# The fourth pillar of inequality? Different levels of policymakers' scientific scenario knowledge widen the gap between World regions

**Jiesper Strandsbjerg Tristan Pedersen** ( jiespertristan@gmail.com )
Faculdade de Ciências da Universidade de Lisboa (Faculty of Science, University of Lisbon)
https://orcid.org/0000-0002-5217-6433

**Carla Gomes**
Instituto de Ciências Sociais da Universidade de Lisboa (ICS-UL) (Social Science Institute of the University of Lisbon)

**Joyeeta Gupta**
3Governance and Inclusive Development, Geography, Planning, and International Development Studies, AISSR, University of Amsterdam

**Detlef van Vuuren**
PBL Netherlands Environmental Assessment Agency https://orcid.org/0000-0003-0398-2831

**Rob Swart**
rob_swart@kpnmail.nl

**Article**

**Keywords:**

**Posted Date:** April 22nd, 2022

**DOI:** https://doi.org/10.21203/rs.3.rs-1562018/v1

# Abstract

Emission scenarios represent a backbone in future climate change analyzes1–3, informing policy responses and designs4–8. Despite increasing scientific publications and improved scenario quality9, this has not been translated into sufficient policy actions10,11. Finalizing the 6th assessment cycle of the Intergovernmental Panel on Climate Change (IPCC), what is needed to enhance the policymaker relevance of scenario work for the next one? The precise role of emission scenarios in policymaking is not explicitly explored in the literature, and the policymakers' perspectives and needs are not expressed. We found, via a survey distributed to national focal points of the 25th Conference of the Parties (COP25) under the United Nations Framework Convention on Climate Change (UNFCCC), a gap between industrialized (Annex-I) and least, semi, and newly industrializing (non-Annex-I) countries on policymakers' knowledge and capacities in using scenarios and applying them meaningfully to policymaking. Overall, policymakers express a divide between how scenarios have been communicated and how they could be presented to increase their policy actionability. Our results demonstrate that two (contrasting) needs are expressed: more simple scenario communication and more national detail. Furthermore, policymakers focus on understanding and using the scenario tools for negotiations and national policy, contrasting the scientific focus on the quality of assumptions, processes, approaches, and methods12–14. For the upcoming COP27 and successive COPs, the scientific community developing scenarios has three crucial gaps to close to increase the scenarios' relevance for policy designs. Provide national scenarios in non-Annex-I, improving policy relevance via a more detailed understanding of policymaker needs and objectives, and closing the knowledge gaps between the non-Annex-I and Annex-I regions. This also translates into increasing policy-relevant research in locations outside the Annex-I regions and setting up scenario training and modeling institutions. A precondition for effective scenario use is that the policymaking community clearly communicates its evolving goals and priorities to the scientific community.


# Introduction

For decades, scenario experts have focused on the quality of scenario assumptions[15,16], process approaches[17], and methods[12] to improve technical-scientific quality, policy relevance[9,18–20], or implications of socioeconomic and greenhouse gas emissions scenarios for climate action[21]. It has increased the complexity of emission scenario series, storylines, and output data[22,23]. However, the question of the policymaker perspectives on scenario improvements to enhance policy relevance is less explored in the scientific literature. It is important to investigate these demands regularly. Many scenario modeling projects include stakeholder interactions and participation in various exercises like the United Nations Framework Convention on Climate Change (UNFCCC) science dialogue and other projects, including stakeholder sessions in the EU, India, China, and Brazil[24–27]. Policy questions change over time, and thus the requirements of scientific emission scenarios also change. Responding to present and future societal challenges like climate change is complex, given the uncertainty of outcomes, different opinions, and decisions based on various insights and value judgments by different stakeholders[28,29].

For evidence-based decision-making, policymakers require the possible information from scientific advisors to respond to societal challenges[30], sometimes communicated with a special effort to policymakers[3]. Often scientific evidence involves assessments of plausible future changes with and without intervention, comprising projections and uncertainty[23]. Here emission scenarios play a key role in scientific[1,2,9] and policy assessments[11,31] of future climate change and response strategies.

Since the 1990s, scientists have continuously tried to enhance the effectiveness of their interactions with policymakers from governments, delegates participating in the Intergovernmental Panel on Climate Change, and negotiators from the UNFCCC[9,25,32]. Such interactions are also part of most projects focused on model-based scenarios. Stakeholders and policymakers have been included in emission scenario developments[33,34]. However, their perspectives and challenges are poorly reported in the scenario literature. It can be expected that both the interest, expectation, and engagement are different for policymakers from industrialized Annex-I countries and developing or industrializing non-Annex-I countries[32,35]. The policy relevance of emission scenarios and how they should or should not be built, contained, and presented have been continuously discussed in the literature[18,20,36]. This paper analyzes the use and policy relevance of emission scenarios perceived by UNFCCC national focal point delegates[37] (see Methods). It aims to explore the understanding of the policymakers' perspectives to increase policy-relevance of emissions scenarios. Notably, the Covid-19 pandemic created an opportunity to approach those busy policymakers since the COP-26 was postponed to 2021.

## Results

# 2.1 The connection between familiarity and policy actionability

The surveyed UNFCCC national focal point delegates perceive policy relevance of emission scenarios differently depending on the knowledge they possess about the tool. Figure 1 shows the connection between the degree of knowledge/expertise (familiarity) and the perceived policy relevance of emission scenarios. High familiarity comprises knowing the tool of emissions scenarios starting from "a little" to "a high degree" to "participated in developing scenarios" (score 4-6), while low familiarity comprises "I have heard about them but not sure what they express" to "not knowing them" (score 1-3).

