

SuPeRBE Training Material

Macro Area of Expertise:

1 Climate change and built environment

Area of Expertise:

1.1 Fundamentals of climate change

Level of competence: 3

Sustainability

It is a trend since the '90s

*“Sustainable development should: meet the **needs of the present generation**, without **compromising the ability of future generations to meet their own needs.**”*

Brundtland Report



Resilience

Less concrete and more recent concept

*“The **ability** of a system, community or society exposed to hazards to **resist, absorb, accommodate, adapt to, transform and recover** from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.”*

United Nations Office for
Disaster Risk Reduction



Climate change

*“Climate change is the term used to **describe changes in the state of the climate** that can be identified by changes in the average and/or the variability of its properties and that persists for an extended period, typically decades or longer.”*

World Meteorological Organization

Greenhouse gases emissions

“Greenhouse gases constitute a group of gases contributing to global warming and climate change. The Kyoto Protocol, an environmental agreement adopted by many of the parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997 to curb global warming, nowadays covers seven greenhouse gases. Converting them to carbon dioxide (or CO₂) equivalents makes it possible to compare them and to determine their individual and total contributions to global warming.”

European Union

Buildings

Buildings must not only consume less, they must also endure more.

In the face of rising temperatures, floods, and energy crises, our built environment must evolve into a force for resilience.

This means designing and renovating spaces that are energy-efficient, climate-proof, and accessible to all - creating not just sustainable structures, but inclusive, beautiful, and future-ready places to live."



Background

The UN's Intergovernmental Panel on Climate Change (IPCC) has published the sixth assessment report (AR6) in August 2021.

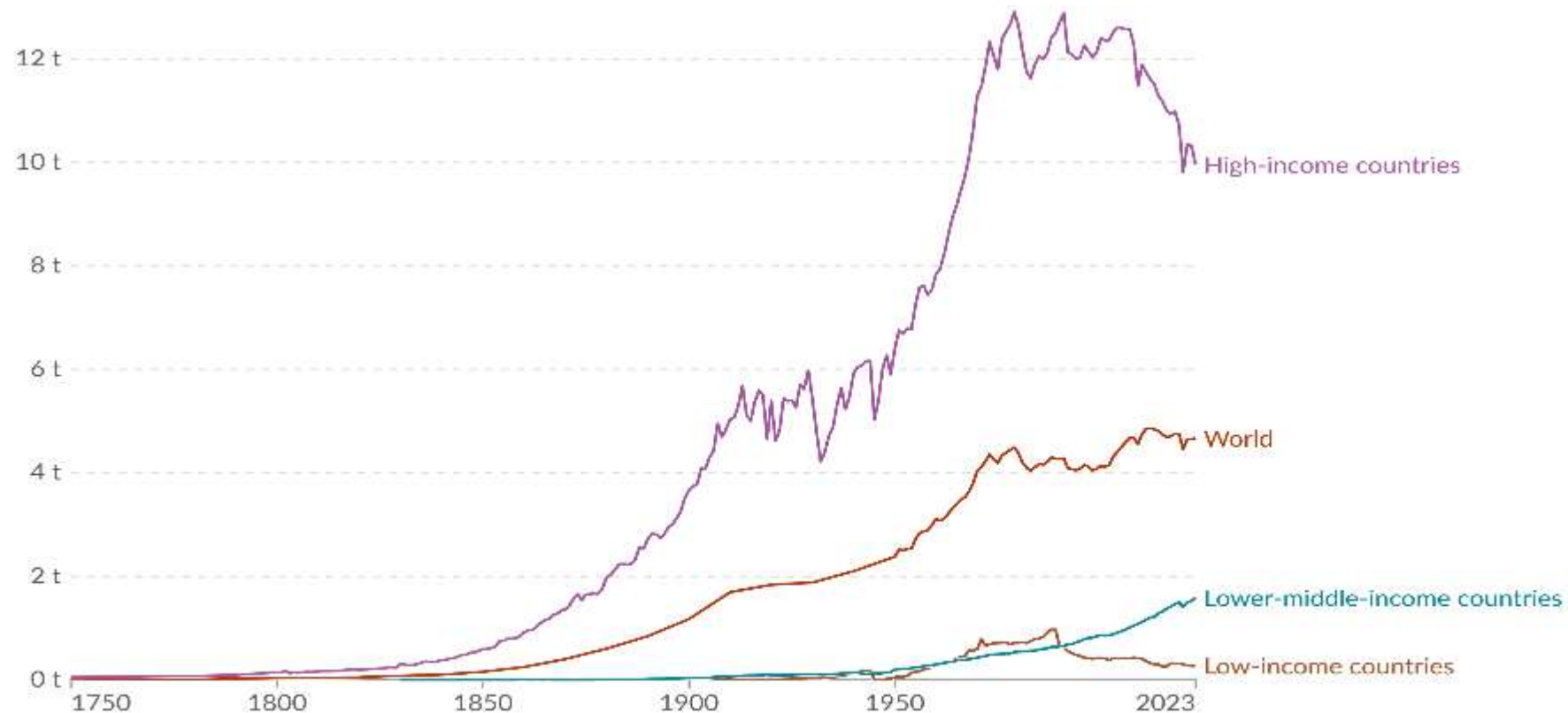
ESTABLISHED FACT

Strong links between human-caused warming and increasingly severe extreme weather

- Many of these changes - particularly to the oceans, ice sheets and global sea levels - are *irreversible*
- In almost all emissions scenarios, global warming is expected to hit 1.5C “in the early 2030s”. Without reaching “net-zero” CO₂ emissions - along with “strong reductions” in other greenhouse gases - the climate system will continue to warm.



Carbon dioxide (CO₂) emissions from fossil fuels and industry. Land-use change is not included.



Data source: Global Carbon Budget (2024); Population based on various sources (2024)

OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

Source: OurWorldinData, 2024

Emissions reduction

Several high-income countries, including the UK and EU member states, have significantly reduced their CO₂ emissions in recent decades.

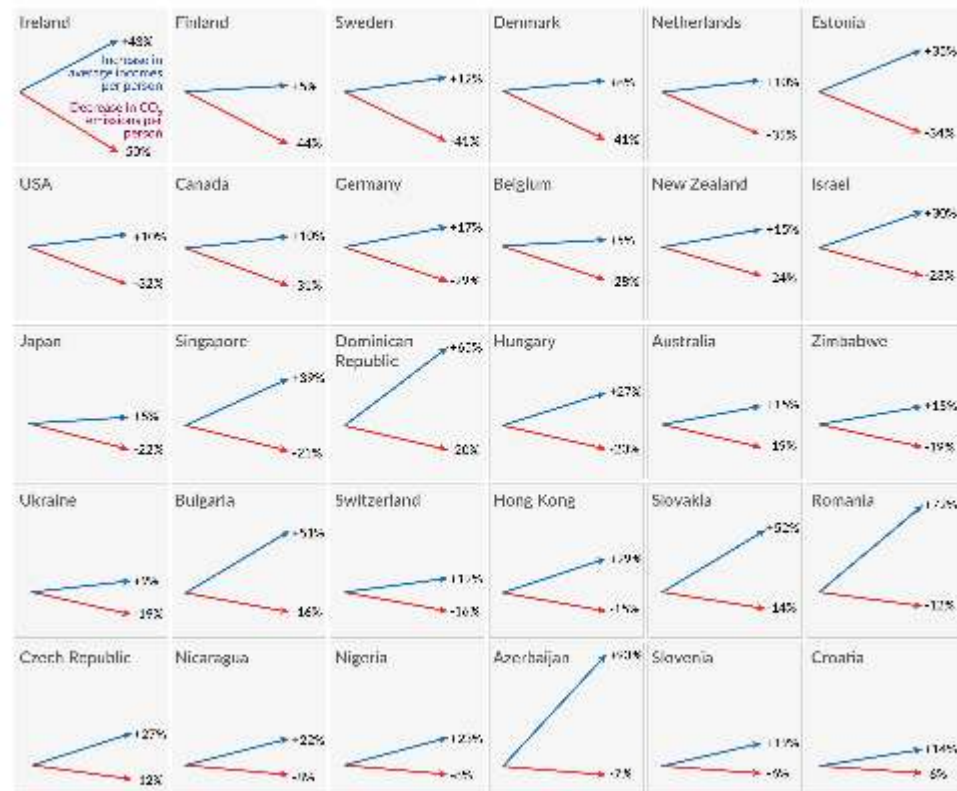
They showing that emission cuts are possible with the right policies and technology.

Decoupling: Countries that achieved economic growth while reducing CO₂ emissions, 2005-20

Our World in Data

Emissions are adjusted for trade. This means that CO₂ emissions caused in the production of imported goods are added to its domestic emissions – and for goods that are exported the emissions are subtracted.

Average incomes are measured by GDP per capita (except for Ireland, for which it is measured by GNI per capita).



Data sources: Global Carbon Project & World Bank

These are more countries that achieved this same, for only those countries for which data is available and for which each change was at least 5% are shown.

OurWorldInData.org – Research and data to make progress against the world's largest problems.

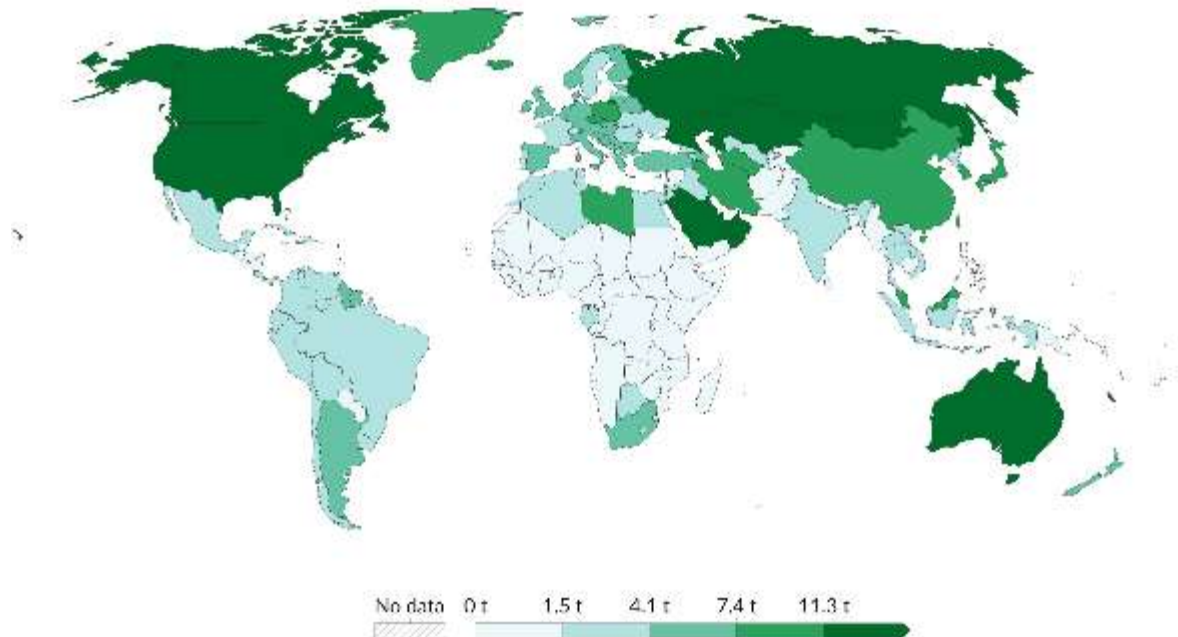
Licensed under CC BY by the author Max Roser

Per capita CO₂ emissions, 2023

Carbon dioxide (CO₂) emissions from fossil fuels and industry¹. Land use change is not included.

