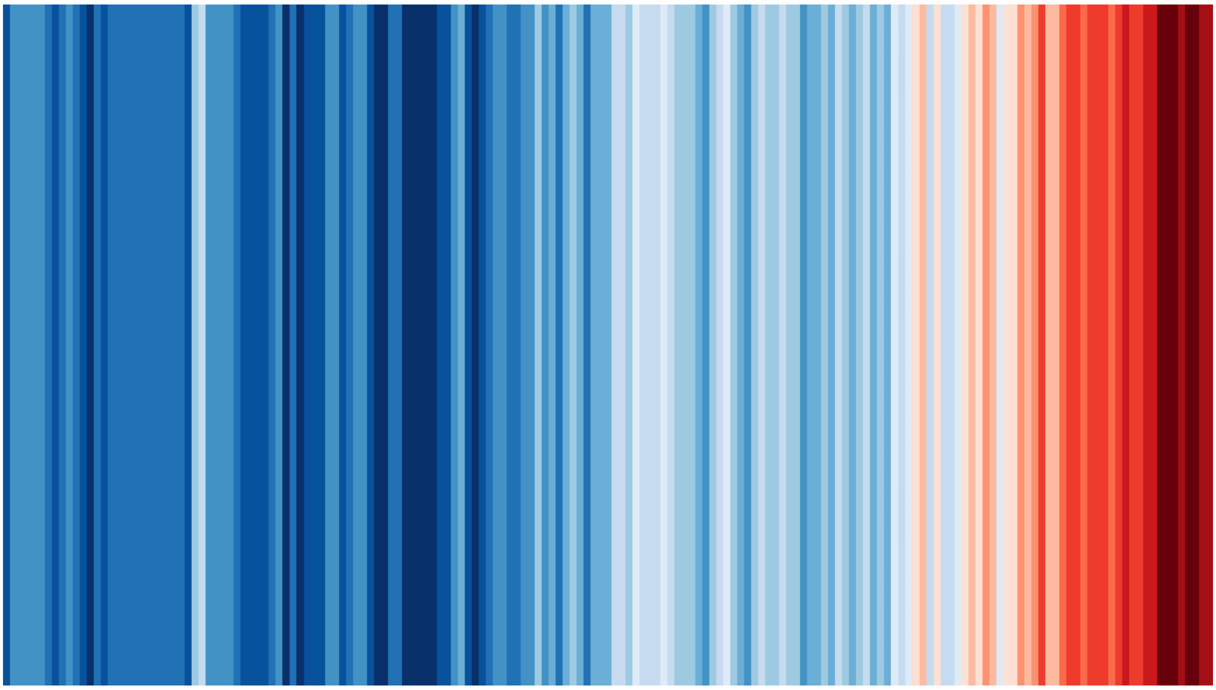
ASSESSMENT OF CLIMATE CHANGE IMPACTS

Environmental risks analysis & management



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1.1. Background information on climate change

1.1.1. What are the main causes and consequences of climate change?

Climate change refers to long-term shifts and alterations in Earth's climate patterns and systems. It is primarily caused by the increase in greenhouse gas concentrations in the atmosphere, essentially due to human activities. The most significant greenhouse gas is carbon dioxide (CO2), but others like methane (CH4), nitrous oxide (N2O), and fluorinated gases also contribute to the greenhouse effect. This effect is a natural phenomenon that allows the Earth to retain heat from the Sun, making it habitable. However, human activities have enhanced the greenhouse effect by releasing more greenhouse gases, which trap heat in the atmosphere and lead to global warming: the long-term increase in Earth's average surface temperature. It leads to rising global temperatures, which in turn cause melting glaciers, ice caps, and polar ice, resulting in sea-level rise. Changes in precipitation patterns can lead to more frequent and intense droughts, floods, and storms. Climate change also affects agriculture, biodiversity, human health, and the economy [1].

