# Climate change – emerging scientific issues

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*Sylvia and Neil summarise the latest report from the Intergovernmental Panel on Climate Change.*

Accompanying online materials

Greenhouse gas emissions resulting from human activity have been increasing since the Industrial Revolution, but in the past five decades the rate of increase has quickened, driven largely by economic and population growth. Globally, emissions continue to rise and are now higher than ever. This has led to atmospheric concentrations of the major greenhouse gases – carbon dioxide, methane and nitrous oxide – that are unprecedented in at least the last 800,000 years.

The IPCC report (2013) is definitive: the world's climate has already changed and the observed changes have caused discernible impacts on natural systems such as plants, animals, river flows and glaciers on all continents and across the oceans (Figure 1). These climate changes have also been shown to affect the human population through exposure to drought, flood, heatwaves and storms. Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.

There are a number of ways of addressing the problem of climate change, including reducing emissions and adapting to changes in sea level and climate, but no single option is sufficient by itself.

The Intergovernmental Panel on Climate Change (IPCC), the leading international body for the assessment of climate change, was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear view on the current state of scientific knowledge about climate change and its potential environmental and socio-economic impacts. The IPCC reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. The latest report was released, in late 2013 and spring 2014 (IPCC, 2014), together with supporting material such as summary videos and posters (IPCC, 2013). The report is available at *www.ipcc.ch/report/ar5*. IPCC reports are regarded as the most authoritative statement on climate change science because:

- the reports are written by hundreds of leading scientists from all parts of the world
- they are reviewed by the whole research community, therefore they represent the state of knowledge at the time they are finalised
- they are reviewed and approved by the world's governments through the UN.

**Figure 1:** The Intergovernmental Panel on Climate Change (IPCC).

## Causes of climate change so far

It is extremely likely that human activities caused more than half of the observed increase in global mean surface temperature from 1951 to 2010 (Figure 2).

Between 1951 and 2010, global surface temperatures rose between 0.08 to 0.14°C per decade. During this time:

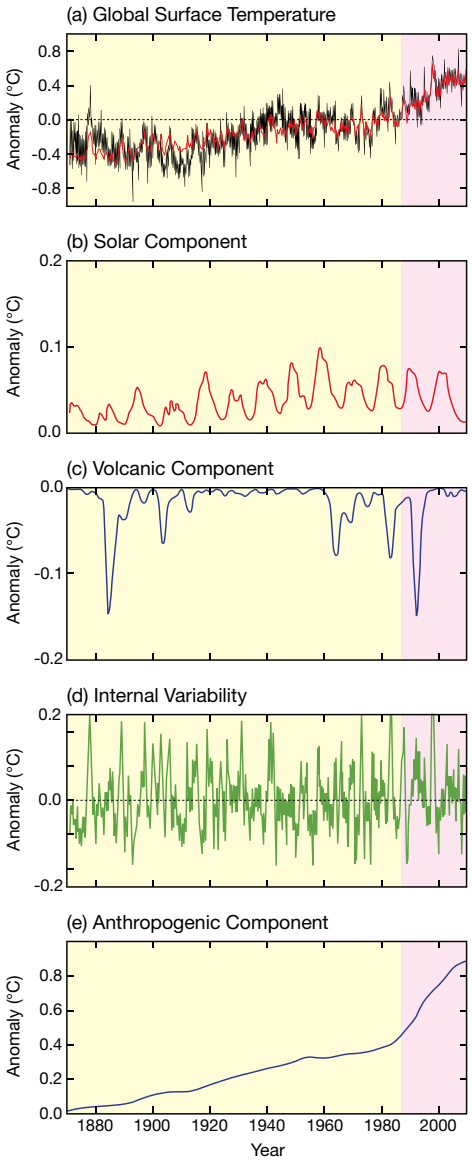


**Figure 2:** Global surface temperatures from 1870 to 2010. (a) the black line shows global surface temperatures (1870–2010) relative to the 1961-1990 average. The red line shows climate model simulations of global surface temperature change produced using the sum of the impacts on temperature from natural (b, c, d) and anthropogenic factors (e). Note the different vertical scales. **Source:** IPCC (2013).

- greenhouse gases contributed a global mean surface warming of between 0.5˚C and 1.3˚C
- Other anthropogenic forcings[1] (such as land use changes and atmospheric pollution) contributed between –0.6˚C and 0.1˚C
- Natural forcings[1] (such as changes in solar activity and in volcanic eruptions) contributed between –0.1˚C and 0.1˚C
- Internal variability, the naturally variable processes within the climate system such as the El Niño-Southern Oscillation, contributed between –0.1˚C and 0.1˚C.

A major contribution to 'other' anthropogenic forcing is aerosols, which in this context refer to small particles of liquids or solids, such as fine dust, dispersed in the air. These come from both natural and human sources, and their interactions with radiation and clouds can affect the climate in multiple and complex ways. Some aerosols scatter and reflect solar radiation and therefore tend to cool the climate, while others absorb radiation, causing warming. The balance between cooling and warming depends on the properties of the aerosol (such as its colour) and local environmental conditions. Anthropogenic aerosols have cooled the Earth since pre-industrial times, masking some of the warming from greenhouse gases. In particular, between about 1950–1980, the quantity of aerosols in the atmosphere caused global 'dimming'.