CO₂ emissions per person vary widely across countries.

High-income nations tend to emit much more per capita than low-income countries, highlighting global inequality in emissions.



Data source: Global Carbon Budget (2024); Population based on various sources (2024)
OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

¹ Fossil emissions Fossil emissions measure the quantity of carbon dioxide (CO₂) emitted from the burning of fossil fuels, and directly from industrial processes, such as cement and steel production. Fossil CO₂ includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Mitigation

*“Mitigating climate change means **reducing the flow of heat-trapping greenhouse gases** into the atmosphere. This involves cutting greenhouse gases from main sources such as power plants, factories, cars, and farms. Forests, oceans, and soil also absorb and store these gases, and are an important part of the solution. Improvements in energy efficiency and structural changes in the economy also contributed to meeting these goals. Now, more ambitious goals are set that include a net 55% or greater reduction below 1990 levels by 2030 and a climate-neutrality objective by 2050”.*

6%

of global emissions
are released by the EU

37%

**reduction in EU
emissions achieved in**
2023 compared to 1990
levels

55%

**is the EU reduction target
by 2030**
compared to 1990 levels

Adaptation

*“Adapting to climate change means **taking action to prepare for and adjust** to both the current effects of climate change and the predicted impacts in the future.”*

European Commission

- Measures to protect people, nature, and the economy from adverse effects, such as building flood defenses, developing drought-resistant crops, or modifying building codes to withstand extreme weather.



Built environment

- Buildings are responsible for 35% of the EU's greenhouse gas emissions and 42% of energy consumption.
- The construction sector is the largest consumer of raw materials in the EU and generates the biggest waste stream by weight.
- Existing buildings must be renovated to meet EU climate goals; new buildings should be zero-emission by 2030.
- Buildings are increasingly exposed to climate risks like heatwaves, floods, and storms, highlighting the need for climate-resilient design.

Climate & Cities

Cities concentrate climate risks and emissions – but smart design, green spaces, and resilient infrastructure can turn them into drivers of climate solutions.

Energy Use in Buildings

The EU's [Energy Performance of Buildings Directive](#) helps make buildings more energy-efficient.

It sets rules to reduce energy use and pollution from buildings, with the goal of creating a nearly **zero-emission building stock by 2050** — helping to fight climate change while making homes and workplaces cleaner, healthier, and more affordable.

around **40 %**

of **energy consumed** in the EU is
used in buildings

over **1/3**

of the EU's energy-related
GHG emissions come
from buildings

+/- 80 %

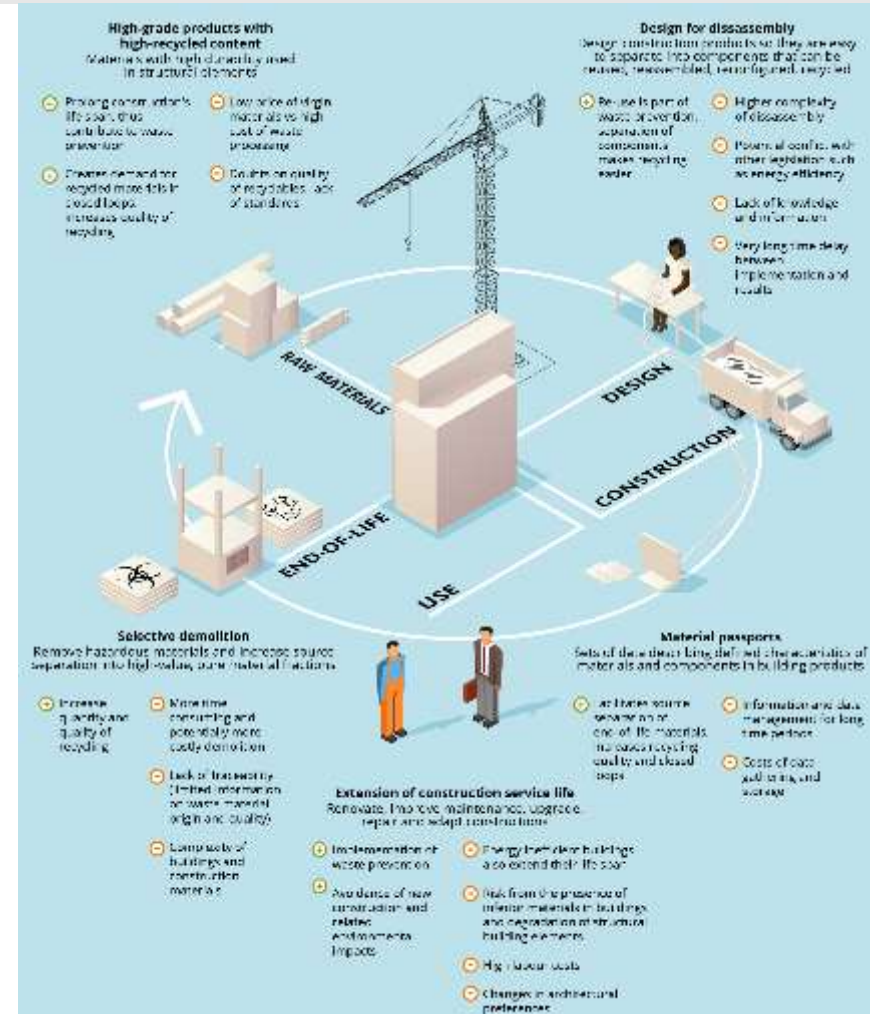
of **energy** used in EU
homes is **for heating,**
cooling and hot water

Circular economy practices

Construction and demolition waste make up just over one-third of total waste generation in the EU.

To reduce this, the EU promotes **reusing and recycling practices**:

- Old products are resold or repaired.
- Biowaste becomes fertiliser or biogas.
- Electronics provide metals for new devices.
- **Construction waste** (40% of total) is being better recycled with new technologies to recover not just concrete, but also **plastics, wood, and insulation**.



Nature-Based Solutions (NBS)

NBS use nature to tackle environmental challenges like rising temperature, flooding, and biodiversity loss. They also bring social and economic benefits.

Examples include:

- Green roofs and parks to cool cities and improve health
- Wetlands and forests to reduce floods and store carbon
- Natural water systems for cleaner, sustainable water

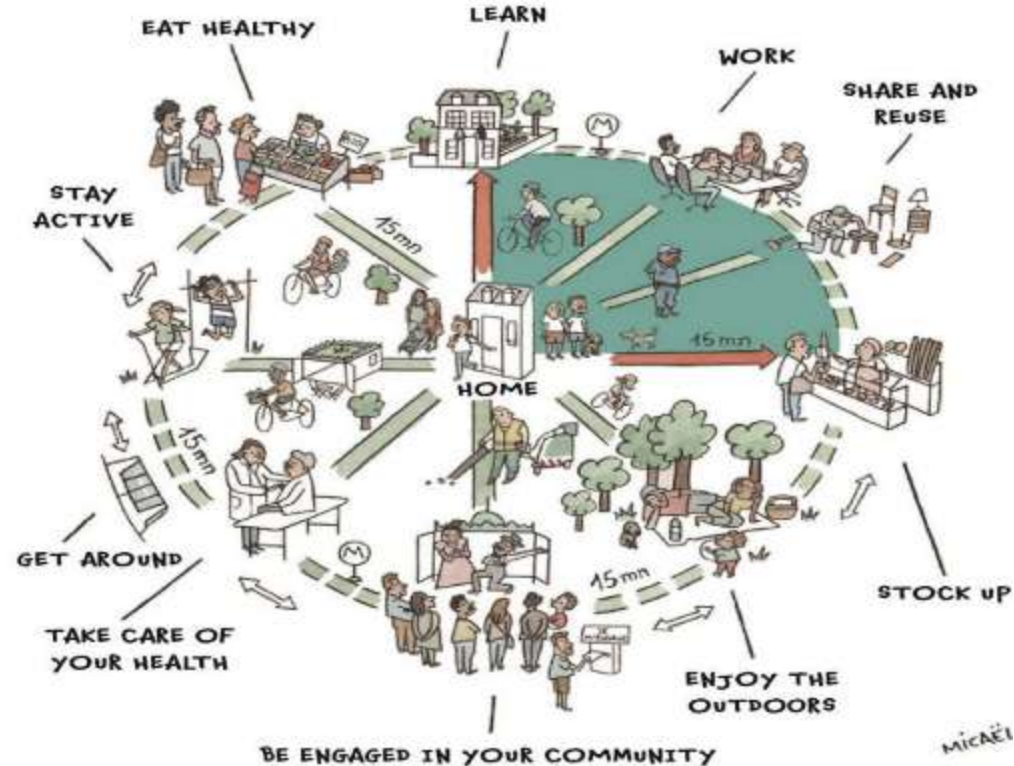
The EU supports NBS through funding, research, and policies like the [EU Green Deal](#) and [Biodiversity Strategy 2030](#) – aiming for healthier environments and more resilient communities.

[Access the OPPLA database with NBS best practices](#)



The 15-Minute City

A 15-minute city is an **urban model** where residents can access most of their daily needs within a short walk or bike ride from home—encouraging active mobility, public health, community ties, and sustainable urban development.



The 15-Minute City - guiding principles

1. Proximity

Access to essential services and amenities within:

5-minute walk (~400 m): Local shops, basic services, primary schools, public parks, and places of worship

15-minute walk (~1,200 m): Urban centers with pharmacies, general stores, public schools, mid-sized employers, and public transport

15-minute bike ride (~5 km): Hospitals, universities, cultural venues, major employers, and regional parks

2. Density

Supports walkability and compact urban form through:

1,000 dwellings within a 400-m radius

9,000 dwellings within a 1,200-m radius

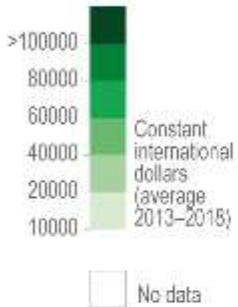
145,000 dwellings within a 5-km radius

3. Diversity

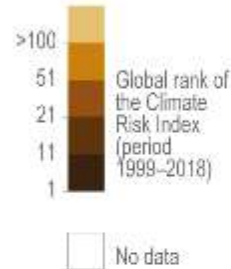
Land use mix and a range of housing types to support social inclusion and economic diversity.

Damages to people and assets, vulnerability and adaptive capacity across Europe

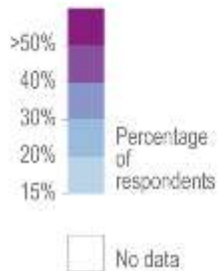
(a) Gross domestic product (GDP) per capita



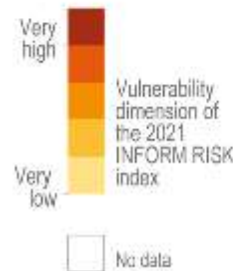
(b) Reported damages and fatalities from climate-related events (1999–2018)



(c) Population very or extremely worried about climate change



(d) Vulnerability of population to disasters and humanitarian crises



Social vulnerability

Certain groups are more vulnerable to climate change impacts due to social, economic, and geographic factors:

- **Age:** Elderly individuals and children are more susceptible to extreme temperatures and health risks
- **Income:** Low-income communities often reside in areas with higher exposure to environmental hazards and have limited resources to adapt
- **Geography:** Regions such as Eastern and Southern Europe, as well as remote or rural areas, may face greater climate risks and have less adaptive capacity



Economic consequences: *inaction vs. adaptation*

Inaction on climate change leads to escalating economic losses due to extreme weather events, infrastructure damage, and health impacts.

