Clim INVEST

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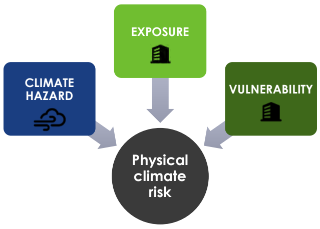
Climate risk

This factsheet is part of a suite of scientific factsheets intended to build financial decision makers' understanding about climate risk assessment, data needs, climate modeling and extreme events. For more detailed information about floods, heat waves, and drought, and associated indicators, see the ClimINVEST hazard factsheets. For more information about climate modeling, see the Climate modeling 101 factsheet. This factsheet focuses on the basic elements of physical climate risk assessment.

Defining physical climate risk

There are three key components of physical climate risk to consider in any analysis:

1. Climate hazards
2. Exposure to the climate hazard
3. Vulnerability to the climate hazard.



CLIMATE HAZARD: Potential occurrence of a trend or event that has adverse consequences to the system of interest. It may comprise the likelihood and magnitude of the event or trend.

EXPOSURE: Propensity or predisposition of the system of interest to suffer adverse consequences from its exposure to the considered hazard.

VULNERABILITY: Presence of the system of interest in a place and setting that could be adversely affected by a climate hazard. It encompasses concepts such as sensitivity or lack of capacity to cope and adapt.

This approach is widely compatible with the Intergovernmental Panel on Climate Change (IPCC) and Task Force on Climate-related Financial Disclosures (TCFD) methodologies.

Climate hazards can be acute or chronic. Acute hazards are isolated events, such as floods, landslides, wildfires, storms, heat or cold waves, droughts and extreme precipitation. Chronic hazards are longer term pattern shifts in precipitation, temperature, ice melt or sea level rise. These hazards can be described using climate indicators drawn from climate models. The frequency, intensity, and probability of most climate hazards is expected to increase as the climate warms. Hazards (e.g. droughts) can be assessed at the global or local level and some assessments may involve further modeling (such as hydrological models for floods) to achieve a higher level of detail.

Exposure is determined by assets' location, financial value and hazard probability, intensity and frequency at a certain location. The scale of exposure can range broadly and could include (but is not limited to) supply chains, companies, sectors, buildings, cities, geographic regions, asset classes, portfolios or sovereigns.

Vulnerability is the degree to which an asset is susceptible to and unable to cope with adverse effects of climate hazards. It is important to note that two assets can be equally exposed to the same hazard but have different levels of vulnerability. Vulnerability is a function of sensitivity (to a hazard) and adaptive capacity. Vulnerability can be assessed at various levels, including but not limited to region, country, sector, company, or asset. It is determined by ground conditions and asset specifications such as building materials, crops grown, etc. and may require access to data that is not readily available.

- ➔ **Sensitivity** determines how the exposed asset is affected when hazards occur. Sensitivity can vary significantly by asset, company, sector or government under study, and depends on specificities like building materials, design and land use – these are elaborated in the following section. Higher sensitivity implies increased physical and financial impacts related to climate hazards. Grouping assets by sector and identifying the most sensitive sectors can provide a quick, high-level assessment and help prioritize assets for further in-depth analyses. For example, assets in the transportation sector and agricultural sector that are exposed to the same drought will not be similarly impacted: the transportation sector assets may experience little direct impact, whereas the agricultural sector assets – depending on the crops grown – may experience significant setbacks. The ClimINVEST project maps potential sector sensitivity to climate hazards and its consequences in terms of physical and financial impacts.

  Sensitivity is part of an asset's vulnerability, but it must be combined with adaptive capacity to get the full picture. For more information about sector sensitivities by hazard, see the **ClimINVEST hazard factsheets**.

- ➔ **Adaptive capacity** is the ability of a company, sector or region to adjust effectively to climate change. A system with high adaptive capacity would be able to cope better with, and perhaps even benefit from, changes in the climate, whereas a system with a low adaptive capacity would be more likely to suffer from the same change.

Assessing climate hazards and exposure

Climate data, from raw data to processed sector-specific indicators, are now easily accessible from public and private sources. However, processing this data outside the climate science community can be challenging.