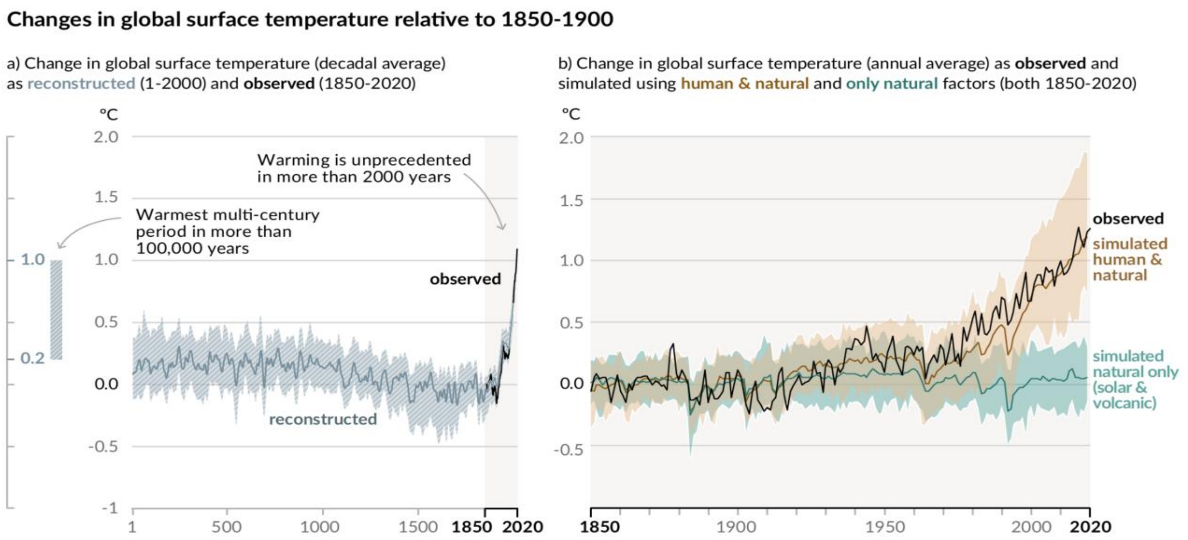
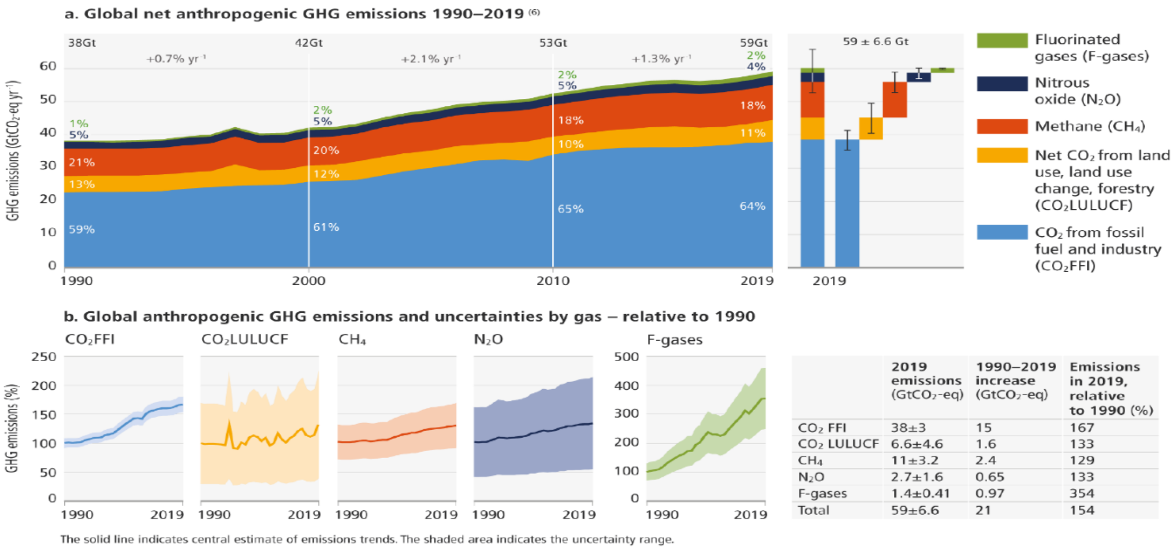