The observed global mean surface temperature has shown a much lower rate of increase over the past 15 years than over the past 30–60 years, with the trend over the period 1998–2012 estimated to be between one third and one half of the trend over the period 1951–2012. Even with this so-called 'hiatus' or pause, the 2000–2010 decade has been the warmest in the instrumental record. The IPCC concluded that the hiatus is probably the result of both a cooling contribution from natural internal variability and a reduced trend in natural forcing (volcanic eruptions and a downward phase of the 11-year solar cycle). During the hiatus, the climate system has continued to accumulate energy, for example warming the oceans and causing the global mean sea level to continue rising.

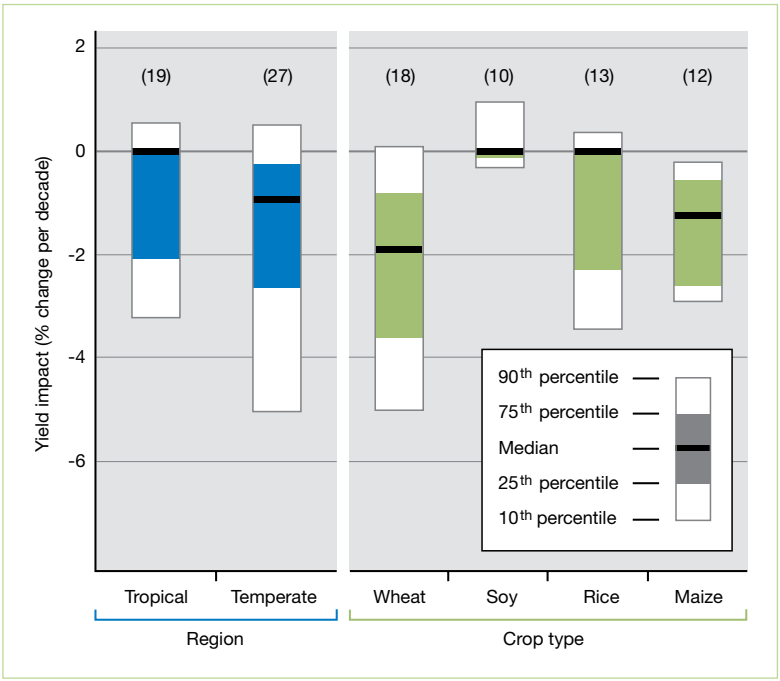


**Figure 3:** The estimated impacts of observed climate changes on yields over the period 1960–2013 for four major crops in temperate and tropical regions. The number of data points analysed for each category is given in brackets. **Source:** IPCC (2013).

## Food security

Since 1960, negative impacts of climate change on crop yields have exceeded positive impacts (although positive trends are evident in some high-latitude regions) (Figure 3). In the same time, climate change has negatively affected wheat and maize yields globally, as well as in many individual regions. The effects on rice and soybean yields have been smaller in major production regions and globally, with particularly few studies available of soy. The majority of the impact has been on food production; however food access, utilization, and price stability may also have been affected. In recent years, several periods of rapid food and cereal price increases following extreme weather events in key producing regions indicate a sensitivity of current markets to climate. There is a large negative sensitivity of crop yields to extreme daytime temperatures of around 30˚C. Temperature trends are therefore important for determining both past and future impacts of climate change on crop yields at sub-continental to global scales. Local temperature increases in excess of about 1˚C above pre-industrial levels are projected to have negative effects on yields for the major crops (wheat, rice and maize) in both tropical and temperate regions, although individual locations may benefit.

## Human security

The notion of human security encapsulates the vital core of human lives: people's ability to be free and live with dignity. Human security has direct material aspects, such as life and livelihood, but also less tangible aspects, such as cultural expression and identity (Adger, 2014). There is rarely a single threat to human security, but climate change – because it increases migration, undermines livelihoods, challenges the ability of governments to safeguard populations and compromises the cultural values that are important for community and individual wellbeing – puts it progressively at risk (Figure 4).

In all regions of the world, people adapt to climate variability by migration and mobility. In the past, major extreme weather events have led to significant population displacement, and changes in the incidence of extreme events will amplify the challenges and risks of such displacement. However, many vulnerable groups, particularly in low and middle-income countries, do not have the resources to migrate to avoid the impacts of floods, storms and droughts. Migration may in any case be undesirable: it can lead to changes in important cultural expressions and practices and, in the absence of institutions to manage the settlement and integration of migrants in destination areas, can increase the risk of poverty, discrimination, violent conflict and inadequate provision of public services, public health and education.