- ✓ **Climate data usability.** Climate data sets are publicly available via large climate model intercomparison projects (see **Climate modeling 101 factsheet** for more details). Handling raw climate data files in the available formats (netcdf) require specialized expertise and appropriate software. The easiest way to interact with climate data is postprocessing through an intermediary. Some platforms like Copernicus and Aqueduct offer ready-to-use publicly available data, maps and indicators; others (often private consultancy companies) offer postprocess climate data for a fee.
- ✓ **Time horizons.** The IPCC considers 20 years as the minimum amount of time needed to establish relevant climate statistics and collect a big enough sample of extreme events. Climate science provides continuous simulations from pre-industrial times to beyond 2100, from which 'time slices' can be selected and compared (e.g. climate statistics derived from current climate data for 1990-2010 can be compared with future climate simulations for 2025-2045). Ideally, the selected time slices should not overlap. Other types of information on shorter time horizons are available, i.e. sub seasonal and seasonal forecasts, as well as decadal predictions. However, climate predictions and forecasts are associated with significant uncertainties. The current internationally recognized climatological standard normal reference period is 1981 to 2010, as defined by the World Meteorological Organization (WMO). For near-term assessments (one to ten years), a current 'time slice' such as 2010 – 2040 can be used. For more information about climate models, see the ClimINVEST **Climate modeling 101 factsheet**.
- ✓ **Scenario uncertainty.** Future climate conditions are determined to a large extent by current and future greenhouse gas emissions. Future greenhouse gas emissions will be determined by socio-economic and political decisions that remain uncertain today, such as the rate and level of deployment of carbon pricing, energy efficiency, renewable energy, electric vehicles, land use and carbon capture and storage applications. The IPCC's 2014 Fifth Assessment Report (AR5) provides us with a range of possible future emissions trajectories which are similarly likely to happen. These Representative Concentration Pathways (RCPs) describe different levels of potential global warming from emissions, going from the most optimistic (RCP 2.6) to the most pessimistic (RCP 8.5) but do not assign probabilities to the individual scenarios. The IPCC's Sixth Assessment Report from Working Group I, which will be published in 2021 will compare five Shared Socioeconomic Pathways (SSPs), socioeconomic and technological trajectories that the world could follow this century.
- ✓ **Local climate.** While climate scenarios are developed on a global scale, the regional and local implications of global warming can vary significantly. Additionally, climate hazards – such as flooding– are highly localized and depend on local topography and hydrology. Physical climate risk assessments should ideally be conducted at a regional or local level to maximize accuracy.

Public resources for climate hazard data

Copernicus is the European Union's Earth observation program. Established in 2014, it pulls together all the information obtained by the Copernicus environmental satellites, air and ground stations and sensors to provide a comprehensive picture of the "health" of the Earth, including climate health. The Copernicus Climate Change Service offers an EU knowledge base in support of mitigation and adaptation policies for climate change. The data is made available free of charge.

Aqueduct, developed and managed by the World Resources Institute, offers publicly accessible tools that map water risks such as floods, droughts, and water stress using open-source, peer-reviewed data.

The European Environment Agency (EEA) is an EU agency, whose task is to provide sound, independent information on the environment. The EEA website contains publicly available, validated data on past, present and future climate as well as climate-related information on predisposing risk-prone contexts (e.g flood-prone areas, soil occupation, etc).

Climate research centers and national meteorological agencies around the world are responsible for generating weather and climate projections. Many of those institutions provide raw or processed climate data (e.g. the DRIAS data portal by Météo-France).

The World Climate Research Programme (WCRP) is an international programme that helps to coordinate global climate research. One of its tasks is the coordination on climate modelling activities from climate research centers.

The Coupled Model Intercomparison Project (CMIP) and the COordinated Regional Downscaling Experiment (CORDEX) aim at providing global and regional climate data and ensuring consistency among the different data sources and modelling centers. The Earth System Grid Federation (ESGF) offers data portals for accessing climate data issued from the CMIP and CORDEX frameworks.

Understanding and assessing vulnerability

Factors that contribute to an asset's overall vulnerability include the following:

- **Construction materials and design.** Older infrastructure may have been built to lower standards without taking climate change into account. Using heat waves as an example, buildings without adequate insulation are more likely to see higher risk of heat stress or increase energy costs due to air condition installations. Materials used for infrastructure in the transportation and energy sectors may not be stress tested at high enough temperatures. For example, the railway tracks in the UK failed under the 2018 heat waves when temperatures hit 35°C; they were stress-tested at 27°C.
- **Land use around the asset.** Urbanization and deforestation can exacerbate the impacts of a climate hazard. Urban areas experience higher temperatures than surrounding areas due to the urban heat island effect; pavements with non-porous surfaces can increase the risk for flooding; deforestation contributes to reduced air quality and soil erosion, which – coupled with extreme rainfall – can create the conditions for landslides.
- **Connectivity of the asset.** Assets in the energy, water, financial services, transportation and ICT sectors are highly interconnected. For example, the physical impact of a hazard – such as a tropical storm – at a power station or along a major transmission line can affect an entire power network. A water treatment plant with reduced capacity may have health implications for an entire community, and reduced access to cellular or internet services can severely impact emergency response or general economic activity.
- **Dependency of the asset.** This is particularly relevant for transportation infrastructure such as ports, train lines and roads. Areas with alternative routes available are less vulnerable, whereas areas with fewer transportation options can see significant setbacks in the case of a climate hazard, like flooding.
- **Time horizons of the asset.** Different sectors have different time horizons. Agriculture operates on a seasonal basis which may make it easier to adjust farming practices (e.g. drip irrigation or drought resistant crop varieties) and reduce vulnerability to a climate hazard in the shorter term. Real estate and other large infrastructure projects have 30-60-year time horizons. Once a structure is built, it becomes more difficult and expensive to adjust for climate resilience. The impacts of climate hazards may therefore have differing levels of relevance or immediacy for each sector.

