Greenhouse gas emissions

FACTSHEET

This factsheet provides essential information on greenhouse gas emissions and how they are considered in climate hazard-based impact assessments

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Without greenhouse gases (GHGs) in the atmosphere, the Earth would be about 33 °C cooler. GHGs act like a blanket around the Earth, keeping most places warm enough for life. However, since the Industrial Revolution in the 18th century, GHG emissions due to human activities such as energy production, transport, agricultural activities, and land clearing have increased the concentration of GHGs in the Earth's atmosphere. This has caused global warming and regional climate change. CO_2 is one of the most important GHGs in terms of trapping heat [1], but methane and nitrous oxide are also important. Further increases in GHG emissions are expected over the coming decades, leading to more global warming and regional climate change. Climate impact assessments need to account for future climate change, and associated GHG emissions.

Emissions pathways

Four plausible GHG emissions pathways underpin most climate projections. These emissions pathways are used in carbon cycle models to estimate atmospheric GHG concentrations, after allowing for uptake in the oceans and land. Different emission scenarios translate to a range of CO_2 concentration pathways. These Representative Concentration Pathways (RCPs) are shown out to the end of the century in Figure 1. These are often termed either low (RCP2.6), medium (RCP4.5 and RCP6.0), and high (RCP8.5) emissions pathways [2]. These pathways are mostly similar to the more recent Shared Socio-economic Pathways (SSPs) now also used ([3]; see below).

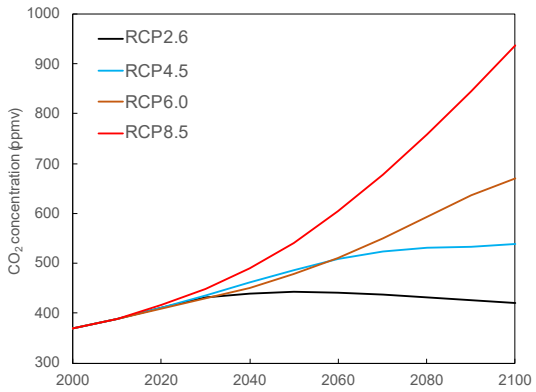

Figure 1 Trends in concentration (ppm) of carbon dioxide (CO_2) from 2000–2100 under four RCP pathways. For more information see [2].

The highest pathway, RCP8.5, reflects a future in which little additional action on reducing greenhouse gas emissions is taken, so emissions continue to increase significantly, with the CO_2 concentration reaching about 940 parts per million (ppm) by the year 2100 – an extreme pathway that now appears unlikely given current policies. This pathway results in very high levels of climate change, leading to global warming of around 2.5 to 5 °C by 2081–2100 relative to 1986–2005.

RCP4.5 is a medium pathway where emissions peak in 2040 and then decline, with the CO_2 concentration reaching about 540 ppm by 2100 – a pathway that appears possible given current policies but falls short of the commitments of the Paris Agreement and features global warming of around 1 to 2.5 °C by 2081–2100 relative to 1986–2005.

RCP2.6 is a low pathway where emissions peak and decline substantially before 2030, with the CO_2 concentration reaching about 420 ppm by 2100. This very ambitious pathway requires global decarbonisation this century, leading to a global warming of 0.3–1.7 °C by 2081–2100 relative to 1986–2005. Allowing for the warming of 0.7 °C that occurred between 1850–1900 and 1986–2005, this would result in likely meeting the 2 °C global warming limit of the Paris Agreement, relative to 1850–1900 (but not the 1.5 °C limit).

RCP6.0 corresponds to a pathway that lies between RCP4.5 and RCP8.5. For comparison, the global carbon dioxide concentration increased from 277 ppm in 1750 to 417 ppm in 2022 [4].

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New emissions pathways

The latest suite of climate model simulations uses an updated set of Shared Socio-economic Pathways (SSPs; [3]). The update from RCPs to SSPs was made as there was new information about the past changes and new understanding about what is likely to happen in the future. There are five SSPs representing different future worlds, for example SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5. The SSPs are like the RCPs in many ways, but with some small differences such as a different starting point, evolution through time, and mix of gases. The socio-economic assumptions have been summarised as: Sustainability (SSP1), Middle of the Road (SSP2), Regional Rivalry (SSP3), Inequality (SSP4) and Fossil-fuelled Development (SSP5). The relationship between SSPs, RCPs and associated global warming levels is tabulated below (Table 1), where the percentage defines the likelihood of staying below the warming levels in each category.

Table 1 Relationship between global warming limits, SSPs and RCPs. For each category, warming is limited to the levels indicated relative to the pre-industrial (1850–1900) level (Source: IPCC [1]).

Category Description	SSPs	RCPs
limit warming to 1.5 °C (>50%) with no or limited overshoot***	Very low (SSP1-1.9)	
return warming to 1.5 °C (>50%) after a high overshoot***		
limit warming to 2 °C (>67%)	Low (SSP1-2.6)	RCP2.6
limit warming to 2 °C (>50%)		
limit warming to 2.5 °C (>50%)		
limit warming to 3 °C (>50%)	Intermediate (SSP2-4.5)	RCP4.5
limit warming to 4 °C (>50%)	High (SSP3-7.0)	
exceed warming of 4 °C (>50%)	Very high (SSP5-8.5)	RCP8.5

*** Limited overshoot refers to exceeding 1.5 °C global warming by up to about 0.1 °C, high overshoot by 0.1 °C–0.3 °C, in both cases for up to several decades.

Choosing a GHG pathway option in an impact assessment

A range of pathways should be considered in impact assessments noting some interesting points to inform your assessment:

- The Paris Agreement target of keeping global warming below 2 °C approximately aligns with SSP1-2.6 (equivalent to RCP2.6 in the Van-KIRAP work) which gives 1.3–2.4 °C global warming by 2081–2100, relative to 1850–1900.
- Current climate policies would lead to 2.1–3.9 °C global warming [5], aligned with SSP2-4.5 (equivalent to RCP4.5 in the Van-KIRAP work) which gives 2.1–3.5 °C by 2081–2100 [6]. There's a 5 % probability of staying below 2 °C [5].
- Government pledges and targets (also called Nationally Determined Commitments) would lead to 2.2–3.4 °C global warming [5], which is also approximately aligned with SSP2-4.5 [6].
- If current climate policies and pledges are not fully implemented, then a stress test with higher global warming is relevant. SSP3-7.0 (not studied in our Van-KIRAP work) gives 2.8–4.6 °C by 2081–2100, while SSP5–8.5 (equivalent to RCP8.5 in the Van-KIRAP work) gives 3.3–5.7 °C by 2081–2100 [6].

Most impact assessments are limited by time and/or funding, so it may not be feasible to consider all pathways. The Van-KIRAP project partners recommend using a minimum of two pathways, namely RCP2.6 and RCP8.5 (or the equivalent SSP1-2.6 and SSP5-8.5) to 'bracket' or 'bookend' a range of possibilities, from roughly Paris-compliant to a 'worst case' pathway (NB. RCP2.6 data are not available for extreme rainfall, nor tropical cyclone wind speeds). This way, we can consider the full range of plausible outcomes, see where the pathway really matters and where it doesn't, and consider decisions that would be smart for the full range of possible future climates.

Van-KIRAP Resources

Vanuatu Climate Futures Portal
Guidance Material
Case Studies
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Fact Sheets

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