Figure 1 – Changes in global surface temperature relative to 1850 – 1900 [2]

1.1.2. The evolution of greenhouse gases concentration in the atmosphere

The evolution of greenhouse gas (GHG) emissions has been characterized by significant increases over time, particularly since the beginning of the industrial era. During the Pre-industrial Era (before 1850), GHG emissions were relatively stable. Human activities, such as agriculture and deforestation, released limited amounts of GHGs. The natural processes of emissions and absorption by ecosystems maintained a relatively balanced carbon cycle. The industrial revolution marked a significant shift as societies began to rely heavily on fossil fuels, primarily coal, for energy generation. The widespread use of coal in factories, transportation, and later the expansion of oil and natural gas use, led to a substantial increase in CO2 emissions. However, GHG emissions remained relatively low compared to current levels. The 20th century saw a rapid acceleration in GHG emissions. With the growth of industrialization, population, and urbanization, energy consumption soared. The burning of fossil fuels, along with changes in land use and agricultural practices, led to a significant increase in CO2, methane, and nitrous oxide emissions. The expansion of transportation, increased energy demand for residential and commercial sectors, and the rise of heavy industries contributed to this upward trend. GHG emissions continued to rise steadily throughout the latter half of the 20th century and early 21st century. Developing countries experienced rapid industrialization, resulting in increased emissions. The burning of fossil fuels for energy, as well as deforestation and changes in land use, remained primary drivers of emissions. The growth of transportation, especially in emerging economies, further contributed to the increase [2], [3]. Increased awareness of climate change and its impacts led to international efforts to address GHG emissions. The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992, leading to various global agreements and initiatives. The Kyoto Protocol (1997) set binding emission reduction targets for developed countries, while the Paris Agreement (2015) aimed to limit global temperature rise well below 2 degrees Celsius above pre-industrial levels.



	2019 emissions (GtCO₂-eq)	1990–2019 increase (GtCO₂-eq)	Emissions in 2019, relative to 1990 (%)
CO_2 FFI	38±3	15	167
CO_2 LULUCF	6.6±4.6	1.6	133
CH_4	11±3.2	2.4	129
N_2O	2.7±1.6	0.65	133
F-gases	1.4±0.41	0.97	354
Total	59±6.6	21	154

Figure 2 – Global anthropogenic GHG emissions from 1990 to 2019 [2]

1.2. Assessing climate change impacts gives us a better understanding

Assessing climate change impacts and environmental risks is crucial because it helps in understanding the magnitude and scope of the impacts and potential risks. The assessments provide scientific data and knowledge that helps policymakers, businesses, and communities comprehend the potential consequences of climate change on various sectors, regions, and ecosystems. This understanding is essential for developing effective mitigation and adaptation strategies [4].

2. Methodology of assessment

2.1. An assessment process in 4 steps

The assessment process aims to gather, analyse, and synthesize relevant information to assess the potential impacts of climate change and environmental risks. It typically involves a multidisciplinary approach, integrating scientific research, data analysis, stakeholder engagement, and expert knowledge. The process helps in understanding the current and future state of the environment, identifying vulnerabilities, and informing decision-making for adaptation and mitigation strategies [5], [6].