Risk mitigation through adaptation measures

- Adaptation measures describe solutions that have been or could be implemented to minimize impact when a climate hazard occur. These measures may change an asset's sensitivity (e.g. the company changed building materials) and exposure (e.g. the company changed the location of its activities). For example, two buildings on the same city block would be exposed to the same flood or heat wave: The building where heating ventilation and air conditioning (HVAC) equipment is moved from the basement to the second floor or higher (i.e. adaptation measure) will be less likely lose functionality of those systems in a flood; the building that has high insulation and energy efficiency (i.e. adaptation measure) would fare better (lower energy costs, reduced heat stress) in a heat wave. Note that in these examples, to properly assess vulnerability to either climate event, data about energy efficiency retrofits and the location of HVAC equipment would need to be factored into an assessment of asset vulnerability; this data is often difficult to access or not available
- There are hard (e.g. investments in infrastructure) adaptation measures and soft (e.g. policy or pricing signals) adaptation measures that can be taken to increase an asset's adaptive capacity. Examples of hard measures include installing air conditioning systems to combat heat stress or building flood walls to manage sea level rise, and soft measures can be insurance coverage for potential damage costs and early warning systems that give populations time to prepare in case a hazard is imminent.

Data needs for risk assessment

In the example below, the factors affecting exposure and vulnerability of train tracks to a flash flood are laid out. As outlined in the red box, the sources of data input for asset sensitivity and adaptive capacity are less definitive and perhaps challenging to access. This is a major hurdle to accurate physical climate risk assessment.

Models are also needed to translate this data into risk information. Focus is given to data, and modelling needs are not included here.

Table 1. Assessing flash flood risk for low-lying train tracks

	Climate hazard	Asset exposure	Vulnerability	
			Asset sensitivity	**Adaptive capacity**
Data input	Climate indicators, scenario selection, grid resolution.	Location of the asset (addresses or GPS coordinates), financial value of the asset, time horizon.	Sector sensitivity, design, construction materials, age, connectivity, area land use, elevation.	Insurance, early warning systems, liquidity reserves to implement potential adaptation measures.
Source	Climate models or bridge platforms e.g. Copernicus.	Climate hazard maps, financial statements, addresses or GPS coordinates.	Construction proposals and blueprints, local topography, electricity grid and invoices.	Satellite imagery, municipal government hazard maps, local policies.
Example	Number of days when rainfall exceeds 50mm in western Norway for a high emission scenario (see *ClimINVEST Flooding* fact sheet for more details).	The next ten years, train tracks from point A to B, value of annual tickets sold for route, probability that the flash flood will happen.	Elevation of tracks, and-use surrounding the tracks.	Ability to install protective walls or buffers to absorb flood waters.

Key considerations in physical climate risk assessment

✓ **Data needs.** As outlined above, climate hazards affect countries, sectors, companies, or assets differently. Understanding which sectors or assets are most sensitive to climate hazards can help prioritize interventions or inform investment decisions. While the analysis of potential vulnerabilities at sectoral level can help prioritize efforts, risk assessment at a company and/or asset level should include company/asset-specific information to describe accurately its exposure, sensitivity and adaptive capacity.

✓ **Financial implications.** Climate hazards may impact more than one part of a value chain and/or different financial aspects. Financial impact can be on the asset value (CAPEX), on revenue generation, on operational costs (OPEX), and on cost of financing.

✓ **Compound risk.** Multiple hazards can happen at the same time, at the same location. Although understanding the potential impact of an isolated climate indicator is a useful exercise, it is more likely that several will be in play at once. For example, extreme rainfall coupled with extreme wind and sea level rise can cause several kinds of flooding (coastal storm surge, pluvial and fluvial flash floods) and potentially cause a landslide on a deforested coastline.

✓ **Modelling limitations.** All potential impacts and risks are not currently modeled for all sectors. This is why some impacts are sometimes only assessed in a qualitative way, with scoring approach based on the asset-specific data and scientific datasets.

References

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ClimINVEST

Tailored climate risk information for financial decision makers

ClimINVEST brings climate scientists and investors together to provide transparency on methodologies for physical climate risk assessment, and develop guidance tools that inform investors' risk management processes. Learn more at www.cicero.oslo.no/en/climinvest

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