

The impact of climate change on social security and the most vulnerable groups

Attribution - when is extreme weather influenced by climate change?

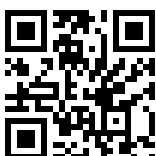
KEY FINDINGS

- Climate change is happening and is already affecting extreme weather events, so much so that the general public can already experience and notice it.
- Rapid studies on attribution of extreme weather events can serve to disentangle the influence of climate change and other factors that affect extreme weather.
- Attribution science is a rapidly advancing field of research that can inform society and policy-making. While it provides valuable information about changing hazards, it should be used in conjunction with other methods to estimate the costs and impacts of extreme events.
- The questions of how to adapt to or mitigate climate change is becoming more relevant with the recent attention for questions of loss and damage. Therefore, on top of the attribution questions that can nowadays be answered, there is a need to keep investigating in attribution science, for instance with research on compound events.
- The projected rapid changes in the climate system will pose major, evolving risks for economic, social, infrastructural, and governance systems in coming decades. Recognising and planning for these risks—a process that is often called adaptation—can reduce costs, improve stability, and protect the most vulnerable people and communities.

Attribution

Communities are facing a range of risks that threaten their well-being due to shifting climate patterns. The Sixth Assessment Report (IPCC AR6) of the Intergovernmental Panel on Climate Change has concluded that the climate is changing due to rising greenhouse gases levels¹.

The impacts of human-caused climate change are already being felt on a global scale, as various weather and climate extremes are being affected in numerous regions. Additionally, the frequency and intensity of extreme weather events are increasing². We can show this with observations and climate models. Moreover,



we are now able to detect trends in extreme weather events. The occurrences of these events bring about significant consequences for society, such as the destruction of crops and farmland, damage to property, severe economic upheaval, and loss of human life.

Attribution provides an answer to the question of whether and to what extent an extreme weather event is related to human-induced climate change. Climate change has evolved especially in recent decades. Related to this, also the relation between extreme weather events and climate change has become more visible over recent decades. However, when we detect a trend in temperature observations, we do not know whether climate change (only) or natural variability caused this trend.

With attribution, we verify this using climate models in which we change greenhouse gases levels to current levels and to past levels, and study the difference between the two climates. If the trend in model temperature corresponds to the trend in observed temperatures, we can be more confident that the observed trend is due to climate change. The same applies to trends in other observations, like precipitation.

How do extreme weather and climate change influence people?



Extreme weather has an impact that extends beyond the event itself, encompassing the vulnerability and exposure of individuals to the event. The impacts of extreme events are not borne equally across geographic regions or economic sectors within Europe, and they are felt most acutely among disadvantaged groups with a high vulnerability to natural hazards.

It is important for both adaptation and mitigation to know whether climate change, other factors, or both influence the extreme weather and its impact. One example of other factors playing a role is that population growth and increase in water demand may affect the relation between meteorological and hydrological drought, as well as the impact of the drought.