We asked which types of scientific knowledge support designing national mitigation policies and international climate treaties? The results strongly show a different opinion on the usability of emission scenarios in policymaking. Industrialized Annex-I country representatives find emission scenarios more applicable in national policymaking than non-Annex-I representatives. In the UNFCCC context, they are defined as developed Annex-I parties[38,39]. They are at the same time more familiar with emission

scenarios and demonstrate more advanced insights into what scenarios express, e.g., an advanced scientific vocabulary.

Interestingly, representatives of the industrializing non-Annex-I countries[38] find emission scenarios less relevant for designing national mitigation policies than international climate treaties. On average, non-Annex-I country representatives perceive emission scenarios as between 3 and 4 (“in-between” and “some degree” useful) in a national context. In contrast, within a UNFCCC context, they are between 4 to 5 (“some degree” to “high degree”) applicable. Content-wise, this can be understood given the focus of modeling exercises.

Non-Annex-I representatives with high scenario familiarity (more knowledgeable) find scenarios more policy-relevant in national and international contexts than those less familiar. For Annex-I representatives, the policy relevance in a national context increases with higher familiarity. In contrast, scenario familiarity hardly plays a role in how Annex-I representatives perceive the scenarios’ policy relevance within the UNFCCC context. This may reflect that detailed scenario knowledge is less important in international negotiations compared to national policymaking.

## 2.2 Improving the policy relevance of emission scenarios

Policy relevance is not stable but changes continuously over time and is different for different policymakers. Thus, scenario requirements may change over time and vary according to policymakers’ needs and perspectives. Figure 2 compares the interaction between scenario knowledge and plausible changes to improve the scenarios’ policy relevance. The figure shows UNFCCC delegates’ perception of five suggested emission scenario adjustments and scenario process adjustments. These include “simpler communication of scenarios," “Easier to implement scenario results into policies," and “scenarios with less complex output data” that is easier to access and process on computers (Figure 2 top) and that researchers define and “include a best-guess scenario," e.g., the most likely future; and “inclusion of policymakers in scenario development processes (Figure 2 bottom). The results show general agreement about a need for a simpler communication of emission scenarios and what the various scenarios express. The figure reveals that for most scenario adjustments, the tendency is that policymakers with high scenario knowledge are most in favor of improvements regarding simple communication and simpler scenarios. On the contrary, the more you know, the less important is it to include policymakers in scenario development processes.

Scenario improvements are generally less important for Annex-I policymakers (Figure 2). Non-Annex-I participants express a higher need for all five examined improvements. Three suggested plausible improvements are perceived as more valuable for policymakers with higher scenario familiarity (including a best-guess, simpler communication, and easier inclusion in policymaking). They can all be considered proxies for less complexity, simpler translation, and easier-to-understand scenarios. On the one hand,

several industrializing non-Annex-I participants express that emission scenarios “should be disclosed more simply and understandably." It implies requests “to lower the complexity of emission scenarios” (Small Island State policy advisor) and make them more “reader-friendly and use simpler language” (Middle East) to increase the policy relevance. Several policymakers think that a better understanding grows the actionability of emission scenarios. “They [the emission scenarios] can be used more and become more relevant if they are better understood and simpler information is used to explain them” (Latin American policy advisor & UNFCCC negotiator).

Additionally, “the policy relevance will improve if analyzed scenarios correlate with economic and political data” (Latin America policy advisor). Non-Annex-I informants request national databases better adjustments to national policies and regional trends (e.g., increased downscaling and nationwide data availability). Several policymakers express that some scenario data do not seem realistic in a national context. On the other hand, non-Annex-I policymakers communicate a need for more human resources and computing power. “Our country is a developing country and, at this moment, lacks the technical capacity and experts to create scientific knowledge on the diverse areas of climate change. We require the input or presence of technical experts to assist in creating relevant tools, methodologies, and policies to address climate change issues” (Small Island State policy enabler).

Several non-Annex-I policymakers request increased institutional capacity building, technical-scientific human knowledge, and technology support. Scenario policy implementation is critical in several non-Annex regions. The need for less complicated scenarios and data reflects a low familiarity with emission scenarios and a lower capacity in human resources and computing power to translate and use scenario data in policymaking. To improve scenarios’ policy relevance, non-Annex-I participants request support to understand the scientific tools better and translate scientific data. It involves improved technology, knowledge, and human capacity.

## 2.2.1 Room for improved regional policy assumptions in mitigation pathways

Specific barriers are discussed within the Paris Agreement regarding mitigation policy implementation. The technology barrier is highly discussed[5,40], while the institutional capacity[41] is less discussed within the UNFCCC and socioeconomic scenarios. There is room to improve the long- and short-term scenarios policy assumptions. Thus, it is no surprise that non-Annex-I participants express low technological capacities for realizing the implementation of their countries’ mitigation policies. Figure 3 shows the UNFCCC delegates’ perception of their country’s capability of implementing their mitigation policies. Annex-I policymakers are confident that their governments have the technology and institutional capacity to enforce mitigation policies. Non-Annex-I policymakers are quite confident that national policies are implementable in practice. This, however, requires strengthening of their technological and institutional

capacities (Figure 3). It reflects the request for mitigation policy financing described in several non-Annex-I party NDCs[11,42].