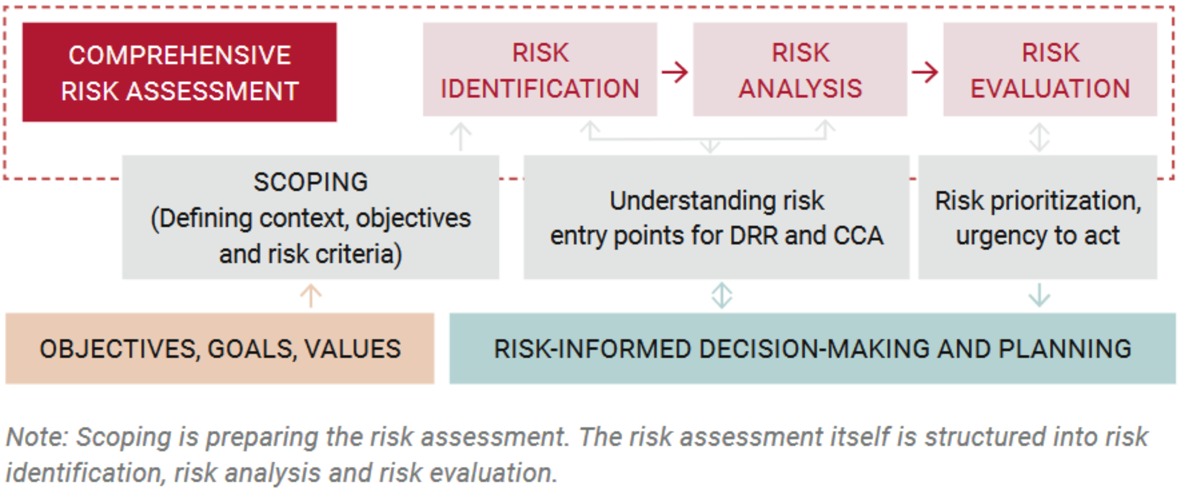


Figure 3 – Phases of a risk assessment according to ISO31000 and the relationship with risk-informed decision-making and planning [6]

2.1.1. Scoping: defining the scope of the assessment

The first step in the assessment process is defining the scope of the assessment. This involves clearly articulating the objectives, boundaries, and focus of the assessment. It includes determining the geographic scale, time frame, and sectors or systems to be assessed. Scope-setting also involves identifying the stakeholders and decision-makers who will be involved in or affected by the assessment.

2.1.2. Identification: gathering data on impacts and risks

The identification step involves gathering information and data related to climate change impacts and environmental risks. This includes reviewing scientific literature, data sources, reports, and other available information. The goal is to identify the potential hazards, vulnerabilities, and exposure to climate change and other environmental factors. It involves analysing various sectors such as water resources, agriculture, infrastructure, human health, ecosystems, and socio-economic aspects.

2.1.3. Analysis: processing the information

In the analysis step, the collected information is processed and analysed to assess the potential impacts and risks. This involves evaluating the magnitude, likelihood, and timing of climate change impacts on different systems and sectors. Analytical tools such as modelling, scenario development, and data analysis techniques are employed to quantify the potential outcomes. The analysis considers both physical impacts (e.g., temperature rise, sea-level rise, extreme events) and socio-economic impacts (e.g., economic losses, human displacement, public health risks).

2.1.4. Evaluation: ranking and synthesising the impacts

The evaluation step involves synthesizing and interpreting the analysed information to provide an overall assessment. It includes assessing the significance of the identified impacts and risks, considering their implications for ecosystems, human societies, and the economy. The evaluation process also considers the effectiveness of existing adaptation and mitigation measures and identifies gaps in knowledge or actions. This step often involves engaging stakeholders, experts, and decision-makers to ensure a comprehensive evaluation and to facilitate the development of appropriate responses.

2.2. Climate models are used to assess impacts and the results are published in relevant documentation

2.2.1. Climate models are the most common tools to assess impacts

The most common tool to assess climate change impacts are the climate models, or general circulation model (GCM): complex computer-based tools used to simulate and predict Earth's climate system [7].

Climate models divide the Earth's atmosphere, oceans, land, and ice into a three-dimensional grid. Each grid cell represents a small portion of the Earth's surface and contains variables such as temperature, humidity, wind speed, and pressure. The grid cells are interconnected to simulate the exchange of energy, moisture, and momentum between different components of the climate system.

The relevant mathematical equations are used to describe the physical processes that influence the climate. These equations are based on fundamental principles of physics, such as fluid dynamics, thermodynamics, and radiative transfer. They represent the laws of motion, conservation of mass and energy, and the interactions of radiation with the atmosphere and surface.

There are many different models depending on what is being modelled: The geography, time scale, or area of impact being studied can vary from model to model depending on the need.

