



# CLIMATE CHANGE MODELLING INFORMATION

Quarterly report – Q4 2023 report

Focus on Loss and Damage and Adaptation Strategies,  
Nationally Determined Contributions, Mid-century strategies



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**Focus on Loss and Damage and Adaptation Strategies, Nationally Determined Contributions, Mid-century strategies**

A report submitted by [ICF S.A.](#)

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## > High-level executive summary

This report under the “Climate change modelling information” series presents recent developments reported by key international climate modelling institutions. This issue sets a particular emphasis on **loss and damage and adaptation strategies**, in addition to the regular sections on Nationally Determined Contributions, and Mid-century strategies. Loss and damage and adaptation strategies are a fundamental topic when looking at climate change. It is important to assess and quantify the adverse impacts caused by the effects of climate change that are beyond the ability of affected communities or ecosystems to adapt and cope. At the same time, it is important to assess and implement the best adaptation strategies to minimise the negative impacts of climate change on human societies, ecosystems and economies, to help them adjust to the changing climate conditions and build resilience to withstand the associated impacts. Modelling aspects related to loss and damages and adaptation strategies is crucial for informed decision making, efficient resource allocation and formulating effective adaptation policies to address the impacts of climate change at local, national and international level.

The first section of the report features different studies on modelling **loss and damage and adaptation strategies** linked to climate change. Research conducted in **Greece** assesses the future flood risks and economic losses from sea-level rise and episodic sea-level extremes of Small Island Developing States (SIDS) worldwide, emphasizing the critical need for investments in adaptation and sustainable development in these States. Another research conducted by the Joint Research Center (JRC) in **Italy** explores various floods adaptation strategies in Europe, assessing the cost and benefits associated with different adaptation options. Another research from **France**, assess crops yield change under climate change and adaptation, showing that adaptation could alleviate projected losses.

The second section features a number of modelling developments linked to the implementation of the **Nationally Determined Contributions (NDCs)**. A study from **Japan** attempts to provide a state-of-the-art assessment of the future of coal transitions under alternative Indian energy system transformation pathways up to 2050, another one from **China** compare and analyse mitigation ambitions of countries updated NDCs, including equity and economic aspects. In the **Netherlands**, the New Climate Institute analyses countries emissions of major emitters, indicating that global ambition is still lacking to achieve the Paris Agreement; the new NDCs submission could be an opportunity to align with these targets.

The third section of the report is dedicated to modelling research linked to **mid-century strategies**. A study in **Australia** offers a method to easily track and compare different fossil fuels producers against climate goals, suggesting that if the companies continued their average growth rate trends, they would exceed their cumulative production budgets for coal, oil and gas by 2050. Another study from the **United Kingdom**, analyses if Brazil’s existing and expected national policies would allow to meet its net-zero pledge, highlighting that ecosystem protection would be the most cost-effective climate mitigation measure for Brazil. Lastly, research in **China**, explores operational decarbonisation for residential buildings in China and the United States providing benchmarks for buildings' carbon neutrality.

## > Introduction

This report is the third quarterly report of 2023 under the series “Climate change modelling information” financed by the European Commission. The objective of this series is to inform the European Commission and the wider climate change and energy modelling community about recent and relevant modelling developments. The data presented in this report is the result of desk research and answers received through the open survey shared with our community of modellers and researchers worldwide.

The survey received inputs from organisations based in Austria, Kenya, Netherlands, Nigeria, Tanzania, Tunisia, and the United States of America.

The survey asked modellers to report relevant developments with a focus on **loss and damage and adaptation strategies**, the implementation of **Nationally Determined Contributions (NDCs)**, and **mid-century strategies**. Although the objective of this report is to present an extensive list of recent developments, it cannot be considered as exhaustive.

The modelling developments discussed in this report are summarised below and further described in the coming chapters.