One non-Annex-I interviewee with high scenario familiarity argued that cultural differences and the capacity of governmental institutions affect policy implementation. “The mentality and institutions in developing countries are very different, for instance, their capacity to deal with corruption. Less efficient institutions cause weak and less accurate policy implementation. We have fewer substantial penalties, meaning that companies cut protected forests creating deforestation in full daylight. Against the law, they give the penalty money to authorities before cutting and saying, 'we will deforest tomorrow.' They see it as a tax, not a penalty” (South American policy advisor). In addition, the policy advisor argued that “scenario models based on cost-benefit analysis” could be supplemented with more national case analyses or combined with multicriteria analyses. “IAMs should consider the AR6 transformative pathways, including new energies, social innovation, and traditional knowledge.” The AR5 recommended that IAM and energy models include narratives (and not only quantitively data) about the political situation and administration[43].

## Discussion: Meeting The Policymaker Needs

# 3.1 Different scenarios for various uses: Connecting policy objectives and scenario improvements

The general barrier to using scenarios is understanding how to use them and for which policy objectives. There are different scenario applications for various policy questions in science, which evolve over time.

Thus, it is problematic to generalize findings for scenario improvements without specifying what kind of scenarios and their specific purposes. At least three objectives are essential for current policymaking and anticipative actions: 1) the evaluation of the National Determined Contributions (NDCs) of the Paris Agreement; 2) evaluating specific details of the energy and socioeconomic futures to inform mitigation (and adaptation) needs and responses, and 3) scenarios as input for impact/vulnerability analyses to inform adaptation policies. For evaluating the policy relevance, it makes sense to connect scenario policy objectives with scenario improvements and scenario types. Best-guess scenarios could be relevant for the first policy objective (NDC assessments). For the second policy objective (evaluation of energy and socioeconomic futures), scenario ranges are relevant, and for the third policy objective, worst-case scenarios, like SSP3-70 and SSP-8.5, are essential.

The survey shows that non-Annex-I and Annex-I informants rank scenario improvements differently. Table 1 shows the priorities of Annex-I and non-Annex-I requests for scenario improvements and connects them to the scientific assumptions of what is needed (blue text). There is general agreement about the

need for simpler scenario communication and making scenarios more easily implemented in policymaking. However, while non-Annex-I prioritizes less complex output data (4.0), Annex-I does not find that scenarios need be easier to process (2.6). Notably, reduced scenario complexity is also retraining the use of scenarios in Annex-I. The interviews revealed that data complexity obstructs scenario applicability "Because the SSPs were too complex, we used the SRES [published in 2000] to develop our national low-emission scenario" (EU policymaker).

Table 1. The top five priorities values of plausible scenario improvements to increase the policy relevance of emission scenarios, as perceived by policymakers (grouped by non-Annex-I and Annex-I), and researcher assumptions of needed improvements from the literature. Brackets express the average values of answers from 1 “No, it is incorrect” to 5 “Yes, it is correct."

| Ranking | non-Annex-I | Annex-I | Scenario developers' assumptions |
|---|---|---|---|
| | Source: survey | Source: survey | Source: scenario literature |
| 1 | Easier to implement in policy (4.0)<br><br>+ capacity building & training (open questions) | Communicate simpler (3.9) | Improved scenario communication via novel methods and increased capacity building [9] |
| 2 | Communicate simpler (4.0) | Easier to implement in policy (3.5) | Plans to develop a user-friendly online database with relevant SSP-RCP information (narratives, extensions, variants, and downscaling products) |
| 3 | Less demanding to process (4.0) | Include policymakers (3.5) | "Scenario products should be provided, for example, through portals tailored to user needs and capabilities" [9]. |
| 4 | Include Best-guess (3.9) | Include Best-guess (3.4) | Scientific divide about how to present/make "Easy-to-understand scenarios"[20,36,44,45] |
| 5 | Include policymakers in scenario development (3.7) | Less demanding to process (2.6) | "Stakeholders should be involved in the co-production of scenario knowledge to improve its usefulness and create ownership" [9]. |

Most policymaker wishes are consistent with the recent scenario developer literature, e.g., making scenario communication simpler, simplifying data, and stakeholder inclusion[9]. They also contradict. While policymakers are relatively positive toward best-guess scenarios, scenario developers disagree internally[20,36,44,45]. Moreover, while some policymakers express concerns about policymaker inclusion, scenario developers practice stakeholder inclusion for national scenario extensions[9,46]. Additionally, research programs funding integrated assessment, including modeling and scenario development (such as Horizon Europe), often include stakeholder engagement as a mandatory requirement.

Including a best-guess scenario is not on top of policymaker requests. Scenario user support and policy relevance have been discussed in the areas of scenario complexity and a need for simpler communication of what scenarios express[19], including supporting policymakers to choose a (most likely) scenario within the uncertainty range[20,36]. Most researchers argue that a century-long best-guess scenario is challenging since short-term fluctuations do not necessarily affect long-term cycles and assumptions[44]. Other researchers stated that without best-guess scenarios, policymakers get confused or do not know how to interpret the scenario ranges[19,20,36]. Policymakers correspondingly express the latter. “There need to be a ‘current policies’ or ‘BAU’ scenario. SSPs are valuable, but in the absence of an identified ‘most likely’ scenario, policymakers will simply pick one” (German policy advisor and UNFCCC negotiator). However, best guess could mean different things. Several policymakers express interest in a current policy pathway rather than a long-term best guess. “To support UNFCCC, constant ‘best available’ information is necessary to compare the Paris temperature goals to current policy pathways, NDC pathways, and plausible ambitious action pathways” (EU policy advisor). Scenarios can be improved by “providing insight on current pathways and projected costs and effects” (Small Island state policy enabler) or “By highlighting current trends in emissions and their unsustainability” (EU policy enabler). In addition, the use of “current policies scenarios, or new-stated policies scenarios, such as IEA, UNEP, and CAT” is argued to have increased the policy relevance. It may inspire “the IPCC scenarios [to become] more action-oriented, e.g., with concrete action-indicators […] increase in renewable energy capacity and targets for particular sectors instead of the more theoretical indicators, such as emissions reductions or intensity changes in sectors” (Dutch policy advisor). There is reason to believe that current policy, NDC, and Paris targets evaluations have high policy relevance, guiding UNFCCC processes. Such current policy scenarios may also cover the need for best-guess guess scenarios.