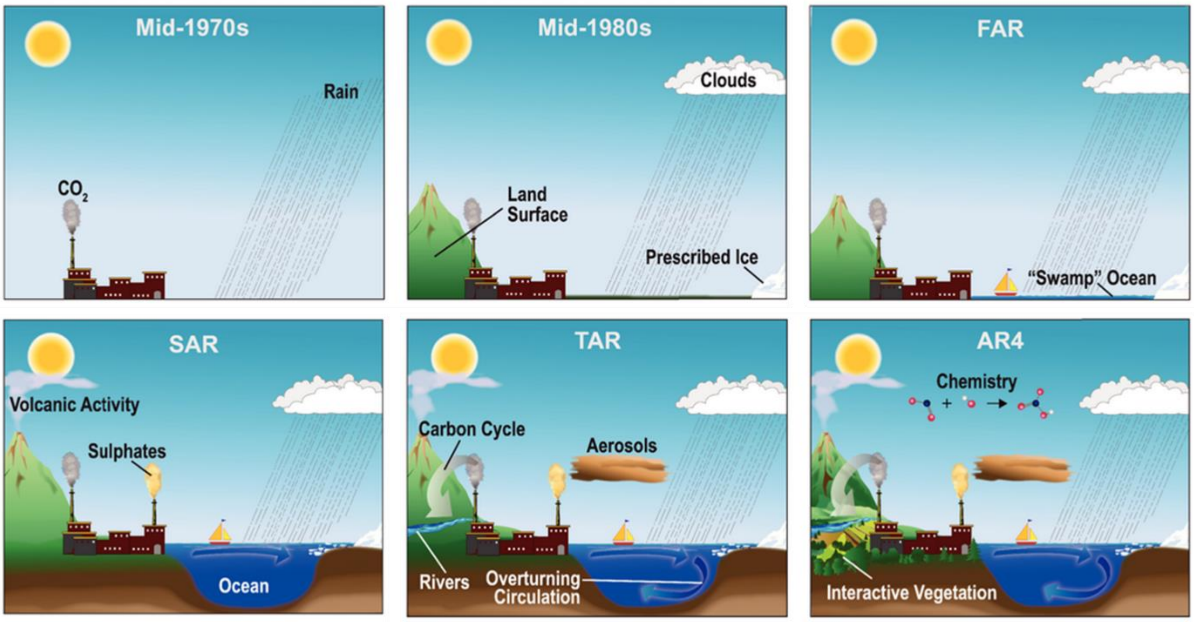


Figure 4 – The world in climate models [7]

2.2.2. Many organisations provide relevant documentation on climate change impacts

Some reliable organisations and websites provide documentation on climate change impacts, financial regulation, and energy-related topics to help companies or policy-makers into assessing their own risks and implementing the most effective actions [8]–[11].

The most famous one is the Intergovernmental Panel on Climate Change (IPCC). It is the leading international body for assessing climate change. Their reports provide comprehensive assessments of the scientific, technical, and socio-economic aspects of climate change. They offer insights into climate impacts, adaptation, and mitigation strategies. The UN also has a specialised branch for climate research: United Nations Framework Convention on Climate Change (UNFCCC). Their website offers resources on climate change impacts, adaptation, and mitigation, including reports, publications, and information on global climate negotiations.

The World Bank provides extensive resources on climate change impacts, financial regulation, and energy-related topics. Their publications cover climate risk assessment, climate finance, renewable energy, and sustainable development. The Financial Stability Board (FSB) is an international body that monitors and makes recommendations about the global financial system. They have a Task Force on Climate-related Financial Disclosures (TCFD) that provides guidance on climate-related financial reporting and risk management.

The International Energy Agency (IEA) is an autonomous agency that focuses on energy-related research and policy analysis. Their reports provide insights into energy transition, renewable energy, energy efficiency, and climate change mitigation strategies.

These organisations are known for their reputable and reliable information on climate change impacts, financial regulation, and energy-related topics. Thanks to all these organisations and reports, we can cross-reference the information to get the most reliable and up-to-date information.