Proactive adaptation involves investing in measures that reduce vulnerability to climate risks, such as enhancing infrastructure resilience and implementing early warning systems.

Studies indicate that the **costs of inaction** significantly outweigh the **costs of adaptation**. For instance, the European Environment Agency highlights that failing to adapt can result in substantial economic damages, whereas timely adaptation measures can mitigate these losses.



Climate Hazards and Social Vulnerability

Low-income and socially vulnerable groups face **disproportionate impacts** from climate hazards:

- Heatwaves: Poorer urban areas often lack trees and green spaces, making them hotter and **increasing risks of illness** and death—especially for the elderly and people in poor health.
- Flooding: Vulnerable populations are more likely to live in flood-prone areas, with less protection and **lower insurance coverage**, making recovery harder.
- Air pollution: Deprived communities often experience worse air quality, increasing **respiratory issues**.

Poorer communities have fewer resources to adapt or respond, and policies may unintentionally burden them more. This raises critical climate justice concerns.

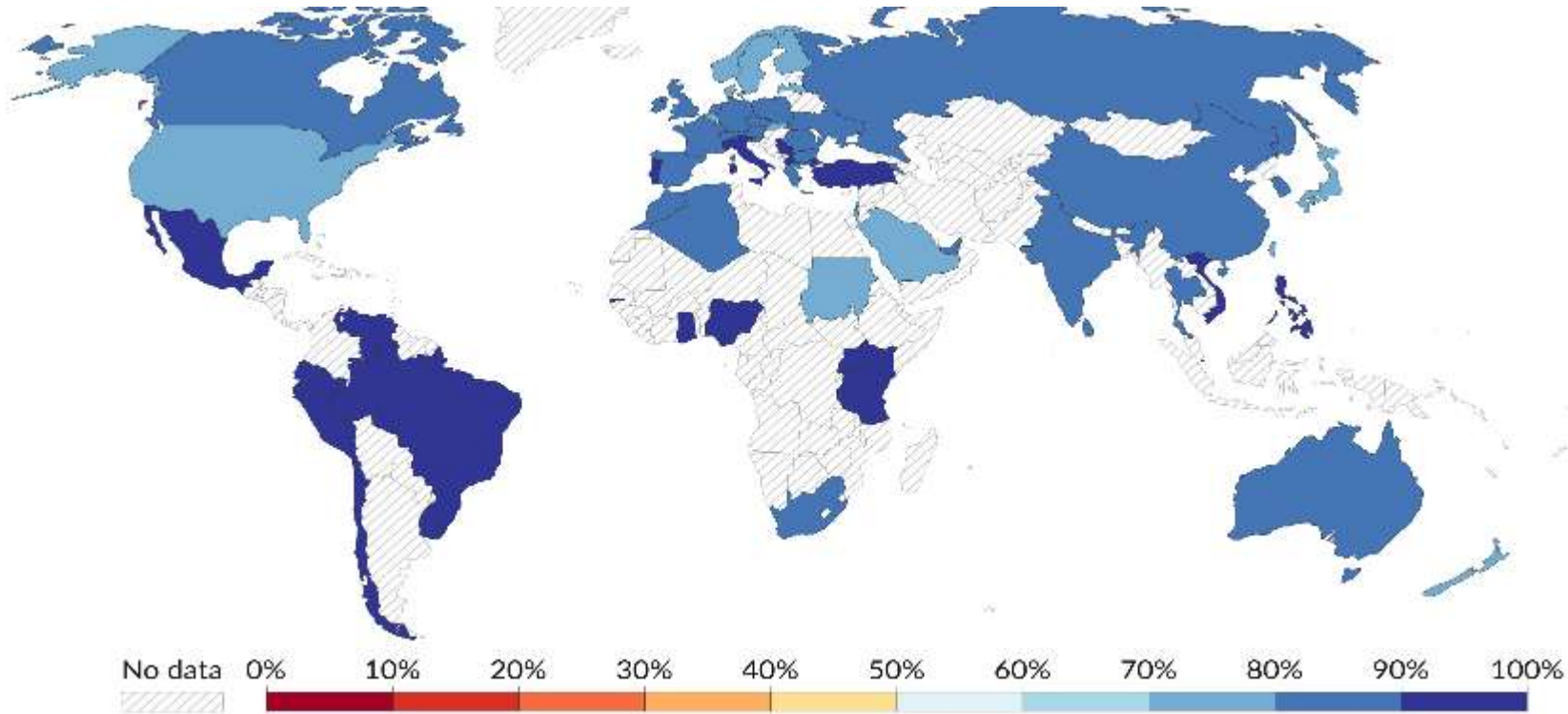
Policies should be designed with equity in mind, ensuring fair access to clean environments and protecting the most vulnerable.



Climate change is one of the most significant global challenges of our time, and addressing it requires a deep commitment not only to scientific accuracy and policy effectiveness but also to **ethical integrity** and **professional responsibility**.



People think climate change is a serious threat, and humans are the cause. Concern was high across countries: even in the country with the lowest agreement, **73% agreed**.



People across the world, and the political spectrum, underestimate levels of support for climate action.

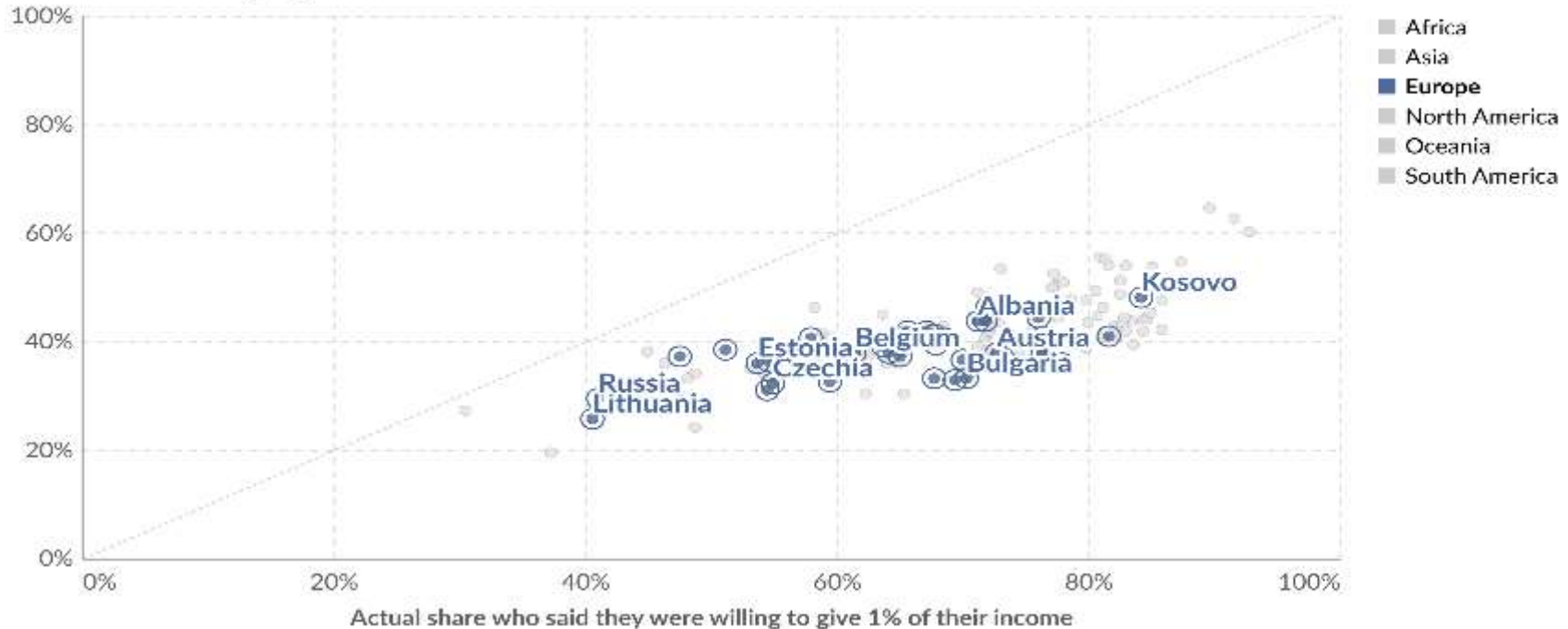
This “perception gap” matters. Governments will change policy if they think they have strong public backing. Companies need to know that consumers want to see low-carbon products and changes in business practices. We’re all more likely to make changes if we think others will do the same.

Hannah Ritchie, OurWorldinData, 2024



Most of us systematically underestimate how widespread support for climate action is. Participants were asked if they'd be willing to give 1% of their income to tackle climate change. **Across the 125-country sample, 69% said “yes”.**

Predicted share willing to give



Populations in low- and middle-income countries are more willing to pay than in rich countries. 83% of those in Bangladesh agreed, compared to 48% in the UK or the US.

This might reflect levels of climate risk: if your livelihood was at risk from climate-related disasters, then you are more willing to give up some of your income.



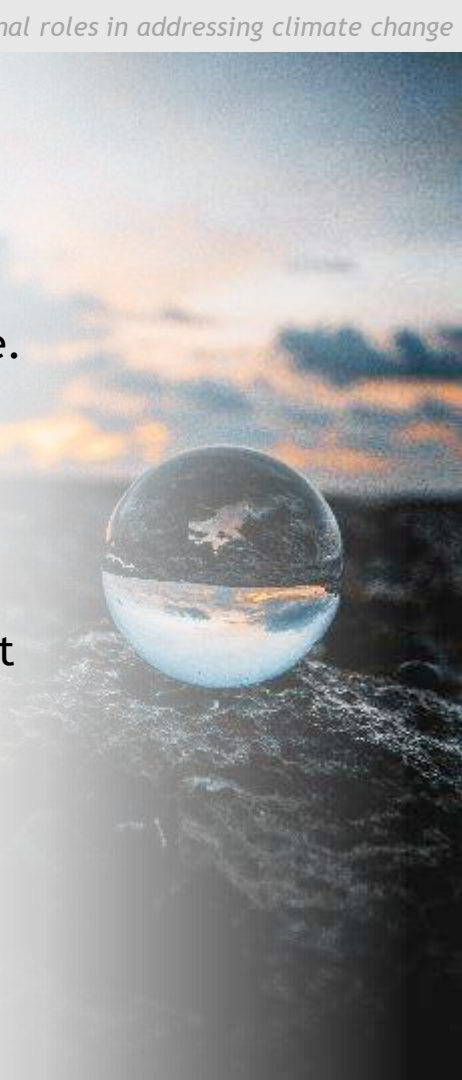
Climate Ethics

Intergenerational Justice: Ensuring climate resilience means safeguarding environmental, social, and economic systems so that future generations inherit a world that remains livable and adaptable.