In general, emission scenarios are perceived as relevant globally and less suitable for national assessments. “A lot of the scientific knowledge is for global scenarios, especially for developed countries. Developing countries need localized scientific knowledge so national policies can be appropriately developed using information relevant to the national scenarios” (Small Island policy enabler and UNFCCC negotiator).

The long-term scenarios need more national detail on solutions to be policy-relevant. "Improve national and regional energy system models (not global IAMs). Include more policy design research that accounts for the national circumstances and multi-level complexity of climate governance" (EU policy-enabler).

There is a great variety in what different policymakers expect from scenarios. One fundamental disparity is between requests for higher spatial and temporal resolution (enabled by enhanced computer technology, requested by some stakeholders, stimulated by research funders, valid for (sub-)national impacts, mitigation, and adaptation analyses) on the one hand, and simplicity and aggregate information on the other (for computation of long-term system transformations, international negotiations). Integrating these disparate requirements into one common scenario framework can be challenging. However, not impossible if presented via different layers of complexity (e.g., on a dynamic web platform). Alternatively, there could be two different scenario mechanisms.

The short-term and long-term scenarios supplement each other. Part of the scenario communication could include information about which scenarios to use for specific policy objectives. The United Nations Environment Programme's (UNEP) Emissions Gap scenarios[10] and the Carbon Action Tracker (CAT) scenarios[47] are relevant for evaluating current NDCs. They are standard IAM scenarios used for a specific purpose and thus support policymaker requests for a current best-guess scenario based on policy evaluations and scenarios that express the gap to achieve the policy targets. However, they are less relevant for evaluating the specific details of the socioeconomic or energy futures or as input for impact/vulnerability analyses. The International Energy Agency (IEA) scenarios are less detailed and transparent but provide a plausible range of energy futures[48]. In contrast, the emission scenarios informing IPCC assessments, e.g., SRES, SSP-RCS[23,33,49], provide comprehensive detail on socioeconomic developments, energy, and emissions pathways relevant to climate and impact assessments[50,51].

## 3.2 Understanding scientific scenario knowledge: A 'new' pillar of inequality?

The Paris Agreement's climate financing covers two pillars of inequality of technological and adaptative capacities between mainly Annex-I and non-Annex-I. At COP26, Loss and Damages were discussed in Glasgow as the third inequality and climate financing pillar. A knowledge gap may introduce a fourth pillar, describing unequal knowledge bases and The open questions reflect two different knowledge bases. Typically, annex-I participants use advanced terms related to scenario models (e.g., IAMs, variables, downscaling) and their variables (e.g., CDR, AFOLU, BECCS). They have more advanced requests, like "The issues of climate change and biodiversity need to be equally covered in scenarios" (US policy advisor). Non-Annex-I describes scenarios in more general terms, like "reduce their complexity" and make them "transmittable to a national policy context." It is plausible that non-Annex-I policy advisors and enablers do not use scenarios as frequently as Annex-I policymakers because they lack sufficient knowledge and the resources to process them.

Non-Annex-I expresses a lack of computer power and human resources to process the highly demanding data and requests expert knowledge to understand how the models work, which variables they communicate, and analyze the data for policy. The most common requests from non-Annex-I representatives (via the open questions) were to increase scientific capacity building in those regions and provide training." Support capacity building & technology Transfers & financial support for research, climate change observations, and modeling" (small island state UNFCCC negotiator with a leading role in policymaking). "Provide capacity building and training when presenting the scenarios" (African non-negotiator and policy enabler). Scenario developers see the capacity building for users as a primary

means to understand better climate change scenario approaches and the SSP-RCP framework[9]. Such exercises have been tried earlier throughout the IPCC history. However, a fundamental difference in knowledge capacities evolves from the fact that scenario developments are concentrated in Annex-I countries[24,52], and thus also possibilities for policy cooperation between modeling teams and policymakers. In Annex-I, there is often a larger group of knowledgeable support staff.

Trust may play a role. Analysts sometimes feel underappreciated, ignored, or misused by policymakers[53,54], while some policymakers, in turn, feel misled or underserved by intelligence[54] or do not understand the communicated scientific results. Several interviewed researchers stated that some policymakers were mainly open to information consistent with their preferred policy direction or saw themselves “at the mercy of science-prescribed decisions” (EU researcher and former IPCC delegate). Contrary, policymakers may have less trust in scientific tools because of low familiarity and lack of knowledge of what they express (e.g., the black box concept)[55,56]. An insufficient insight could explain why non-Annex-I participants see emission scenarios as less relevant for national policymaking (Figure 1). They may not trust the numbers in the black boxes since they do not have access and resources (human resources, advisors, and technology) to assess the assumptions or translate the data into their policy or negotiating strategy. Another reason for lower policy relevance in non-Annex-I could be that policymakers do not trust the scenarios because they are primarily developed in Annex-I countries[57,58]. Concerns about western bias in scenario assumptions and data have been expressed historically by non-Annex-I researchers[59,60], and a similar policymaker distrust is represented in UNFCCC COP negotiations[61–63].