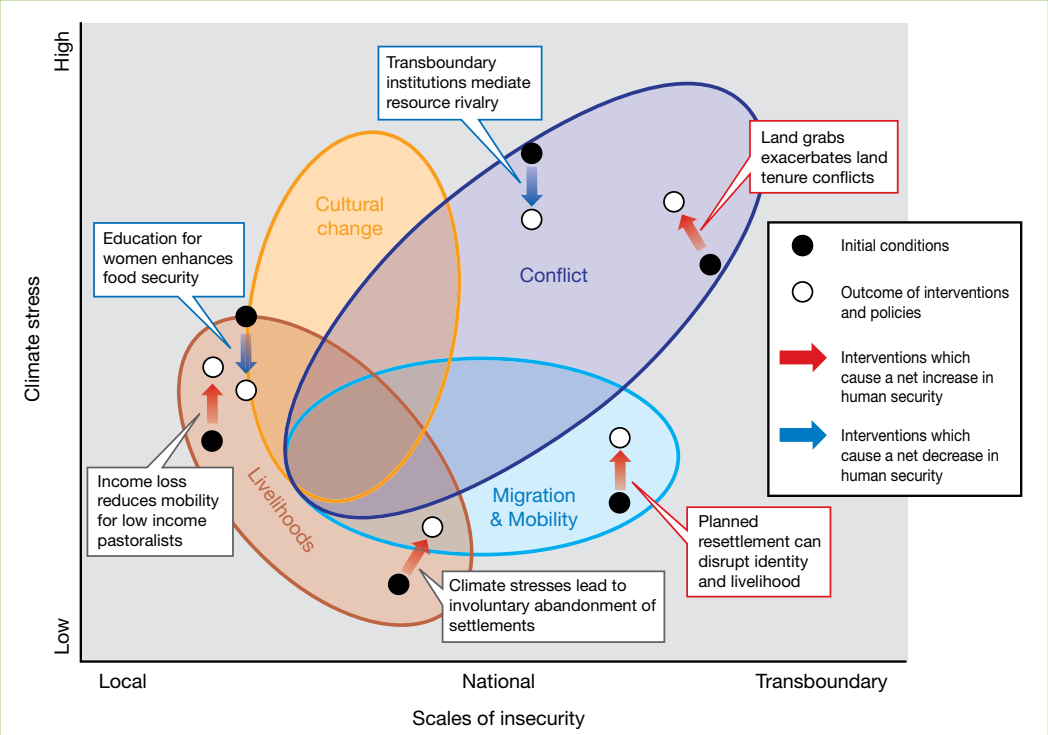


**Figure 4:** Synthesis of evidence on the impacts of climate change on elements of human security and the interactions between livelihoods, conflict, culture and migration. **Source:** IPCC (2013).

## *Future challenges of climate change*

- **Physical impacts:** Sea level rise, extreme events and hydrologic disruptions pose major challenges to vital transport, water, and energy infrastructures and can weaken states socially and economically.
- **Territorial impacts:** For example in areas highly vulnerable to sea level rise.
- **Trans-boundary impacts:** Changes in sea ice, shared water resources, and the migration of fish stocks have the potential to increase rivalry between states.
- **Violent conflict:** This can undermine livelihoods, impel migration and weaken valued cultural expressions and practices.
- **Adaptation and mitigation strategies:** Strategies which aim to reduce exposure to climate change, for instance large infrastructure developments or the resettlement of communities against their will, carry risks of disrupted livelihoods, displaced populations, deterioration of valued cultural expressions and practices, and in some cases violent conflict.

On the basis of current evidence about the observed impacts of climate change on environmental conditions, in future climate change will be an increasingly important cause of global human insecurity, and the greater the impact of climate change, the harder it will be to adapt. | TG

### Note

[1] Forcing represents any external factor that influences global climate by heating or cooling the planet. Examples of forcings are volcanic eruptions, solar variations and anthropogenic (human) changes to the composition of the atmosphere.

### References

Adger, N. (2014) 'IPCC report: Climate change and the things people care about'. Available online at *www.carbonbrief.org/blog/2014/04/safe-and-secure-the-ipcc-report-and-human-security* (last accessed 7 July 2015).

IPCC (2013) 'Climate Change 2013: The physical science basis'. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available online at *www.ipcc.ch/report/ar5/wg1* (last accessed 7 July 2015).

IPCC (2014) 'Climate Change 2014: Impacts, adaptation and vulnerability'. Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available online at *https://ipcc-wg2.gov/AR5/report/full-report* (last accessed 7 July 2015).

### Useful weblinks

Government Office for Science (2011) 'Migration and Global Environmental Change: Future challenges and opportunities'. Available online at *www.gov.uk/government/publications/migration-and-global-environmental-change-future-challenges-and-opportunities* (last accessed 7 July 2015). This illustrates how households in coastal Bangladesh respond differently to different natural hazards. Images from this could be used as the basis for a Living Graph exercise.

Royal Meteorological Society (2014) 'IPCC updates for geography teachers'. Available online at *www.metlink.org/ipcc-updates-geography-teachers* (last accessed 7 July 2015).

The Climate Change, Agriculture and Food Security Program's 'Big Facts' website *(https://ccafs.cgiar.org/bigfacts)* is a great source of accessible facts and images for independent student research.

### Online resources

A case study on the impact of climate change on the Patuakhali district of Bangladesh, plus teaching ideas accompanies this article. Go to *www.geography.org.uk/tg* and click Autumn 2015.

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