biodiversity (*high confidence*).
- Examples of feasible and effective EbA include **natural flood management** on coast and rivers, **urban cooling**, **reducing wildfire risk**.
- To realise potential benefits and avoid harm, it is essential that EbA is deployed in the right places and with the right approaches for that area, with inclusive governance (*high confidence*).
- EbA and other NbS are vulnerable to climate change. They may need to adapt if they are to remain effective and will increasingly be under threat at higher warming levels.
- There are risks of maladaptation and environmental damage from some approaches to land-based mitigation. Documented examples of adverse impacts of, include afforestation of grasslands, savannas and peatlands and risks from bioenergy crops.
- The term NbS is highly controversial in some countries

Safeguarding biodiversity and ecosystems is fundamental to climate resilient development

SPM.D.4 Safeguarding biodiversity and ecosystems is fundamental to climate resilient development, in light of the threats climate change poses to them and their roles in adaptation and mitigation (*very high confidence*). Recent analyses, drawing on a range of lines of evidence, suggest that maintaining the resilience of biodiversity and ecosystem services at a global scale depends on effective and equitable conservation of approximately 30% to 50% of Earth's land, freshwater and ocean areas, including currently near-natural ecosystems (*high confidence*). {2.4, 2.5, 2.6, 3.4, Box 3.4, 3.5, 3.6, 12.5, 13.3, 13.4, 13.5, 13.10, CCB NATURAL, CCB INDIG}



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