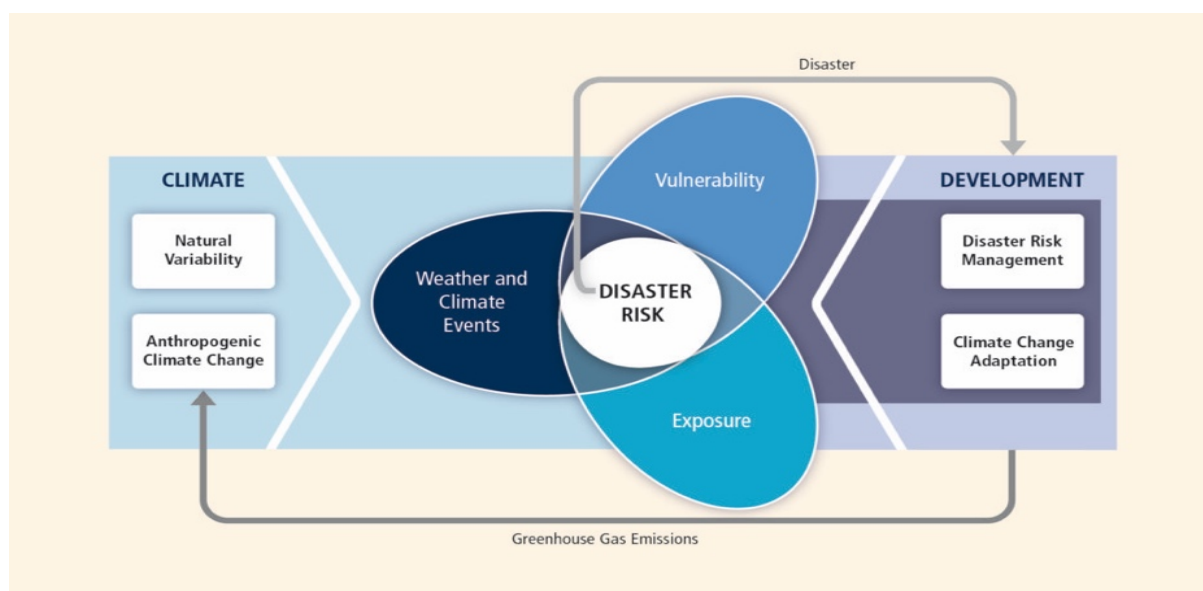
To disentangle the influence of climate change and other factors, we need attribution studies that are based on scientific evidence rather than non-scientifically based statements. Such studies ought to include both the hazard and vulnerability, as well as exposure. Attribution statements could potentially serve to provide more information in discussions about loss and damage.

Sometimes the influence of climate change on the impact of extreme weather is clear, and sometimes it is more complex to explain the relation between the two. With regard to the influence of extreme weather on disaster risk, we can point out several relationships between weather and climate change, among others:

- **Heat waves.** Often the relation between extreme temperature and climate change is clear and visible: generally, in a warmer climate hot temperatures are becoming more common and more extreme.
- **Heavy precipitation.** The relation between heavy rainfall and climate change is physically clear: a warmer atmosphere can hold more moisture, and therefore more water can rain out of the atmosphere in the same time frame. But other factors, like wind circulation, also play a role in extreme rainfall. Therefore, the relation between an extreme rainfall event and climate change is often clear, but slightly more difficult than the attribution of temperature extremes.
- **Drought.** Drought can be due to various combinations of low rainfall, high temperatures and interactions between land surface and the atmosphere. Generally, drought events last longer than heatwaves or heavy precipitation events. In the case of droughts, the answer to the attribution question is therefore more dependent on the region where the drought occurs than in the case of heatwaves or extreme rainfall.

Indirect impacts. Sometimes the specific weather event is not directly related to climate change, but indirectly the impact of extreme weather can be larger due to climate change. For example, in a certain region where average temperatures are higher than without climate change, or when a heatwave occurs and this heatwave is now hotter than it would have been without climate change. In that case, a dry season may cause more impacts in the current on-average warmer climate than in a cooler climate with the lower temperatures of the past.

Figure 1. Interplay between Weather and climate events, Vulnerability and Exposure³.



Examples of attribution studies

In this section, three examples of recent attribution studies are mentioned, including the level of complexity in explaining the relation of the extreme weather event to climate change. The examples also show how attributions of actual events can lead to different conclusions on the relations between an event and climate change.

Heatwave in Pacific Northwest America, June 2021

An example of an attribution study with a very clear climate change signal is the study *"Western North American extreme heat virtually impossible without human-caused climate change"*. Several cities located in the U.S. states of Oregon and Washington, as well as the western provinces of Canada, experienced temperatures exceeding 40°C. Notably, the village of Lytton in Canada established a new all-time temperature record of 49.6°C. Due to human-induced climate change, the likelihood of an event of this magnitude has increased by at least 150 times⁴.

In this study the conclusion is that extreme temperatures are now higher due to climate change, and this event would even have been virtually impossible without climate change.