Suppose lower familiarity causes a more inadequate implementation of scenarios (and scientific knowledge) in non-Annex-I policies and gives Annex-I policymakers an advantage in COP negotiations. In that case, it is essential to “Provide more training to technicians involved in emissions scenarios” and to “Help us make decisions” (small island state policy advisor).

## Climate Mitigation And Improved Knowledge Bases

Our results matter regarding the core challenge of climate change mitigation. The policymaker’s perspective on emission scenarios is overlooked in the literature, and however, crucial to sufficiently improve their (and other scientific tools’) policy relevance. Despite a great effort of modeling institutions in cooperation with policymakers and stakeholders, it is mainly with Annex-I and a few of the wealthiest non-Annex-I countries[25–27]. The (non-Annex-I) UNFCCC delegates express a need for scenario training and scenario knowledge. Thus, the scientific community in climate change can improve their understanding of how scientific tools like emissions scenarios can and cannot support policymaking in non-Annex-I countries. Part of the scenario communication could include how to use which scenario types for which specific policy objectives - e.g., evaluating climate change risks and adaptation needs and cost benefits and effectiveness of mitigation options. In addition, the policymaking community

needs to communicate its goals and priorities to the scientific scenario development community. It is worth noting that divergent policy questions require various scientific information here. Policy relevance is not stable but changes continuously over time and is different for different policymakers.

There is a great variety in what different policymakers expect from scenarios. One fundamental disparity is between requests for greater national detail, spatial and temporal resolution, and more simple scenario communication and aggregate information. To integrate such disparate requirements into one common scenario framework, the SSP-RCPs could be presented in various levels of detail via a web platform designed via policymaker, stakeholder, and researcher co-creation.

The Annex-I and non-Annex-I policymakers express significant differences in scenario knowledge, displaying another pillar of global inequality. The (Annex-I) research community needs to close the knowledge gap between industrializing and industrialized climate change science and policy fields, including political funding. This means that scenario developers could further include the critical knowledge needs of (non-Annex-I) policymakers, advisors, and the national research community. It could also mean increasing research in locations outside the Annex-I territory and setting up training to teach build capacity amongst researchers, policy advisors, and policymakers on how to use complex scientific tools such as scenarios.

While scientists have discussed the inclusion of best-guess scenarios for two decades, the examined policymakers appear to be more interested in a current policy scenario and scenarios expressing what is needed to reach international targets. That is already provided by the short-term scenarios assessing the NDCs, for the past ten years[64].

Finally, technological development support from Annex-I to non-Annex-I is highly discussed at the COPs, reflecting the climate change financing under the PA. The reliability of (short-term) scenarios could be improved by including assumptions reflecting institutional capacities and cultural barriers to policy implementation.

# Methods

The study collected data on the perceptions of emission scenarios, knowledge about (familiarity with) them, possible improvement, and their policy relevance from a large representative sample (N = 62)

derived from a population (N = 299) of formally listed national focal points of the parties of the Conference of the Parties (COPs) of the United Nations Framework Convention on Climate Change (UNFCCC) (UNFCCC, 2020b). The population represented 196 of 197 parties, including a broad representation of negotiators and advisory party members. Twenty-one emails were not delivered. Sixty-two answered the survey partially or entirely (response rate of 22%). The survey was hosted online through SurveyXact.

The sample included 39 participants from least, semi, and newly industrializing non-Annex-I countries (63%) and 23 from industrialized Annex-I countries[38] (37%), significantly representative of the examined population. Most Annex-I participants represented European countries (18), with fewer responses from the United States (1), Australia (2), and Asia (0). However, this is a logical consequence of the methodological choice of examining the national focal point population. The average age was 45 years – non-Annex-I (Mean(M)=43) and Annex-I participants (M=48). The participants identified their primary role as either policymaker (67%), researcher (19%), or stakeholder/other (14%). They expressed their primary role in policymaking as following, informing, or advising policies (policy advisors), leading, or coordinating policies (policy enablers). For the analyses, we grouped informants by least, semi, and newly industrializing non-Annex-I and industrialized Annex-I country representatives.

The study focused on the perception and use of emission scenarios. It additionally examined the two other scenario types (impact and climate scenarios[1]. The study included three other scientific tools used in policymaking: policy roadmap, economic assessment of mitigation costs versus costs of no action, and climate-impact costs. Moreover, the study measured emission scenario familiarity as either high (knowing the tool of emissions scenarios between “in-between” to” yes to a high degree” (score 4-6)) or low (from “not knowing” to “not really knowing” them (score 1-3)). Five options for improving the emission scenarios’ policy relevance, debated in the literature, were explored. Data was processed in Atlas, Excel, and R. Answers are provided in SI Excel (some citations are slightly adjusted to improve readability). See variables and coding in SI Word, chapter 2.

# References


1. Moss, R. H. *et al.* The next generation of scenarios for climate change research and assessment. *Nature* **463**, 747–756 (2010).

2. IPCC. Climate Change 2022: Mitigation of Climate Change — IPCC. *Intergovernmental Panel on Climate Change* 2913 https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/ (2022).

3. IPCC. *Climate Change 2022: Impacts, Adaptation and Vulnerability: Summary for Policymakers*. https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_SummaryForPolicymakers.pdf (2022).

4. APA. Roadmap for Carbon Neutrality 2050 (RNC2050): Long-Term Strategy for Carbon Neutrality of the Portuguese Economy. (2019).

5. UNFCCC/COP. *Paris Agreement*. *United Nations Framework Convention on Climate Change* https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf (2015).

6. UNFCCC. Information portals and sources of scenario data. *United Nations Framework Convention on Climate Change* https://unfccc.int/topics/science/resources/information-portals-and-sources-of-scenario-data (2020).