Intragenerational Equity: Climate change disproportionately affects vulnerable populations. Climate strategies must account for social justice, focusing on fair distribution of risks and resources.

Precautionary Principle: Where scientific knowledge is incomplete, but the risk of harm is high, precautionary measures should guide design, planning, and policy.

Responsibility: Developed countries and large corporations, having contributed more to emissions, bear greater responsibility. Ethical climate action includes transparent reporting, acknowledging past harms, and corrective measures.



Responsibility of professionals

Scientists and Researchers: To Communicate findings honestly and clearly, avoid exaggeration or understatement. Provide open access data, peer review and interdisciplinary collaboration.

Academia: As an institution that provides the highest possible level of education and combines science with research, the university is responsible for education with regard to sustainability and the use of innovative solutions to global challenges.

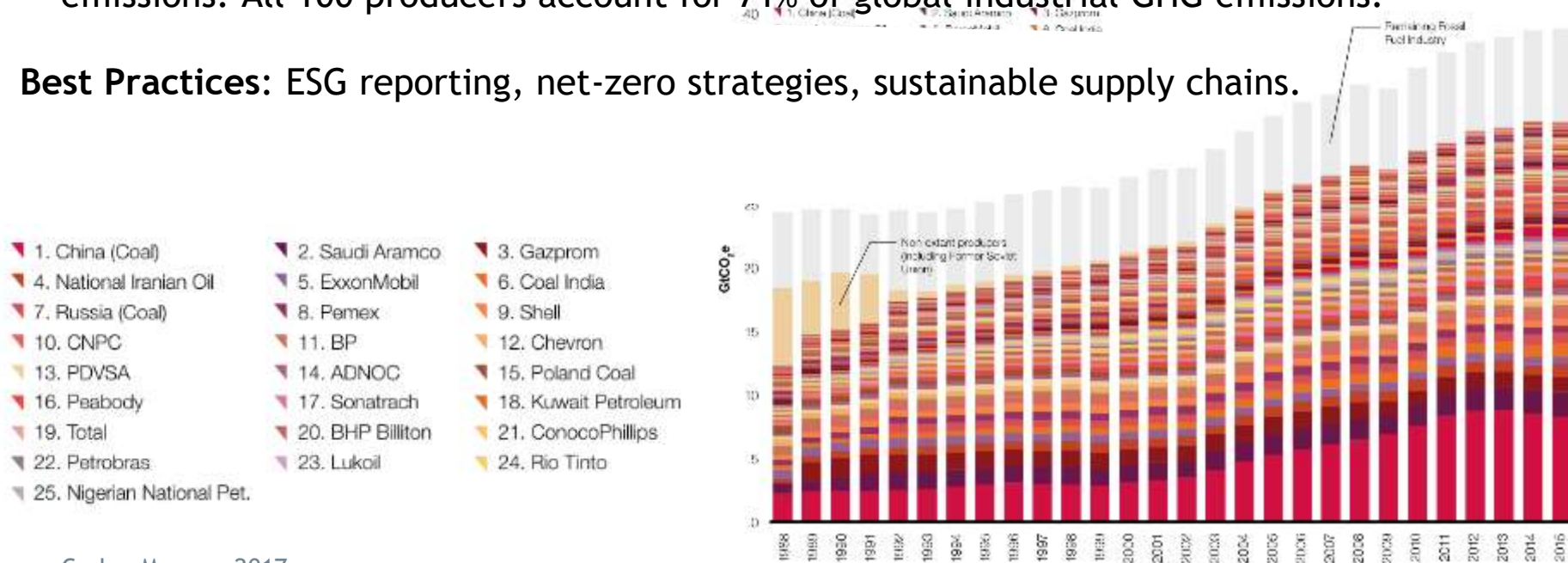


ACADEMICS

Responsibility of professionals

Corporate and state sector: Reduce environmental impact and align operations with science-based climate targets. According to the Carbon Majors Database (CDP, 2017), 25 corporate and state producing entities account for 51% of global industrial GHG emissions. All 100 producers account for 71% of global industrial GHG emissions.

Best Practices: ESG reporting, net-zero strategies, sustainable supply chains.



Responsibility of professionals

Policy makers and Public Officials: Their responsibilities go beyond technical regulation—they are ethical stewards of the public interest, architects of systemic change, and defenders of climate justice.

- They are entrusted with protecting the **health, safety, and long-term welfare** of citizens.
- Policy makers must consider the **long-term impacts of laws**, subsidies, infrastructure, and land-use plans.
- Richer countries and governments bear a **greater burden** under the principle of *common but differentiated responsibilities* (UNFCCC).
- Use the **best available science** from IPCC, national academies, and climate scientists.
- Resist political pressure to delay, deny, or distort scientific facts.

Responsibility of professionals

Architects: Play a crucial role in designing structures that not only reduce emissions but can also withstand climate impacts (e.g., floods, heatwaves).

Urban and Regional Planners: Are vital in shaping communities that are socially and ecologically resilient. This includes climate risk zoning, promoting green infrastructure, and ensuring inclusive planning processes that address vulnerability and equity.

Engineers: Ensure the technical soundness of climate-resilient infrastructure. Ethical engineering today involves adaptive design, redundancy planning, and the integration of nature-based solutions alongside traditional infrastructure.

Professional code of conduct

Do No Significant Harm: Actions taken by professionals must not compromise the adaptive capacity of ecosystems or communities. This includes avoiding maladaptive practices that may offer short-term benefits but increase long-term vulnerabilities.

Making Sustainable and Resilient Choices: From material selection to energy systems, professionals must choose options that support long-term resilience. This includes lifecycle thinking, carbon footprint reduction, and water-sensitive urban design.

Decision-making and public accountability

Transparent and Inclusive Decision-Making: Ethical resilience planning requires public engagement, especially with vulnerable populations most at risk from climate impacts. **Participatory processes** lead to more equitable and locally relevant solutions.

Accountability in Practice: Professionals must be held accountable not only to their clients and regulators but also to the broader public. As climate risks increase, so does the moral weight of decisions—particularly those related to land use, resource allocation, and emergency preparedness.

Climate Science for the Built Environment



UN Sustainable Development Goals

- Global goals adopted by all UN member states (2015-2030)
- 17 Goals with 169 targets - from poverty to climate
- Apply to all countries and sectors - including construction

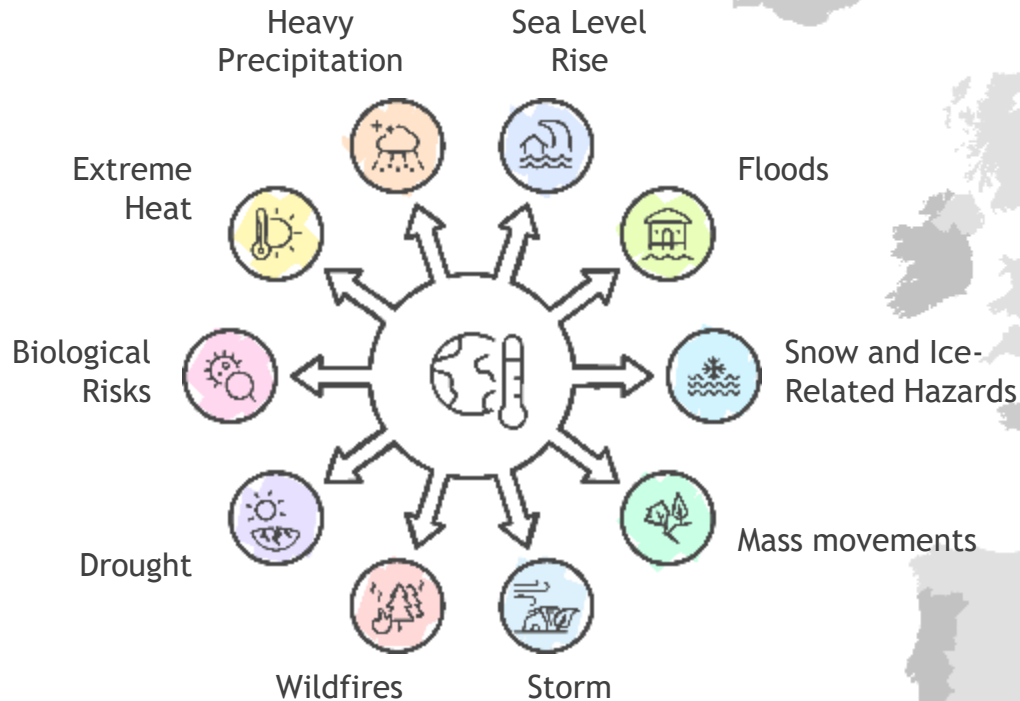


SDGs in Construction?

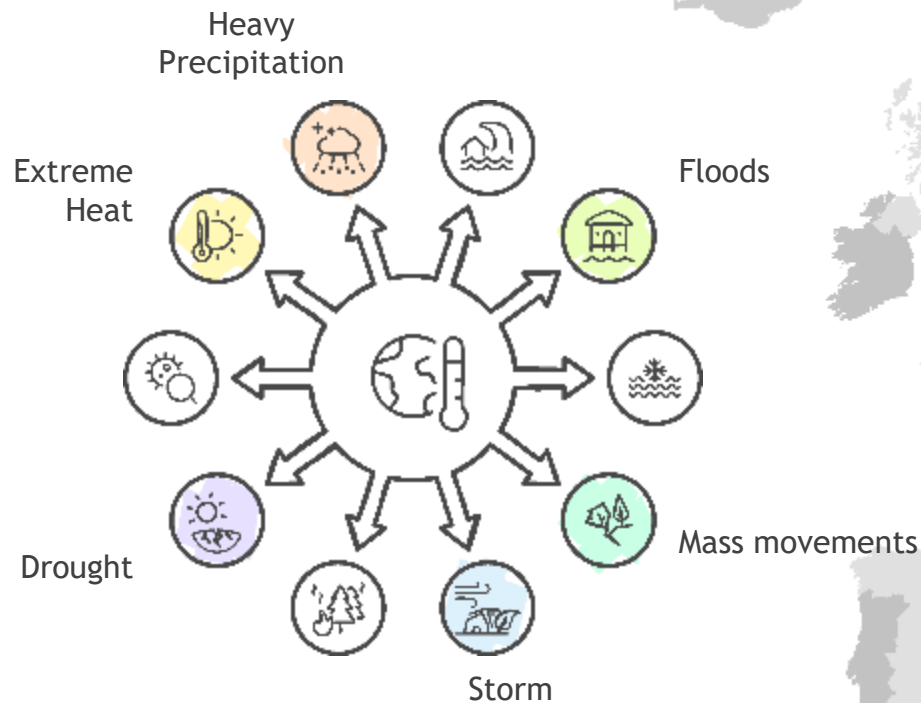
- **SDG 3 | Good health and well-being**
people spend 90% of their time indoors
- **SDG 7 | Affordable and clean energy**
40% of the total energy consumptions in Europe is consumed by the construction sector
- **SDG 11 | Sustainable cities and communities**
urban areas are responsible for 70% of all the emissions
- **SDG 12 | Responsible consumption and production**
> 33% of the resources is used by the built environment
- **SDG 13 | Climate action**
construction sector causes > 33% of the greenhouse gas emissions
- **SDG 17 | Partnerships for the goals**
> 70 organizations worldwide have joined the global network for sustainable buildings



Climate Change and its Associated Risks



Acute hazards for buildings by the EU Taxonomy





Heatwaves and Urban Overheating

Heatwaves are **prolonged periods of extreme heat** that strain buildings and human health. Urban areas are particularly vulnerable due to the **heat island effect** and poor thermal comfort in buildings.