### **Modelling developments linked to loss and damage and adaptation strategies:**

- [Small Island Developing States under threat by rising seas even in a 1.5 °C warming world \(Greece\)](#)
- [Cost-effective adaptation strategies to rising river flood risk in Europe \(Italy\)](#)
- [Adaptation Strategies Strongly Reduce the Future Impacts of Climate Change on Simulated Crop Yields \(France\)](#)

### **Modelling developments linked to nationally determined contributions (NDCs):**

- [Assessing enhanced NDC and climate compatible development pathways for India \(Japan\)](#)
- [Comparison and analysis of mitigation ambitions of Parties' updated Nationally Determined Contributions \(China\)](#)
- [Greenhouse gas mitigation scenarios for major emitters \(Netherlands\)](#)

### **Modelling developments linked to mid-century strategies:**

- [Evaluating fossil fuel companies' alignment with 1.5 °C climate pathways \(Australia\)](#)
- [Nature-based solutions are critical for putting Brazil on track towards net-zero emissions by 2050 \(United Kingdom\)](#)
- [Pathway for decarbonizing residential building operations in the US and China beyond the mid-century \(China\)](#)

## > Modelling developments linked to loss and damage and adaptation strategies

- A recently published [study](#) by the [University of the Aegean](#), Mitilene in Greece assessed future flood risk from sea-level rise and episodic sea-level extremes of Small Island Developing States (SIDS) worldwide. The research group evaluated coastal flood risks throughout the present century under various emissions scenarios (a 1.5 °C scenario, a low, a moderate, a high, and a very high emissions scenario). The modelling framework used in this study incorporated probabilistic dynamic simulations of relative sea-level rise, tides, waves, and surges to estimate extreme sea levels (ESLs) along SIDS coastlines. Utilizing two-dimensional (2D) hydrodynamic modeling, the study team identified land areas subject to permanent inundation and episodic flooding by ESLs, while considering artificial flood protection and natural defenses provided by reefs and mangroves. Human exposure and direct economic losses were also quantified by combining flood inundation maps with detailed exposure mapping (population, land use, GDP per capita) and empirical vulnerability relations.

**Results show** that, by the end of this century, in the absence of adaptation measures, climate change is projected to exacerbate current direct economic losses from coastal flooding by over 14 times (under high-emissions scenarios). Limiting global warming to below 1.5 °C could mitigate nearly half of the damage. Nonetheless, meeting this climate target would not entirely shield several SIDS from experiencing economic setbacks equivalent to significant proportions of their GDP, potentially resulting in compelled migration from low-lying coastal areas.

**Policy implications:** the study emphasizes the critical need for investments in adaptation and sustainable development in Small Island Developing States (SIDS). Additionally, it highlights the need for dedicated support to assist developing countries in addressing loss and damage caused by climate change.

- An [analysis](#) published on *Nature Climate Change*, led by the [Joint Research Centre](#) (JRC), Ispra Italy, explored the costs and benefits across Europe of four adaptation strategies (namely raising dykes, detention areas, flood-proofing, and relocation). The research group assessed flood losses considering different global warming scenarios (1.5°C, 2°C and 3°C, respectively) until the end of the century. To conduct flood hazard and risk projections, the research team used a large ensemble of climate and long-term socioeconomic projections for the European Union. For each adaptation strategy, a cost–benefit analysis (CBA) optimizing the net present value (NPV) was conducted, considering discounted overall costs, and avoided economic damages over the lifetime of the measure. Costs were derived from a literature-based risk reduction measures database, while benefits were calculated as the difference in economic damages with and without adaptation.

**The study finds** that reducing flood peaks using detention areas is economically the best option. In a scenario without climate mitigation (a scenario of 3 °C global warming), detention areas can lower projected flood losses in Europe by 2100 from around EUR 44 billion to around EUR 8.1 billion per year. At the same time, they can lower the population exposed by around 84%, achieving a risk level comparable to today's level. The economic investment required over 2020–2100 would provide a return of around EUR 4 for each EUR 1 invested. The risk reduction potential of

strengthening of dykes is somewhat lower (around 70%) for a comparable annual investment. Implementing building-based food proofing and relocation measures is less cost-effective but can reduce impacts in localized areas.

**Policy implications:** the analysis can better support policymakers in choosing and developing policies to support the best adaptation option to floods, in terms of cost-benefits, considering the impacts of future climate change scenarios.