7. UNFCCC. Science in the negotiations. *United Nations Framework Convention on Climate Change* https://unfccc.int/topics/science/the-big-picture/science-in-the-negotiations (2021).

8. van Beek, L., Hajer, M., Pelzer, P., van Vuuren, D. & Cassen, C. Anticipating futures through models: the rise of Integrated Assessment Modelling in the climate science-policy interface since 1970. *Global Environmental Change* **65**, 102191 (2020).

9. O'Neill, B. C. *et al.* Achievements and needs for the climate change scenario framework. *Nature Climate Change* (2020) doi:10.1038/s41558-020-00952-0.

10. UNEP. *Emissions Gap Report 2021*. *United Nations Environment Programme* https://www.unep.org/resources/emissions-gap-report-2021 (2021).

11. UNFCCC. *Nationally determined contributions under the Paris Agreement: Synthesis report by the secretariat*. https://unfccc.int/sites/default/files/resource/cma2021_08_adv_1.pdf (2021).

12. Schweizer, V. J. & O'Neill, B. C. Systematic construction of global socioeconomic pathways using internally consistent element combinations. *Climatic Change* **122**, 431–445 (2014).

13. IPCC. Scenario Process for AR5. *International Panel of Climate Change web page* vol. Modified M http://sedac.ipcc-data.org/ddc/ar5_scenario_process/ (2014).

14. Kriegler, E. *et al.* A new scenario framework for climate change research: the concept of shared climate policy assumptions. *Climatic Change* **122**, 401–414 (2014).

15. Pielke, R., Wigley, T. & Green, C. Dangerous assumptions. *Nature* **452**, 531–532 (2008).

16. Rosa, I. M. D. *et al.* Multiscale scenarios for nature futures. *Nature Ecology & Evolution 2017 1:10* **1**, 1416–1419 (2017).

17. Elsawah, S. *et al.* Scenario processes for socio-environmental systems analysis of futures: A review of recent efforts and a salient research agenda for supporting decision making. *Science of the Total Environment* **729**, 138393 (2020).

18. Cline, W. R. Scientific Basis for the Greenhouse Effect. *Source: The Economic Journal* **101**, 904–919 (1991).

19. Schenk, N. J. & Lensink, S. M. Communicating uncertainty in the IPCC's greenhouse gas emissions scenarios. *Climatic Change* **82**, 293–308 (2007).

20. Schneider, S. H. What is "dangerous" climate change? *Nature* **411**, 17–19 (2001).

21. Fuss, S. *et al.* Betting on negative emissions. *Nature Climate Change* **4**, 850–853 (2014).

22. Leggett, J. *et al.* Emissions scenarios for the IPCC: an update. in *Climate change 1992: the supplementary report to the IPCC scientific assessment* 69–95 (1992).

23. Riahi, K. *et al.* The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. *Global Environmental Change* **42**, 153–168 (2017).

24. WCRP. WCRP Coupled Model Intercomparison Project (CMIP). *World Climate Research Programme* https://www.wcrp-climate.org/wgcm-cmip (2020).

25. PLB. About COMMIT. *COMMIT, PBL Netherlands Environmental Assessment Agency* https://themasites.pbl.nl/commit/about-commit/ (2019).

26. ENGAGE. ENGAGE – Feasibility of Climate Pathways. *Envisioning a New Governance Architecture for a Global Europe (Engage)* http://www.engage-climate.org/ (2022).

27. CD-LINKS. CD Links Project. *Linking Climate and Development Policies – Leveraging International Networks and Knowledge Sharing* https://www.cd-links.org/ (2019).

28. Dunlap, R. E. Climate Change Skepticism and Denial. *American Behavioral Scientist* **57**, 691–698 (2013).

29. Evans, S. *et al.* COP26: Key outcomes agreed at the UN climate talks in Glasgow. *CarbonBrief* https://www.carbonbrief.org/cop26-key-outcomes-agreed-at-the-un-climate-talks-in-glasgow (2021).

30. Mach, K. J. & Field, C. B. Toward the Next Generation of Assessment. *https://doi.org/10.1146/annurev-environ-102016-061007* **42**, 569–597 (2017).

31. Bloomberg. Delivering on America's Pledge | Americas Pledge On Climate. *Bloomberg IP Holdings LLC* https://www.americaspledgeonclimate.com/report-delivering-on-americas-pledge/ (2021).

32. IPCC. *Towards new scenarios for analysis of emissions, climate change, impacts, and response strategies: Technical Summary*. https://www.ipcc.ch/site/assets/uploads/2018/05/expert-meeting-ts-scenarios-1-1.pdf (2007).

33. Nakicenovic, N. & Swart, R. *Special Report on Emissions Scenarios*. (Cambridge University Press, 2000).

34. Kok, K., Biggs, R. (Oonsie) & Zurek, M. Methods for Developing Multiscale Participatory Scenarios: Insights from Southern Africa and Europe. *Ecology and Society* **12**, (2007).

35. Lahn, B. In the light of equity and science: scientific expertise and climate justice after Paris. *International Environmental Agreements: Politics, Law and Economics* **18**, 29–43 (2018).

36. Hausfather, Z. & Peters, G. P. Emissions – the 'business as usual' story is misleading. *Nature* **577**, 618–620 (2020).

37. UNFCCC. *National focal points*. https://unfccc.int/process/parties-non-party-stakeholders/parties/national-focal-point (2020).