2.2.3. Other models can assess risks related to the impacts

Having assessed the impacts of climate change, it is necessary to assess the associated risks. For this, there are several other mathematical models. The following 3 models have been developed for the analysis of economic, energy and environmental risks in the EU [12].

- GEM-E3 is designed to analyse the interactions between the economy, energy systems, and the environment, thus, for analysing climate and energy policies, including assessing the impacts of greenhouse gas emissions reduction targets, evaluating the economic implications of renewable energy deployment, and examining the interactions between environmental regulations and economic development [13].
- PRIMES is an energy system model which provides a detailed representation of the European energy system and enables the analysis of energy policies and their implications on various dimensions, such as energy supply, demand, and environmental impacts [14].
- GLOBIOM focuses on land use, agriculture, and forestry sectors and their interactions with energy, climate, and biodiversity. It also evaluates the effectiveness of climate mitigation and adaptation policies in the agriculture and forestry sectors at the global scale [15].

3. What are the key impacts and risks of climate change?

3.1. Rising temperature and sea-level rise: the most well-known impacts

The first impact of climate change that everyone thinks of is rising temperatures. This is accompanied by an increase in the frequency and intensity of heatwaves. In all climate models, the greater the warming, the greater the likelihood of a heat wave and the higher the maximum temperature of that heat wave. In general, these are all climatic events that are likely to occur more frequently and more intensely: heatwaves, droughts, floods, hurricanes, and wildfires. These events can cause significant damage to infrastructure, disrupt ecosystems, and threaten human lives and livelihoods. Also, as the planet warms, glaciers and ice sheets melt, contributing to sea-level rise. This poses a threat to coastal communities, infrastructure, and ecosystems. In addition, climate change alters precipitation patterns, leading to shifts in rainfall distribution, intensity, and timing. Some regions may experience more frequent and intense rainfall, leading to an increased risk of flooding. Other regions may face more prolonged droughts, affecting water availability, agriculture, and ecosystems [2].

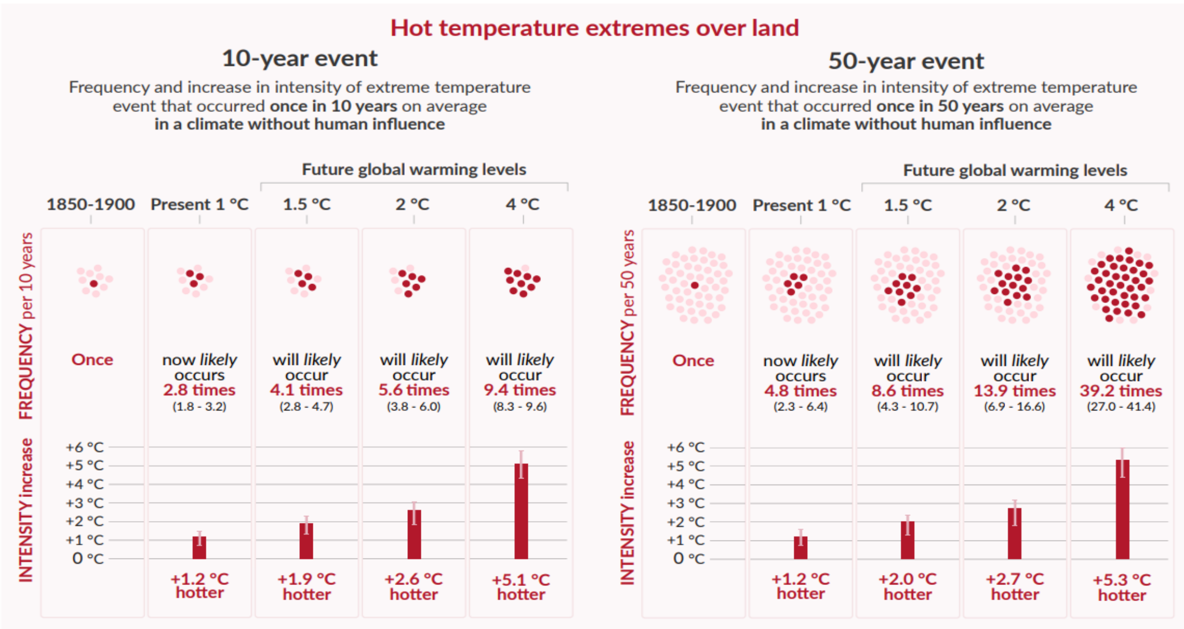


Figure 5 – Hot temperature extremes over land [2]