- A [research](#) published on the *Earth's Future* journal, led by the [Laboratoire des Sciences du Climat et de l'Environnement](#) assessed how climate change and adaptation affect four major crops looking at their yield change. The research group tested multiple types of statistical and machine learning models to synthesize thousands of computer simulations of crop yield change under future climate into one meta-model, that can be used for crop yield prediction at any location. The three categories of tested models were Random Forest (RF), gradient-boosting (GB) models, and linear mixed (LM) models, with and without spatial correlation. The meta-model was used to produce global maps of yield change for a likely future climate scenario (the Representative Concentration Pathway 4.5) and identify the most influential variables affecting yield change.

**The study shows** that when adaptation practices are applied, some areas are predicted to experience yield gains, especially at northern high latitudes. For most locations, adaptation is the most influential factor determining the projected yield change for maize, rice and wheat. Without adaptation, all crops are expected to experience average global yield losses of 6%–21%. Adaptation alleviates this average projected loss by 1–13 percentage points relative to maintaining the same management practices. Maize is most responsive to adaptive practices with a projected mean yield loss of –21% without adaptation and –7.5% with adaptation.

**Policy implications:** these results reveal the critical importance of implementing adequate adaptation strategies to mitigate the impact of climate change on crop yields. Managing crops adaptively, considering the crops type and areas they grow, can reduce yield losses in the future.

## > Modelling developments linked to Nationally Determined Contributions (NDCs)

- A [study](#) published on *Energy Strategy Review* and led by the [National Institute for Environmental Studies](#) assessed the socio-technical, financial and macro-economic implications of India's energy sector transformation away from coal, moving towards its net zero target by 2070. Researchers analysed the challenges and the opportunities from the transition of the energy sector, combining the bottom-up technology-rich energy system model, AIM/Enduse India, with a macroeconomic computable general equilibrium model (GCE), GEM-E3. The model used provided details on the complex interactions of energy transition with the economy, capital and labour market in the country. The analysis was performed for three scenarios: a baseline scenario, that consider all the current implemented policies, an enhanced NDC scenario, which considers current implemented policies and those implemented after the NDCs submission in 2015, and a Climate Compatible Development Scenario, which considers India's pledges at COP26.

**The study shows** that emissions in India will not peak before 2050 with current NDCs, but may peak around 2040 considering India's net zero pledges. According to the study, India will see a large sectoral shifts in labour market due to decarbonization. Decarbonisation requires India to not only restructure its coal-based electricity and industry sector as well as its transport and buildings sectors, but also to implement the process in an equitable manner, ensuring that no state, region, or household is left behind.

**Policy implications:** considering future policies and India's net-zero target by 2070, it will be particularly important to consider opportunities from the energy sector transition so that no one is left behind.

- A research group from the [Tsinghua University](#) presented a new framework that combines equity and economic costs to compare and analyse mitigation ambitions of Parties' updated NDCs. The research group used multiple equity-principled allocations to derive the alignment of the updated NDCs with the Paris Agreement goals. It also further applied a computable general equilibrium model to assess the economic costs of implementing the updated NDCs. The study is available at this [link](#) and was published on the *Advances in Climate Change Research* journal.

**Results show** that global 2030 emissions may meet the selected global 2 °C pathway if all Parties achieve their most ambitious mitigation efforts, but there is still an emissions gap (of 10–15 GtCO<sub>2</sub>) to achieve the 1.5 °C pathway. With respect to equity considerations there is a lack of ambition on 'equal cumulative per capita emissions' under 2 °C, even more under 1.5 °C where there is no alignment with any equity principles, looking at the updated NDCs of the USA, the EU (including the UK in this study), and Japan. In terms of economic costs, the GDP and welfare losses of China, Brazil and South Africa incurred by achieving the updated NDCs are not lower than those of the three developed Parties.

**Policy implications:** the study suggests that developed countries should take the lead in further ratcheting up the NDCs as, well as strengthening financial and technological support to developing countries so that the world could close the gap to 1.5 °C.