38. UNFCCC. *United Nations Framework Convention on Climate Change*. (Parties of the Convention, 1992).

39. UNFCCC/COP. *Kyoto Protocol to the United Nations Framework Convention on Climate Change*. FCCC/CP/1997/L.7/Add.1 (CONFERENCE OF THE PARTIES, Third session, 1997).

40. COP/UNFCCC. Decision-/CP.26 Glasgow Climate Pact. (2021).

41. Andrijevic, M., Crespo Cuaresma, J., Muttarak, R. & Schleussner, C. F. Governance in socioeconomic pathways and its role for future adaptive capacity. *Nature Sustainability* **3**, 35–41 (2020).

42. Government of India. *India's Intended Nationally Determined Contribution: Working Towards Climate Justice*. *National Determined Contribution, UNFCCC* https://www4.unfccc.int/sites/submissions/INDC/Published Documents/India/1/INDIA INDC TO UNFCCC.pdf (2015).

43. IPCC. *Climate Change 2014 Mitigation of Climate Change*. (Cambridge University Press, 2014).

44. van Vuuren, D. P. *et al.* What do near-term observations tell us about long-term developments in greenhouse gas emissions? *Climatic Change* **103**, 635–642 (2010).

45. Grübler, A. & Nakicenovic, N. Identifying dangers in an uncertain climate. *Nature* **412**, 15 (2001).

46. Patel, M., Kok, K. & Rothman, D. S. Participatory scenario construction in land use analysis: An insight into the experiences created by stakeholder involvement in the Northern Mediterranean. *Land Use Policy* **24**, 546–561 (2007).

47. CAT. Countries. *Climate Action Tracker* https://climateactiontracker.org/countries/ (2021).

48. IEA. World Energy Outlook 2021. *International Energy Agency* https://iea.blob.core.windows.net/assets/4ed140c1-c3f3-4fd9-acae-789a4e14a23c/WorldEnergyOutlook2021.pdf (2021).

49. Gidden, M. J. *et al.* Global emissions pathways under different socioeconomic scenarios for use in CMIP6: a dataset of harmonized emissions trajectories through the end of the century. *Geoscientific Model Development* **12**, 1443–1475 (2019).

50. IPCC. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K.* (Cambridge University Press, 2021).

51. IPCC. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. (Cambridge University Press. In Press. , 2022).

52. IEA. *World Energy Model Documentation. October 2021*. https://iea.blob.core.windows.net/assets/932ea201-0972-4231-8d81-356300e9fc43/WEM_Documentation_WEO2021.pdf (2021).

53. Geden, O. The Paris Agreement and the inherent inconsistency of climate policymaking. *Wiley Interdisciplinary Reviews: Climate Change* **7**, 790–797 (2016).

54. Steinberg, J. The Policymaker's Perspective: Transparency and Partnership. in *Analyzing Intelligence: National Security Practitioners' Perspectives* (eds. George, R. Z. & Bruce, J. B.) 93–101 (2014).

55. Koomey, J., Schmidt, Z., Hummel, H. & Weyant, J. Inside the Black Box: Understanding key drivers of global emission scenarios. *Environmental Modelling & Software* **111**, 268–281 (2019).

56. Jancovici, J.-M. What is an emission scenario? Is it important for the future? *Website* https://jancovici.com/en/climate-change/predicting-the-future/what-is-an-emission-scenario-is-it-important-for-the-future/ (2007).

57. EMF. Energy Modeling Forum. *Energy Modeling Forum* https://emf.stanford.edu/ (2020).

58. WCRP. WCRP-CMIP CMIP6_CVs version: 6.2.53.6. https://wcrp-cmip.github.io/CMIP6_CVs/docs/CMIP6_institution_id.html.

59. Parikh, J. K. IPCC strategies unfair to the South. *Nature* (1992) doi:10.1038/360507a0.

60. Sardar, Z. Colonizing the future: the 'other' dimension of futures studies. *Futures* **25**, 179–187 (1993).

61. Pedersen, J. Is Glasgow COP26 a new Copenhagen, overlooking the countries in most need? *SHIFT Blog | Environment Territory and Society Research Group (ICS-ULisboa)* https://ambienteterritoriosociedade-ics.org/ (2021).

62. Dimitrov, R. S. The Paris Agreement on Climate Change: Behind Closed Doors. *Global Environmental Politics* **16**, 1–11 (2016).

63. Gupta, J. *The Climate Change Convention and Developing Countries: From Conflict to Consensus?* vol. 8 (Springer Netherlands, 1997).

64. UNEP. *The Emissions Gap Report 2010*. https://www.unep.org/resources/emissions-gap-report-2010 (2010).

## Declarations

# Conflict of interest

The authors have declared no conflicts of interest in this article. Four authors have been IPCC authors for more than one assessment cycle. One was involved in developing the SA90, IS92, and SRES scenario sets, and one in developing the RCP-SSP-SPA scenario framework.