The consequences of climate change are expected to occur globally, affecting various regions and ecosystems in different ways. However, some key areas may experience more sever impacts. For instance, rising sea levels and increased coastal flooding are major concerns for low-lying coastal regions and small island nations. Another example are the Arctic and Antarctic regions, experiencing some of the most rapid changes due to climate change. The melting of glaciers and ice sheets affects the delicate ecosystems and wildlife adapted to cold environments.

3.2. Impacts lead to many cascading risks

From these climatic impacts, a whole cascade of risks exists. Climate change can indeed contribute to mass migration in several ways. Its impacts can render certain areas uninhabitable or unsuitable for agriculture, livestock rearing, or human settlement. This can lead to forced displacement of populations as they are compelled to leave their homes and seek more favourable living conditions.

It can also disrupt agricultural activities, fisheries, and other livelihood sources, particularly in vulnerable regions heavily dependent on natural resources. Changes in precipitation patterns, prolonged droughts, and declining crop yields can lead to income loss, food insecurity, and poverty. In such circumstances, people may be compelled to migrate in search of better economic opportunities [16].

Food insecurity can also be triggered by pests and diseases because climate change can influence the spread and intensity of pests and diseases that affect crops and livestock. Rising temperatures and altered weather patterns can create more favourable conditions for pests, such as insects and fungi, leading to increased infestations and crop damage. Disease outbreaks in livestock can also reduce meat and dairy production, affecting food availability and livelihoods. Furthermore, climate change can contribute to soil degradation, erosion, and desertification, particularly in vulnerable regions. Extreme weather events, such as intense rainfall and droughts, can exacerbate these processes. Land degradation reduces agricultural productivity, depletes soil nutrients, and limits the ability to cultivate crops, leading to food insecurity.

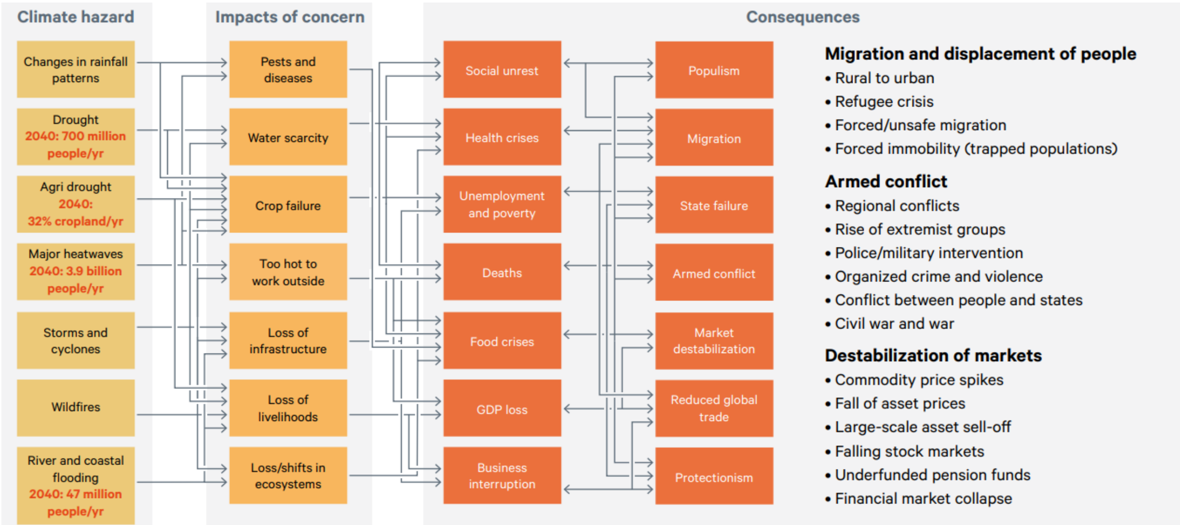


Figure 6 – Major systemic risk dynamics [16]