- A report led by the [New Climate Institute](#) in collaboration with the [PBL Netherlands Environmental Assessment Agency](#) and the [International Institute for Applied Systems Analysis \(IIASA\)](#), recently published their [findings](#) analysing greenhouse gas mitigation scenarios for major emitters, considering current policies and mitigation commitments. The research included policies adopted until July 2023 and NDCs submissions through September 2023. Different models were used in the study to estimate the impact of individual policies in subsectors: IMAGE integrated assessment modelling framework, with the inclusion of a global climate policy model (FAIR), a detailed energy-system model (TIMER), and a land-use model (IMAGE land). GLOBIOM was also used to complement calculations with those on land-use and agricultural policies.

**The study finds** current policies result in 2030 emissions reduction between -6% and +8% compared to 2019 levels, which are still falling short of the Paris Agreement's aligned 43% reduction. Among the considered countries, those on track to meet their NDCs targets are China, Egypt, Ethiopia, India, Iran, Mexico, Morocco, Russia, Saudi Arabia, Türkiye and Viet Nam. Australia and the European Union (EU) are now likely on track to meet their targets.

**Policy implications:** although some countries are in line with meeting their NDCs target, global ambition is still lacking to reach the Paris Agreement-aligned target of reducing global emissions by 43% by 2030. This study could inform countries when developing and submitting their new NDCs.

## > Modelling developments linked to Mid-century strategies

- An [article](#) led by the [University of Queensland](#) and published on *Nature Climate Change*, tracked the fossil fuel companies' alignment with the 1.5 °C climate pathways. Focusing on the absolute fossil fuel production as a proxy for embedded emissions, the research group developed a new methodology that uses publicly available data, consider coal and is applicable regardless whether the company has an emissions reduction target. The methodology was used to assess the largest producers of coal, oil and gas (142 companies) against three 1.5 °C IPCC Shared Socio-economic Pathways (SSP1-1.9, SSP2-1.9 and SSP5-1.9) from 2014 and against the International Energy Agency's Net Zero Emissions pathway from 2020.

**Results show** that between 2014 and 2020, 64%, 63% and 70% of coal, oil and gas companies, respectively, produced more than their production budgets under the IPCC's Paris Agreement-compliant scenario. They also show that if the companies analysed continued their average growth rate trends from 2010 to 2018, they would produce up to 68%, 42% and 53% more than their cumulative production budgets for coal, oil and gas, respectively, by 2050.

**Policy implications:** the study offers a method to easily track and compare different fossil fuels producers against climate goals and could provide insights on which areas require more policy intervention.

- A [research](#) led by the [University of Oxford](#) and published on the journal *Global Change Biology*, analyse if Brazil's existing and expected national policies will allow the country to meet its net-zero GHG emissions pledge by 2050. The research group applied a detailed regional integrated assessment modelling approach, including the contribution of nature-based solutions, such as the protection and restoration of ecosystems, and engineered solutions, such as bioenergy with carbon capture and storage. Specifically, they used the GLOBIOM-Brazil model, and an optimisation model, called BLUES model, built on the MESSAGE model generation platform (Model for Energy Supply Strategy Alternatives and their General Environmental Impact), which perform integrated assessment energy and land-use system modelling.

**The study shows** that by fully implementing Brazil's Forest Code (FC), a key policy for emissions reduction in Brazil, combined with zero legal deforestation and additional large-scale ecosystem restoration, would reduce the emission gap to net-zero by 62% by mid-century, keeping Brazil on a path towards net-zero GHG emissions by around 2040.

**Policy implications:** the study highlights that ecosystem protection is the most cost-effective climate mitigation measure for Brazil and that Brazil should go beyond existing policies and target to align its short- and long-term climate targets, as well as to build climate resilience while curbing biodiversity loss.

- A [research](#) led by the [Chongqing University](#) and published on the journal *Applied Energy* compares the operational decarbonization process of China's and the United States (US) residential buildings from 2000 to 2060. The study used the end-use emission model with the decomposing structural decomposition (DSD) method to estimate historical operational decarbonization considering changes in the end-use activities. It combined this model with the Monte Carlo simulation to dynamically assess potential carbon trajectories, benchmarks of end uses and emission factors, and the process of realizing carbon-free residential buildings.