Heavy rainfall in Western Europe, July 2021

An example of a more complex study that showed a link between extreme precipitation and climate change is the study *"Heavy rainfall which led to severe flooding in Western Europe made more likely by climate change"*. Severe flooding occurred in North Rhine-Westphalia and Rhineland-Palatinate in Germany, as well as in Luxembourg, Belgium, and the Netherlands, from July 12th to July 15th 2021. The flooding was caused by heavy rainfall which was associated with the cut-off low-pressure system named "Bernd," and affected the river Meuse and some of its tributaries⁵.

In this study, the conclusion clearly showed that climate change had intensified rainfall patterns. The study, however, also showed that the region where the rain fell played a crucial role in determining its impact, as did other factors such as water management, landscape, land use, and warning system organisation. For instance, when rain falls over a flat area this will presumably cause less flooding than when it falls over an area with steep slopes where the water runs directly to the lowest point. These are the aspects of vulnerability and exposure that add to the impact.

The analysis of this event was more complex due to high variability of rainfall events. To be able to draw conclusions on the role of climate change, a larger region in Western Europe had to be taken into account, which served to combine more data and makes the trend better visible with respect to rainfall variability.

Drought in Central South America, 2022

An example where climate change indirectly impacts the vulnerability of people to extreme weather is the study *"Vulnerability and high temperature exacerbate impacts of ongoing drought in Central South America"*.

Argentina and neighbouring countries have been experiencing drought conditions since 2019, and in the last four months of 2022, the region received only 44% of the average precipitation. This marks the lowest rainfall in 35 years and it has had a significant impact on the area⁶. The study showed that although a trend towards less precipitation does not (yet) emerge from natural variability, higher temperatures in the region - which have been attributed to climate change - indicated that climate change probably reduced water availability in the region.

Current status of attribution science

We can distinguish between rapid attribution analyses and slower, more research-oriented attribution studies.

Rapid studies

Although there is scientific evidence that climate change is happening and is affecting extreme weather, the general public is not always aware of it. Rapid attribution studies are suited to inform both the general public and decision-makers. There is a need to empower people and therefore a need to produce and disseminate knowledge about extreme weather and climate change. Whenever people experience extreme weather and the growing impacts of extreme weather, and they are informed about the link to climate change directly afterwards, the urgency and willingness to act are larger. Therefore, rapid attribution is a powerful tool to inform society.

The World Weather Attribution (WWA) initiative is a collaboration between scientists, experts on vulnerability and exposure, and communications experts. The objective of WWA is to give timely answers to the attribution question, including aspects on vulnerability and exposure. Local knowledge, attribution of the weather extreme to climate change, and knowledge of vulnerability and exposure are combined and communicated. Because of the timeliness of these attribution statements, this information is useful for decision-makers who have to decide on adaptation and mitigation strategies, as with these statements decisions can be made in the aftermath of the extreme weather events. Moreover, with the extreme weather event fresh in people's minds, the general public and the policy arena are still likely to be interested.

Research-oriented studies

Not all extreme weather events are suited to conduct rapid studies, and not all extreme weather events that are suited for rapid studies can be analysed. This is due to the high number of extreme weather events compared to the available human resources. With research we can carry out more elaborated studies in which we look more in-depth into mechanisms behind the extreme weather event, or determine where we can use impact models.

One of the new fields of interest are compound events. Examples of compound events are (but are not limited to):

- Concurrent dry-hot periods, such as the conditions over Europe in the summer of 2018, e.g. leading to water stress.
- Combined cold spells and weak winds in winter. These conditions can create a situation where energy demand is high, but power production from renewables is low, which could lead to higher risk of energy shortfall.
- Co-occurring droughts in multiple breadbasket regions. This potentially causes widespread global crop failure and global food insecurity.
- Pre-conditioned events such as a wet season followed by heavy rainfall. Due to pre-conditioning, a flood following heavy rainfall will be enhanced.

Ideally, these research topics and analyses of extreme weather finally feed back into operational attribution and serve to help decision-makers in planning for adaptation and mitigation strategies.

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