4. Case study: the CAPRA platform

4.1. A risk and impact analysis platform in Latin America

The CAPRA (or eCAPRA, Enhanced Comprehensive Process for Assessing Risk) platform is a specific risk assessment tool developed thanks to a partnership between the Centre for Coordination of Natural Disaster Prevention in Central America (CEPREDENAC), the United Nations International Strategy for Disaster Reduction (UN ISDR), the Inter-American Development Bank (IADB) and The World Bank, since 2008 [17]. CAPRA is designed to assess and manage risks associated with development projects, particularly in the context of climate change adaptation and disaster risk reduction in Latin America. It provides a systematic approach to identify, analyse, and prioritize risks, enabling project planners and managers to make informed decisions and implement appropriate risk reduction measures.

The CAPRA tool aims to enhance resilience and sustainability in project planning and implementation by incorporating risk considerations into decision-making processes. It assists in identifying areas of intervention, setting priorities, and allocating resources to mitigate risks and build adaptive capacity.

4.2. A thorough process for the most accurate results possible

The platform follows a systematic process to do so. The platform begins by collecting relevant data, including hazard information, climate projections, socio-economic data, and spatial data such as maps and satellite imagery. This data provides the foundation for the risk assessment process. Then, multiple hazards that may affect the project area, such as floods, storms, droughts, or other climate-related events are assessed. It analyses historical data, climate projections, and other relevant information to estimate the likelihood and intensity of these hazards. For these hazards, the platform evaluates the exposure and vulnerability of assets, such as infrastructure, ecosystems, and communities, to the identified hazards. It considers factors like physical exposure, socio-economic conditions, and adaptive capacity to determine the potential impact of the hazards on the project area.

Using the collected data and assessments, the platform employs risk modelling techniques to quantify and map the risks associated with the identified hazards. It combines hazard likelihood, asset exposure, and vulnerability to generate risk profiles and maps, highlighting areas of high risk within the project area. A prioritization is then possible as the platform supports decision-making process. It considers various factors, such as the potential consequences, cost-effectiveness of risk reduction measures, and stakeholders' priorities, to inform risk management strategies and interventions. Based on that, the platform assists in identifying appropriate risk reduction strategies and adaptation measures. It provides guidance on selecting and implementing interventions to reduce the identified risks and enhance resilience.

Finally, the platform supports ongoing monitoring and evaluation of risk reduction measures. It enables tracking the effectiveness of implemented interventions, updating risk assessments over time, and facilitating adaptive management based on changing conditions and new information.

5. Conclusion

The impacts of climate change are wide-ranging and require urgent attention from global communities. The assessment of these impacts is required to understand the risks, vulnerabilities, and potential consequences associated with climate change. The eCAPRA platform serves as a valuable example, showcasing the power of integrated risk assessment and management in addressing climate change impacts. Through the platform, decision-makers can access a comprehensive and systematic approach to identify, analyse, and prioritize risks.

However, addressing climate change impacts cannot be accomplished by isolated efforts alone. Collaboration is needed to succeed. The need for collaborative action is evident, from local communities to national governments and international organizations. With partnerships, sharing knowledge and expertise, and aligning efforts, stakeholders can leverage collective resources and perspectives to tackle the complex challenges posed by climate change.

In conclusion, addressing climate change impacts requires a holistic approach that combines robust assessment methodologies, collaborative action, and mainstreaming of risk considerations. By leveraging tools like eCAPRA and working together, we can forge a path towards a more sustainable and resilient future. It is our collective responsibility to take action, mitigate the impacts of climate change, and ensure the well-being of current and future generations.

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