Built Environment

(buildings, infrastructure, cities)

- Overheated interiors,
- Higher energy demand for cooling
- Urban heat island effect
 - cities stay hot overnight

People

(health, safety, quality of life)

- Health risks: heatstroke, dehydration
- Reduced work performance, poor sleep
- High risk for elderly and people with chronic illnesses





Storms

Windstorms are caused by rapid changes in atmospheric pressure, which are often associated with stronger currents and more dynamic weather systems. Damage caused by summer **convective storms** and winter **cyclonic winds**, which damage roofs and trees, is becoming increasingly common.

Built Environment

(buildings, infrastructure, cities)

- Damaged roofs, windows, façades
- Uprooted trees, scattered debris
- Power outages, transport disruption

People

(health, safety, quality of life)

- Risk of injury or death from flying objects
- Disruption of daily life (work, school, transport)
- Increased feeling of insecurity





Heavy precipitation

Short but **intense rainfall events** are becoming more frequent due to higher air temperatures, which increase the atmosphere's capacity to hold moisture. When this moisture is released, it can result in downpours that urban drainage systems were not designed to handle.

Built Environment

(buildings, infrastructure, cities)

- Overloaded drainage systems, local flooding
- Damage to roofs, façades, interiors
- Soil erosion around buildings
- Flash floods

People

(health, safety, quality of life)

- Risk of injury in flooded areas
- Property loss, evacuation
- Disruption of transport and basic services





Flood

Floods occur when water flow exceeds the capacity of natural or artificial drainage systems. In urban areas, this risk is increased by soil compaction with impermeable surfaces, outdated infrastructure, and changes in snowmelt patterns and river regimes.

Built Environment

(buildings, infrastructure, cities)

- Flooded basements and utility rooms
- Damage to structural elements and insulation
- Infrastructure outages (roads, electricity, sewage)

People

(health, safety, quality of life)

- Drowning risk, contaminated water
- Loss of housing and income
- Long-term stress and trauma





Mass movement

Landslides and soil movement are most often triggered by **water saturation** after heavy or prolonged rainfall. In areas with steep terrain, construction activities, deforestation, or poor drainage further destabilize slopes and increase risk.

Built Environment

(buildings, infrastructure, cities)

- Structural damage or collapse on unstable slopes
- Broken infrastructure
- Relocation or costly reconstruction may be needed

People

(health, safety, quality of life)

- Life-threatening situations
- Property loss, displacement
- Difficulties in insuring homes in high-risk areas





Droughts

Droughts occur when **precipitation levels stay below average** for extended periods. In Central Europe, winter droughts reduce water availability for spring and summer, and higher evaporation rates due to heat intensify the problem, stressing water supplies and green spaces.

Built Environment

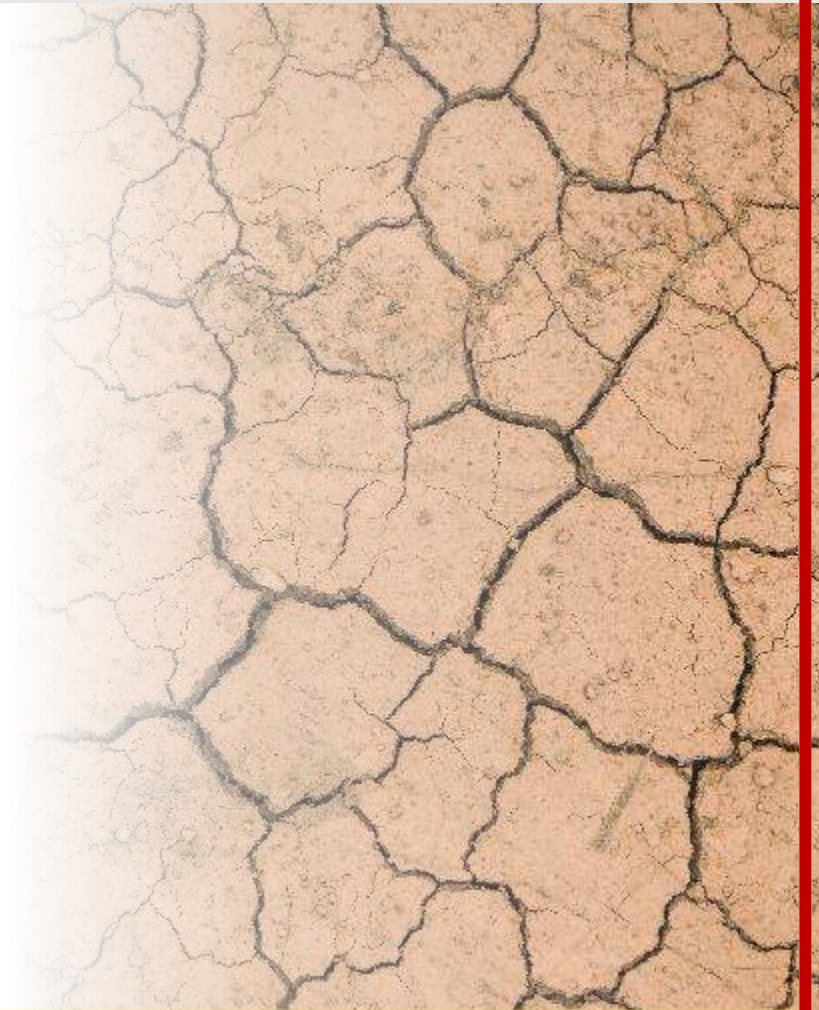
(buildings, infrastructure, cities)

- Lower groundwater levels → unstable foundations
- Dried-out green roofs, landscaping failure
- Water supply restrictions for maintenance

People

(health, safety, quality of life)

- Limited access to water (irrigation, daily use)
- Reduced quality of life, especially in heat-stressed cities
- Mental stress from prolonged dryness



How do buildings affect climate change?

Every building has an impact - it either adds to the problem or helps reduce it. Good design, material choices, and efficient use make a difference.



Contributes to Climate Change

- Uses **high-emission materials** (e.g. concrete, steel)
- Has **high energy consumption** for heating and cooling
- Depends on **fossil fuels** (gas, coal, non-renewable electricity)
- **Lacks adaptation features** (no shading, no water retention)



Does Not Worsen Climate Change

- Uses **low-carbon or recycled materials** (e.g. wood, reused bricks)
- Is **energy-efficient** (e.g. passive or low-energy buildings)
- Uses **renewable energy** (e.g. solar panels, heat pumps)
- **Includes climate adaptation** (e.g. green roofs, shading, water systems)

Climate change causes

- Scientists attribute the **global warming trend** observed since the mid-20th century to the human expansion of the "**greenhouse effect**" – warming that results when the atmosphere traps heat radiating from Earth toward space.
- Over the last century, **burning of fossil fuels** like coal and oil has increased the concentration of atmospheric carbon dioxide (CO₂). To a lesser extent, the clearing of land for agriculture, industry, and other human activities has increased concentrations of greenhouse gases.

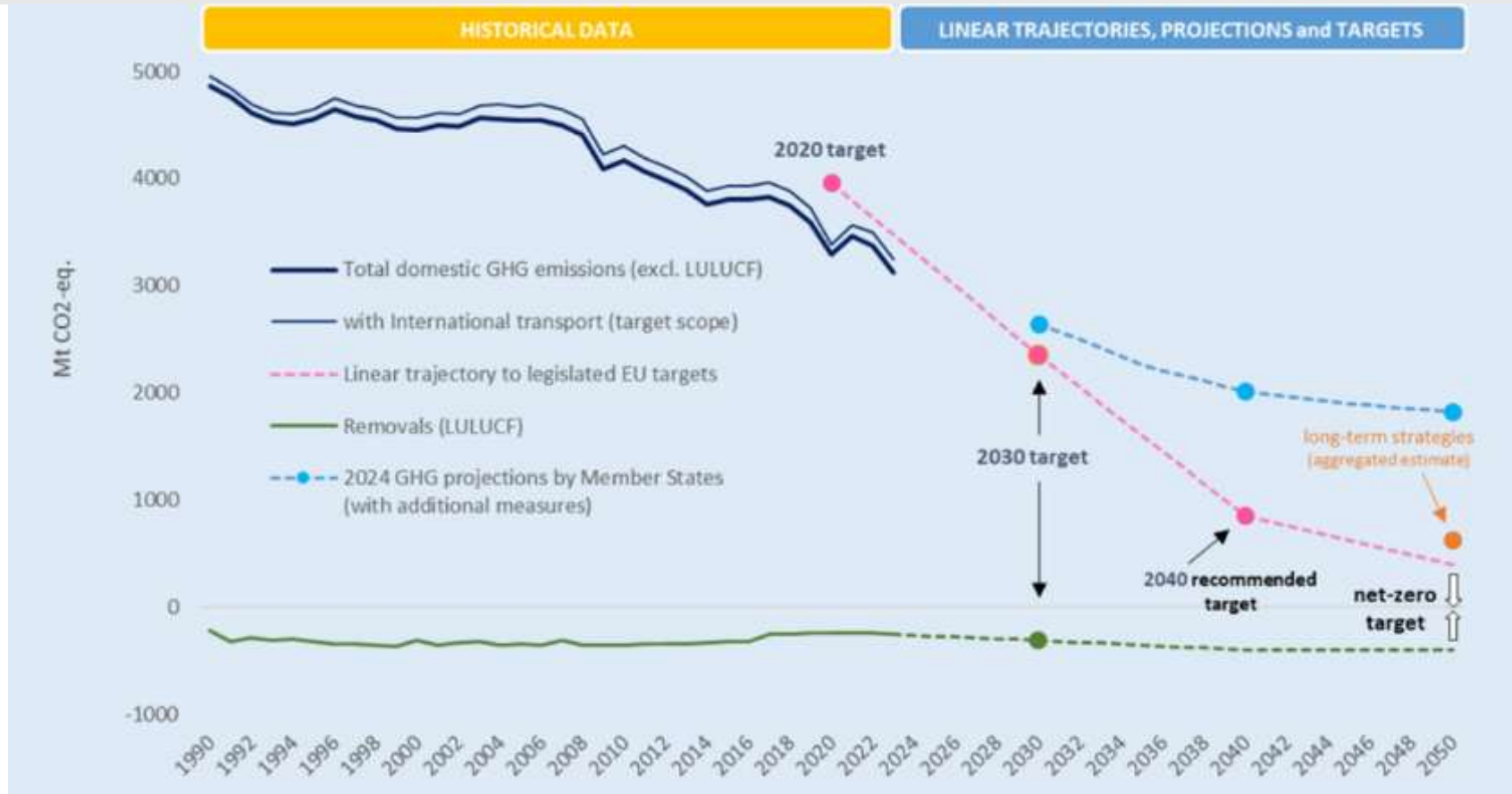
Main Greenhouse gases contributing to the Greenhouse Effect

Carbon Dioxide (CO₂): A vital component of the atmosphere, CO₂ is released through natural processes (like volcanic eruptions) and through human activities, such as burning fossil fuels and deforestation.