**The results show** operational carbon neutrality for residential buildings in 2060 is promoted by an increase in clean power generation proportion, building-integrated power generation level, building electrification level, and a reduction in end-use energy intensity. Specifically, building-integrated power generation in China only costs about 40 % of what it costs in the US.

**Policy implications:** the study offers data benchmarks for buildings' carbon neutrality of top economies to further promote carbon neutrality in the buildings of emerging economies.

➤ Overview of upcoming events

Event	Date and location	Objectives	Topics covered	Deadlines
<a href="#">Openmod workshop 2024</a>	March, 26 – 28, 2024, Grenoble, France	The annual openmod workshop brings together energy researchers and modellers from Europe and further to present and discuss the latest developments in open energy modelling.	The workshop covers topics related to energy modelling.	-
<a href="#">EGU General Assembly 2024</a>	April, 14-19, 2024, Vienna, Austria	The European Geoscience Union (EGU) General Assembly 2024 brings together geoscientists from all over the world to one meeting covering all disciplines of the Earth, planetary, and space sciences. The EGU aims to provide a forum where scientists, especially early career researchers, can present their work and discuss their ideas with experts in all fields of geoscience.	The Assembly covers all disciplines of the Earth, planetary, and space sciences.	Call for abstracts is closed. Registration is open.
<a href="#">12th International Congress on Environmental Modelling and Software</a>	June 23–27, 2024, Michigan, USA	Every two years, the International Environmental Modelling & Software Society (iEMSs) holds an international congress. The purpose of this conference is to foster discussion and encourage the interchange of challenges, solutions, ideas, and new methods and techniques in	Conference streams are: 1) Decision making and public participation in environmental modelling; 2) Modeling environmental fate of contaminants, human well-being and ecological public health, 3) Computational methods, workflows, informatics and integrated systems in environmental	Registration is open.

		environmental modelling and software. Each conference is organized around a different theme	modelling; 3) System design, identification and uncertainty in modelling complex environmental & agricultural systems; 4) Socio-environmental systems modelling for planetary health and environmental sustainability; 5) (Big) data solutions for environmental systems planning, management, and operation.	
<a href="#">International Energy Workshop (IEW) 2024</a>	June, 26-28, 2024, Bonn, Germany	The IEW is a leading conference for the international energy modelling community. The IEW provides a venue for scholars and researchers to compare modelling tools, to discuss modelling advances for emerging energy sector issues, and to observe new trends in the global energy sector.	A (non-exclusive) list of potential conference topics is available on the conference website. Topics include: net-zero emissions and climate neutrality, role of renewable energy in the energy transition, climate resilience of energy systems, etc.	Deadline for paper submission is 1 February 2024.
<a href="#">9th GEWEX Open Science Conference</a>	July, 7-12, 2024, Sapporo, Japan	The conference will celebrate 30+ years of GEWEX research, the strong role of the Japanese research community and set the stage for the next phase of research addressing the World Climate Research Programme (WCRP) main challenges on water resources, extremes and climate sensitivity through observations and data sets, their analyses, process studies, model development and exploitation, applications, technology transfer to operational use, and research capacity development and	The conference is organized around three themes: <ul style="list-style-type: none"> <li>• Water, Climate, Anthropocene</li> <li>• Extremes and Risks</li> <li>• Water, Energy and Carbon Processes</li> </ul>	Registration is open. Deadline for abstract submission is 1 February 2024

		training for the next generation of scientists worldwide.		
<a href="#">EMS Annual Meeting 2024</a>	September 2-6, 2024, Barcelona, Spain	The Annual Meetings of the EMS aim at fostering exchange and cross-fertilization of ideas in the meteorological, climatological and related communities, focusing particularly on strategic issues relevant to the future of meteorology in Europe.	A particular focus of the EMS Annual Meeting 2023 will be on <i>The role of weather and climate research in the achievement of a climate-neutral Europe.</i>	-
<a href="#">AGU Annual Meeting 2024</a>	December, 9-13, 2024, Washington, D.C., USA	AGU Advancing Earth and space science meeting fosters learning and collaboration, and promotes topics that enhance perspectives across Earth and space science.	-	-