## Figures

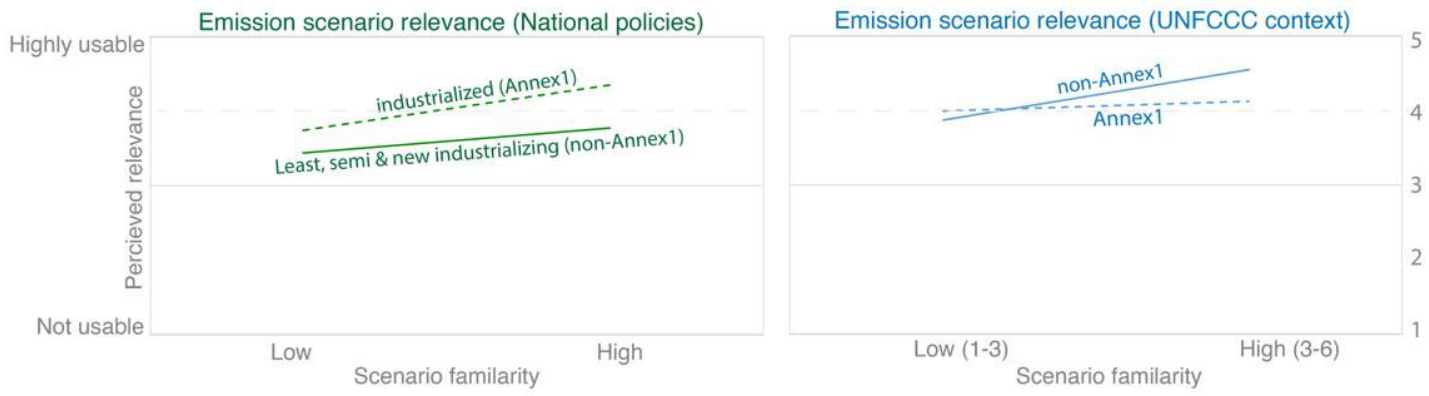


**Figure 1**

Policy relevance of emission scenarios as perceived by UNFCCC delegates. Low familiarity (Score 1-3: “I have heard about them but not sure what they express” to “I do not know them”), High familiarity (score 4-6: “I know emissions scenarios a little,” to “I participated in developing scenarios”).


## Figure 2

Improved policy relevance of emission scenarios perceived by non-Annex-I (solid lines) and Annex-I policymakers. Low and high reflect values reflect the informants' knowledge of and familiarity with emission scenarios (horizontal axis). Highly versus not used reflect informants' opinion if specific scenario changes would increase the policy relevance of emission scenarios.

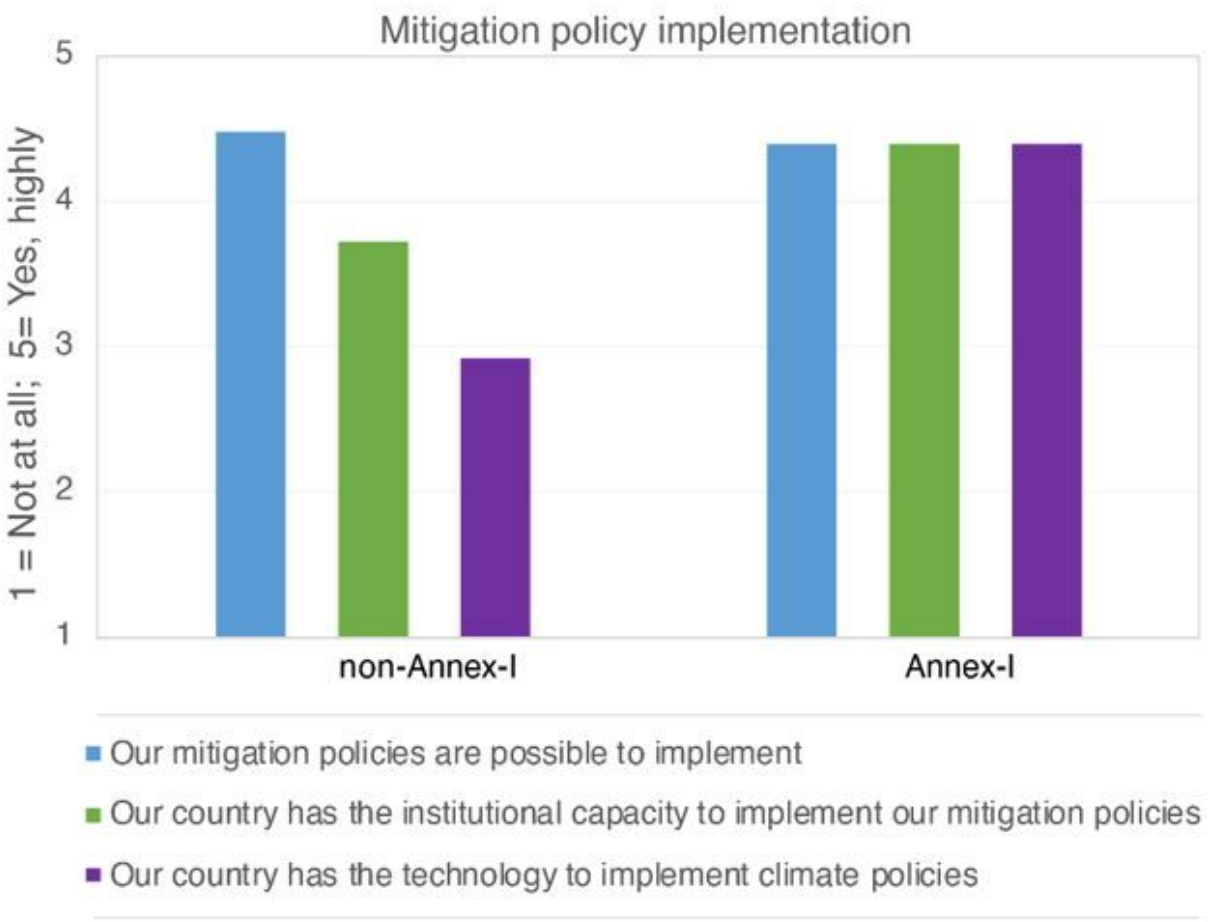


**Figure 3**

Perceived mitigation policy implementation grouped by non-Annex-I and Annex-I participants

# Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryInformation.docx
- SupplementaryInformationDataExcel.xlsx