Methane: It comes from both natural and human-caused sources, i.e., from plant-matter breakdown in wetlands and is also released from landfills and rice farming. Livestock animals emit methane from their digestion and manure. Leaks from fossil fuel production and transportation are another major source of methane, and natural gas is 70% to 90% methane.

Nitrous Oxide: Gas produced by farming practices and released during commercial and organic fertilizer production and use. It also comes from burning fossil fuels and burning vegetation.

Chlorofluorocarbons (CFCs): They do not exist in nature - they are entirely of industrial origin. They were used as refrigerants, solvents (a substance that dissolves others), and spray can propellants.



Overview of historical data, projections and targets for EU-level emissions [1990-2050].

EU Climate Law: net-zero emissions by 2050

- It writes into law the goal set out in the [European Green Deal](#) for Europe's economy and society to become **climate-neutral by 2050**.
- Set the long-term direction of travel for meeting the 2050 climate neutrality objective through all policies, in a socially fair and cost-efficient manner.
- Stronger provisions on adaptation to climate change

1st

**Climate-neutral
continent
by 2050**

>55%

**reduction in GHG
emissions by 2030,
compared to 1990 levels**

3 bln

**Additional trees
to be planted in the EU by
2030**

National Energy and Climate Plans (NECPs)

- Strategic planning tool to deliver a fair, resilient, and climate-neutral Europe, and to steer the much-needed investments for the climate and energy transition, helping to mobilise private and public spending.
- The NECPs enable each EU country to outline **precise actions and policies** to achieve the 2030 climate and energy targets.
- The NECPs define how EU countries will tackle the five dimensions of the Energy Union: decarbonisation, energy efficiency, energy security, internal energy market, research, innovation and competitiveness.
- The National Energy and Climate plans 2021-2030 for each EU Member state are [available here](#) in the local language.

EU Adaptation Strategy

- The European Union can adapt to the unavoidable impacts of climate change and become **climate resilient by 2050**.
- Adaptation actions must be informed by **robust data and risk assessment tools** that are available to all - from families building homes, businesses in coastal regions and farmers planning their crops.
- Strategies and plans at **all levels of governance** with three cross-cutting priorities: integrating adaptation into macro-fiscal policy, nature-based solutions and local adaptation actions.
- Gathering more and better data on climate-related risks and losses, and enhancing Climate-ADAPT as the European platform for adaptation knowledge.

Risk typology: EU Taxonomy Appendix A

The EU Taxonomy outlines a detailed catalogue of climate-related hazards that must be taken into account as a minimum standard, as specified in the Climate Delegated Act (Annex I, Appendix A). These hazards are categorized into two main types:

Chronic climate trends - Gradual, long-term changes (e.g., rising temperatures, slow-onset events such as desertification).

Acute climate-related events - Sudden, extreme weather events (e.g., storms, heatwaves, floods).

EU Taxonomy

OBJ.2 - CLIMATE CHANGE ADAPTATION



1. The economic activity has implemented physical and non-physical solutions ("adaptation solutions") that substantially reduce the most important physical climate risks that are material to that activity.
2. The physical climate risks that are material to the activity have been identified from those listed in [Appendix A](#) by performing a robust climate risk and vulnerability assessment with the following steps:
 - a. screening of the activity to identify which physical climate risks from the list in [Appendix A](#) may affect the performance of the economic activity during its expected lifetime;
 - b. where the activity is assessed to be at risk from one or more of the physical climate risks listed in [Appendix A](#) to this Annex, a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity;
 - c. an assessment of adaptation solutions that can reduce the identified physical climate risk.
3. The climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports⁽⁷²⁴⁾, scientific peer-reviewed publications and open source⁽⁷²⁵⁾ or paying models.

EU Taxonomy

OBJ.2 - CLIMATE CHANGE ADAPTATION



4. The adaptation solutions implemented:

- do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities;
- favour nature-based solutions⁽⁷⁷⁶⁾ or rely on blue or green infrastructure⁽⁷⁷⁷⁾ to the extent possible;
- are consistent with local, sectoral, regional or national adaptation plans and strategies;
- are monitored and measured against pre-defined indicators and remedial action is considered where those indicators are not met;
- where the solution implemented is physical and consists in an activity for which technical screening criteria have been specified in this Annex, the solution complies with the do no significant harm technical screening criteria for that activity.

5. In order for an activity to be considered as an enabling activity as referred to in Article 11(1), point (b), of Regulation (EU) 2020/852, the economic operator demonstrates, through an assessment of current and future climate risks, including uncertainty and based on robust data, that the activity provides technology, product, service, information, or practice, or promotes their uses with one of the following primary objectives:

- increasing the level of resilience to physical climate risks of other people, nature, cultural heritage, assets and of other economic activities;
- contributing to adaptation efforts of other people, of nature, of cultural heritage, of assets and of other economic activities.

Climate Impact Metrics (example)

Thermal metrics:

- Cooling/Heating Degree Days (CDD/HDD)
- Peak indoor temperatures
- Passive survivability indicators

Energy and carbon metrics:

- Operational energy use (kWh/m²/year)
- Embodied carbon (kgCO₂e/m²)
- Total life-cycle emissions (via LCA)
- Renewable energy contribution (%)
-

Climate risk metrics:

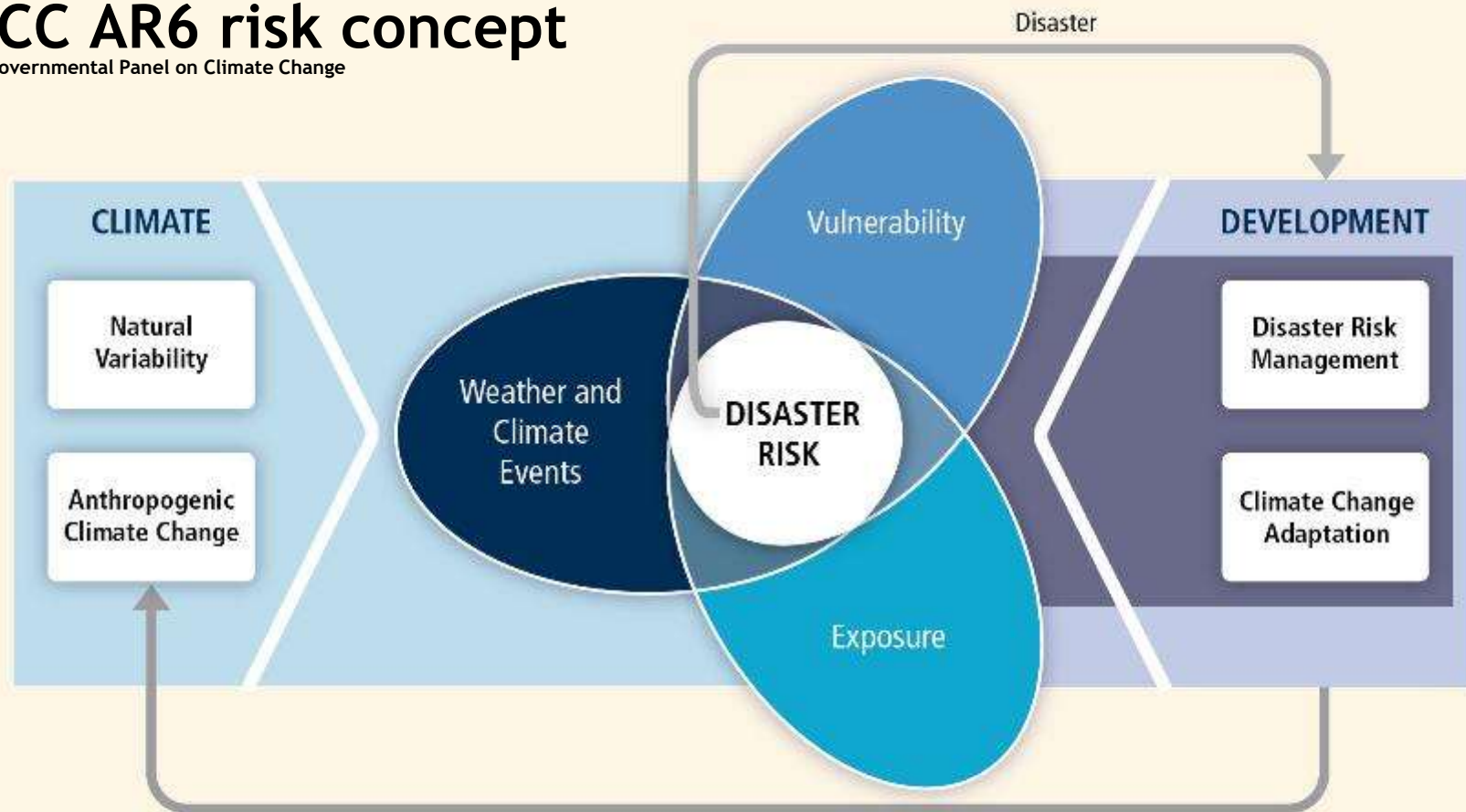
- Flood return periods (1-in-100-year events)
- Rainfall intensity thresholds
- Wind load probabilities
- Social vulnerability index
 - Combines exposure, sensitivity, and adaptive capacity (used in spatial analysis).

Tools/Frameworks for Climate Impact Analysis

- [IPCC risk matrix](#) (vulnerability, hazard, and exposure)
- EU Climate-ADAPT tools (e.g., [Urban Adaptation Map Viewer](#))
- [EU Level\(s\) common framework for sustainability](#)
- Sustainability and resilience assessment rating systems
- Local adaptation guidelines

IPCC AR6 risk concept

Intergovernmental Panel on Climate Change



RISK = HAZARD x EXPOSURE x VULNERABILITY

Hazard

It refers to the **climate-related events or trends**, such as extreme weather (e.g., heatwaves, floods, storms) or long-term processes (e.g., sea-level rise, desertification), that can lead to adverse impacts on human or ecological systems

Exposure

It involves the **presence of people, ecosystems, infrastructure, or assets** in areas that could be negatively affected by climate hazards

Vulnerability

It represents the **susceptibility of the exposed systems** to harm, considering physical, social, economic, and environmental factors that reduce or amplify the impact of climate hazards.

EU Climate-ADAPT platform indicators

Source: EEA Climate-ADAPT, n.d.

Urban Adaptation Map Viewer



About Heat River flooding Coastal flooding Pluvial flooding Water scarcity Wildfires Vector-borne diseases Social vulnerability Adaptation City factsheets

River flooding

River flooding is caused by high precipitation or snowmelt in the river basin upstream of a given location. River flooding is the second natural hazard in Europe in terms of the economic losses caused (after storms). Under the changing climate, the hydrological cycle is likely to intensify, which will increase the magnitude of river flood events in large parts of Europe. Regulation of rivers and land cover changes in catchment areas, such as deforestation or soil sealing through construction within flood plains and retention areas, contribute to the risk of flooding.

What is the issue?

Flooding causes fatalities, injuries and stress, affects housing and infrastructure. Population groups that are most vulnerable to flooding are those with mobility problems (e.g. the elderly, the disabled or those in poor health), who may not be able to leave their homes when a flood approaches. These groups may also be affected indirectly, if flooding disrupts their power supply or access to healthcare. People on lower incomes who cannot afford flood insurance or flood-resilience improvements to their houses are also more likely to be affected.

Currently existing dikes, embankments and other flood defence structures protecting infrastructure and buildings in low-lying areas close to rivers may not be able to withstand the higher flood water levels in the future. In addition, in many cities, pressure for growth is pushing development into flood risk areas, increasing the value of the potential



EU Climate-ADAPT platform indicators

Source: EEA Climate-ADAPT, n.d.

Urban Adaptation Map Viewer



About Heat River flooding Coastal flooding Pluvial flooding Water scarcity **Wildfires** Vector-borne diseases Social vulnerability Adaptation City factsheets

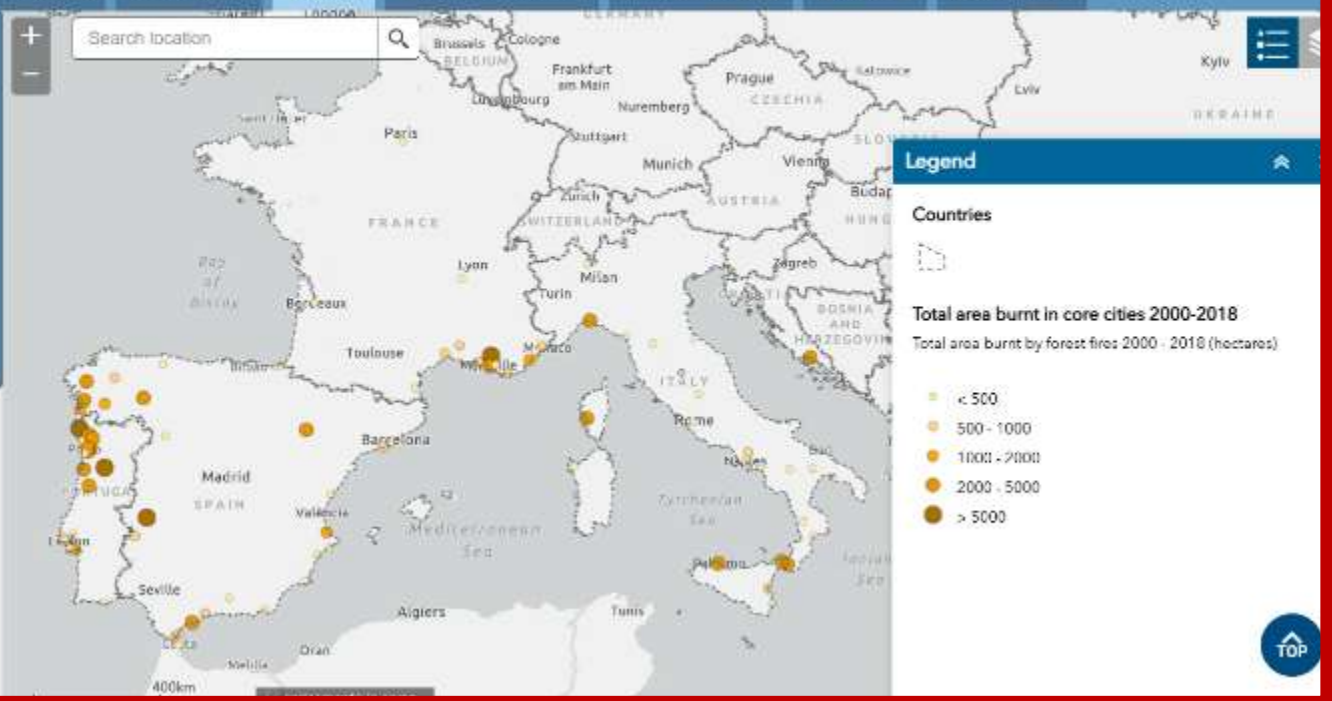
Wildfires

The risk of wildfires on the fringes of many European cities is growing due to more frequent occurrence of heatwaves and droughts. The highest wildfire hazard occurs in southern European countries, in particular in Portugal, Spain, southern France, southern Italy and Greece, where in 2018 nearly 100 people lost their lives in fires in the coastal area of Attica. However, the changing climate shifts the fire-prone areas northwards; the dry and hot conditions of summer 2018 in northern Europe lead to over 40 large forest fires across Sweden, necessitating assistance from other European countries.

What is the issue?

Climate change projections indicate an increase in air temperature, heat waves and dry spells, and a decrease in summer rainfall across many European countries, contributing to increased ignition probability and fire spread. Also ongoing changes in land use around some cities - urban sprawl, which increases the urban-rural interface, abandonment of agricultural land causing development of shrubland, tree plantations - intensify the wildfire risk.

Wildfires are a threat not only to forests and rural areas, but also to houses and infrastructure at the rural-urban interface. Furthermore, smoke and ash can affect people's health far beyond the burnt area. Some social groups may be more vulnerable than others, either because of reduced capacity to escape direct impacts, or due to difficulties in replacing lost assets. In particular, the elderly and children as well as those in poor health are at higher risk due to their low mobility and being highly affected by stress and



Metrics from Level(s)

	1	Green house gas emissions along a building's life cycle	1.1 Use stage energy performance	kilowatt hours per square metre per year [kWh/m²/yr]	1.2 Life cycle Global Warming Potential	kgCO ₂ equivalents per square metre per year					
	2	Resource efficient + circular material	2.1 Bill of quantities	Unit quantities mass + years	2.2 Construction + demolition waste + materials	kg of waste + materials per m²	2.3 Design for adaptability use	Adaptability score	2.4 Design for deconstruction, reuse + recycling	Deconstruction score	
	3	Efficient use of water resources	3.1 Use stage water consumption	m³/yr water per occupant							
	4	Healthy + comfortable spaces	4.1 Indoor air quality	Parameters for ventilation, CO ₂ + humidity	Target list of pollutants: TVOC, formaldehyde, CMR, VOC, LCI robe, mold, benzene, particulates, radon	4.2 Time outside of thermal comfort range	% of the time out of range during the heating and cooling seasons	4.3 Lighting + visual comfort use	Level 1 check list	4.4 Acoustics + protection against noise	Level 1 checklist
	5	Adaptation + Resilience	5.1 Protection of occupier health + thermal comfort	Projected % time out of range in the years 2030 and 2050 [see also 4.2]	5.2 Increased risk of extreme weather events	Level 1 checklist [under development]	5.3 Increased risk of flood events	Level 1 checklist [under development]			
	6	Optimised life cycle cost and value	6.1 Life cycle costs	Euro per square metre [€/m²/yr]	6.2 Value creation + risk exposure Indoor air quality	Level 1 checklist					

Metrics from Level(s)



1. Greenhouse gas emissions along a buildings life cycle

Minimise the whole life carbon output, considering both energy consumption during the use phase of the building and embodied energy.

Indicators:

- 1.1 Use stage energy performance (kWh/m²/yr)
- 1.2 Life cycle Global Warming Potential (CO₂ eq./m²/yr)



5. Adaption and resilience to climate change

Futureproof building performance against a changing climate and extreme weather.

Indicators:

- 5.1 Protection of occupier health and thermal comfort
- 5.2 Increased risk of extreme weather
- 5.3 Sustainable drainage



6. Optimised life cycle cost and value

Take a long term view of the whole life costs and market value to deliver more sustainable buildings.

Indicators:

- 6.1 Life cycle costs (€/m²/yr)
- 6.2 Value creation and risk factors

Life Cycle Assessment (LCA)

LCA is a methodology used to evaluate the **environmental impacts** of a product, process, or service throughout its entire life cycle (ISO 14040:2006)

LCA considers the **various stages** of a product's life, including raw material extraction, manufacturing, distribution, use, and disposal



Environmental Impact Categories

Life Cycle Assessment aims to evaluate the contributions of products or buildings on different environmental issues such as climate change (i.e., Global Warming Potential), water consumption, land use and resource use.

A wide range of environmental issues is covered to ensure a comprehensive assessment. In the construction sector, 16 impact categories are usually analysed.



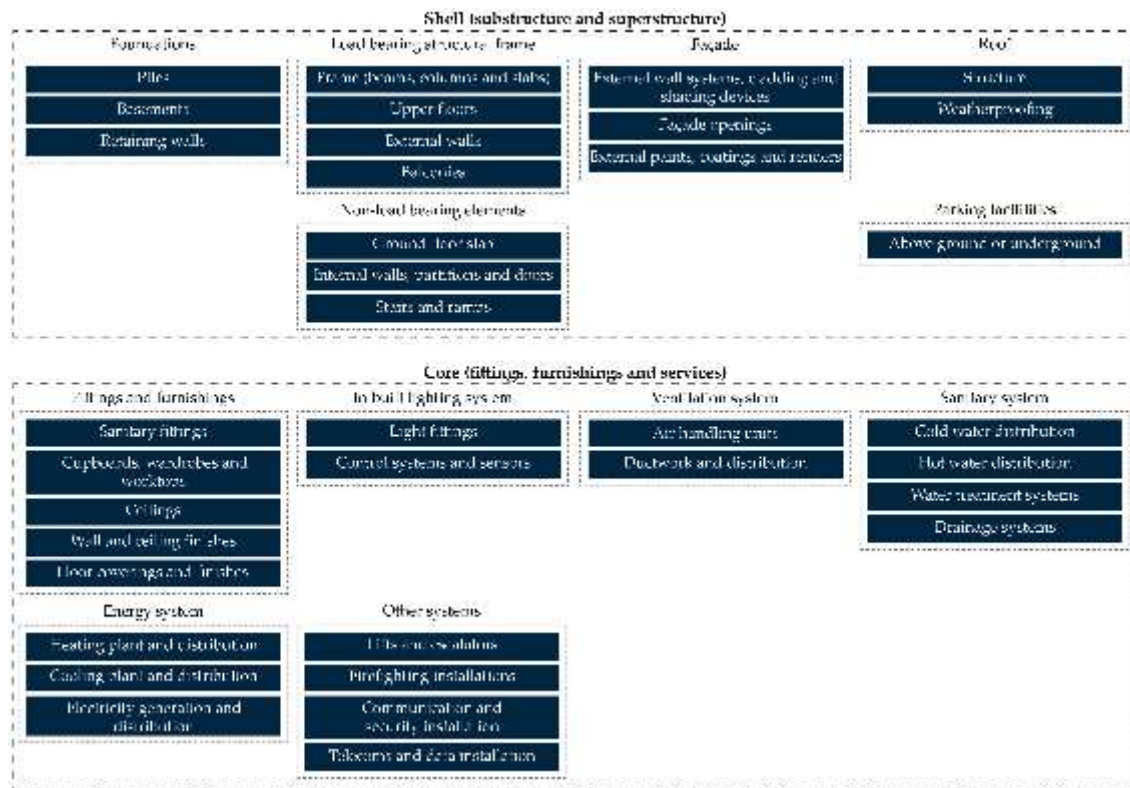
Example: Environmental Impact Categories

This indicator refers to the increase in the average global temperatures as a result of greenhouse gas (GHG) emissions. The greatest contributor is generally the combustion of fossil fuels such as coal, oil, and natural gas.

The global warming potential of all GHG emissions is measured in kilogram of carbon dioxide equivalent (kg CO₂ eq), namely all GHG are compared to the amount of the global warming potential of 1 kg of CO₂.

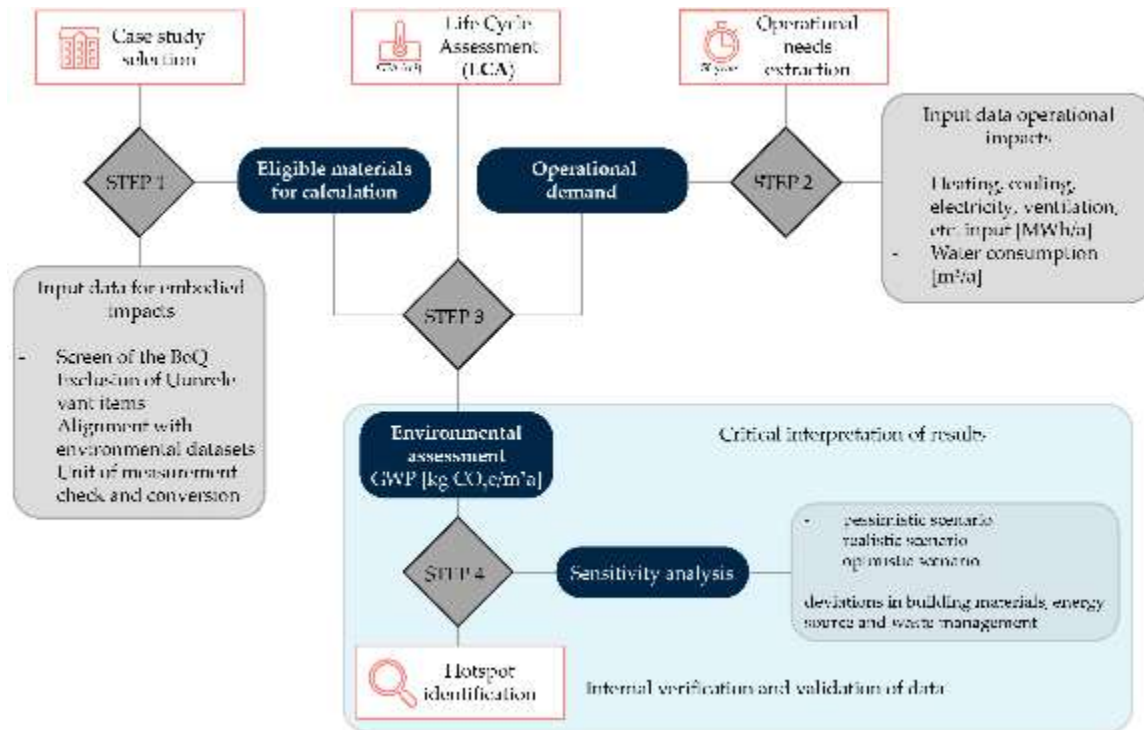


Example: LCA of a building



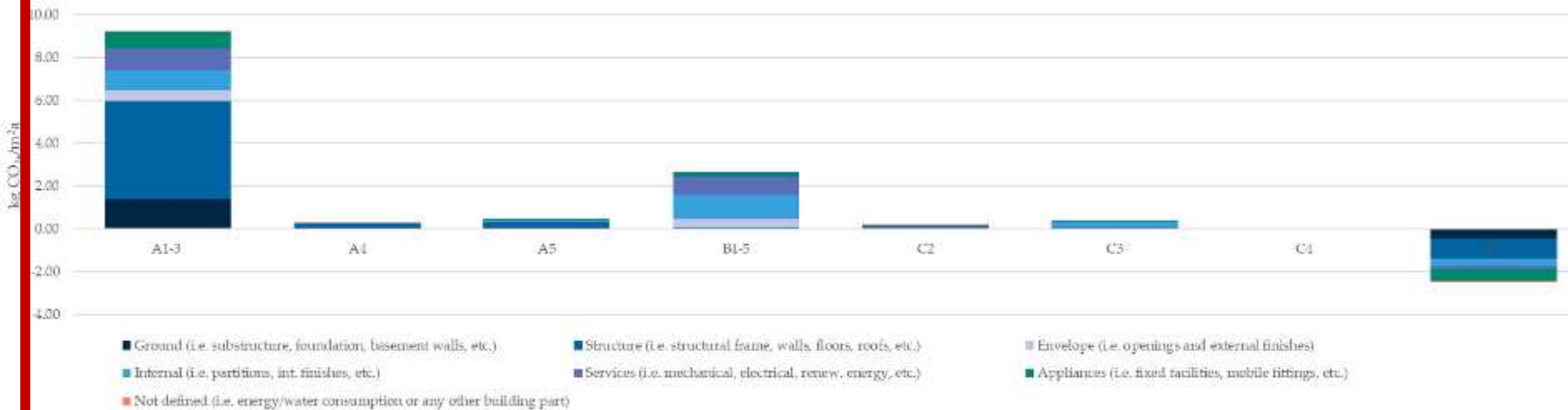
Building classification system defined by Level(s)

Example: LCA of a building



Workflow of the LCA calculation for any building case study

Example: LCA of a building



Example of a residential building case study GWP embodied impact divided by building parts, from module A to module D

Environmental Product Declarations (EPDs)

EPDs signal a manufacturer's commitment to measuring and **reducing the environmental impact** of its products and services and report these impacts in a hyper-transparent way.

With an EPD, manufacturers report **comparable, objective and third-party verified data** that show the good, the bad and the evil about the environmental performance of their products and services.

When developing an EPD, the environmental performance of the product shall be described from a **life cycle perspective** by carrying out an LCA of the product. The results of the LCA study and other information mandated by the reference Product Category Rules (PCR) and General Programme Instructions shall be compiled in the EPD reporting format.



Example: EPD information

FENIX

EPD®

Results of the environmental performance indicators

Mandatory impact category indicators according to EN 15804

Results per functional or declared unit

Indicator	Unit	A1 A3	A4	A5	B1	B2	B3	B4	B6	B6	B7	C1	C2	C3	C4	D
GWP-fossil	kg CO ₂ eq.	2,77E+01	1,54E+00	7,25E-02	ND	ND	ND	ND	ND	ND	ND	5,26E-01	2,19E-01	5,26E-01	5,14E+00	0
GWP-biogenic	kg CO ₂ eq.	2,90E-01	3,59E-03	2,13E-04	ND	ND	ND	ND	ND	ND	ND	4,13E-04	5,25E-04	4,13E-04	1,89E-02	0
GWP-total	kg CO ₂ eq.	4,87E-02	5,31E-04	1,80E-05	ND	ND	ND	ND	ND	ND	ND	4,15E-05	7,37E-05	4,15E-05	3,09E-04	0
GWP-fossil	kg CO ₂ eq.	2,81E+01	1,54E+00	7,27E-02	ND	ND	ND	ND	ND	ND	ND	5,27E-01	2,20E-01	5,27E-01	5,16E+00	0
ODP	kg CFC 11 eq.	5,57E-06	3,48E-07	1,03E-09	ND	ND	ND	ND	ND	ND	ND	1,13E-07	4,97E-08	1,13E-07	1,08E-07	0
AP	mol H ⁺ eq.	1,77E-01	7,24E-03	2,87E-04	ND	ND	ND	ND	ND	ND	ND	3,27E-03	8,77E-04	3,27E-03	2,72E-03	0
EP-freshwater	kg P eq.	3,52E-03	1,02E-04	1,04E-05	ND	ND	ND	ND	ND	ND	ND	1,58E-05	1,47E-05	1,58E-05	1,46E-04	0
EP-marine	kg N eq.	1,54E-02	2,14E-03	6,88E-05	ND	ND	ND	ND	ND	ND	ND	1,36E-03	2,68E-04	1,36E-03	8,76E-04	0
EP-terrestrial	mol N eq.	4,26E-01	2,34E-02	6,48E-04	ND	ND	ND	ND	ND	ND	ND	1,48E-02	2,93E-03	1,48E-02	8,30E-03	0
POCP	kg MNVOC eq.	1,11E-01	7,06E-03	2,32E-04	ND	ND	ND	ND	ND	ND	ND	4,18E-03	8,98E-04	4,18E-03	2,28E-03	0
ADP-minerals & metals	kg Sb eq.	7,57E-03	6,45E-06	5,34E-07	ND	ND	ND	ND	ND	ND	ND	2,11E-07	7,99E-07	2,11E-07	3,01E-06	0
ADP-fossil	MJ	4,33E+02	2,52E+01	8,28E+01	ND	ND	ND	ND	ND	ND	ND	7,17E+00	3,31E+00	7,17E+00	5,52E+00	0
WDPP	m³	1,64E+01	6,57E-02	2,34E-02	ND	ND	ND	ND	ND	ND	ND	1,04E-02	8,43E-03	1,04E-02	4,42E+00	0

Acronym

GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-total = Global Warming Potential (and use and land use change); ODP = Ozone Depletion potential of the stratospheric ozone layer; AP = Acidification potential; Accumulated Excessance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater and compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine and compartment; EP-terrestrial = Eutrophication potential, Accumulated Excessance; POCP = Potential of tropospheric ozone; ADP-minerals & metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (use) deprivation potential, deprivation-weighted water consumption.

* Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.

Life Cycle Costing (LCC)

- LCC is a method for assessing the **total cost** of facility ownership. It takes into account all costs of acquiring, owning, and disposing of a building or building system.
- LCC is especially useful when project alternatives that fulfill the same performance requirements, but differ with respect to initial costs and operating costs, have to be compared in order to select the one that maximizes net savings.
- LCC refers to [ISO 15686-5](#) and [EN 16627](#).

LCC Assessment Scope

- **A0-A5 *pre-construction and before use stage***: Costs of purchase, building product, costs related to the transport between factory and site, project feasibility, planning, design, engineering and construction costs, site clearance and landscaping (e.g. lawn, trees, and similar within the curtilage and other external works costs).
- **B1-B3 *operation and maintenance costs***: Building-related facility management costs, repair costs; ground maintenance; redecoration.
- **B4-B5 *replacement/refurbishment***: Planned adaptation or refurbishment, replacement of major systems and components (incl. associated design and project management).
- **B6-B7 *operational energy/water use***: Energy costs (incl. fuel and electricity for heating, cooling, power, domestic hot water, and lighting, and water-related costs).
- **C1-C4 *deconstruction***: Demolition costs; transport costs associated with deconstruction and disposal; fees & taxes (e.g. landfilling); waste processing costs.

Present-Value Analysis

Discount Rate

Converts future cash flows to present values for comparison.

Reflects the opportunity cost of capital (minimum acceptable return).

At EU level: Use national guidelines or EU-recommended real discount rates (e.g., 4% real rate per European Commission guidance in cost-benefit analysis for investment projects).

Cost Periods

Study Period: From base date through planning, construction & service life.

Must be uniform for all alternatives (*typically 30-50 years for buildings/infrastructure in EU practice*).

Inflation Treatment

Constant prices: Exclude general inflation; often used in public sector investment analysis.

Current prices: Include inflation; suitable for private investment cases or when comparing with real-world payments.

Both approaches yield the same present-value LCC if applied consistently.

Resources and Further Reading

- IPCC reports (summary for policymakers) - [*downloadable here*](#)
- EU-wide assessment of the final updated National Energy and Climate plans (NECPs) [2025] - [*available here*](#)
- LCA methodology - more details [*available here*](#)
- Climate-ADAPT Case studies - more information and case study catalogues [*here*](#)