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Science-policy: UNFCCC policymakers' perspective of scientific scenarios and their policy relevance

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Scenarios play a pivotal role in linking climate science to policy action, informing the Intergovernmental Panel on Climate Change (IPCC) reports and international negotiations within the United Nations Framework Convention on Climate Change (UNFCCC) and its annual Conferences of the Parties (COPs)^{1–3}. However, policymakers' (PMs) perspectives remain understudied. Here, we surveyed UNFCCC National Focal Points (N = 278/n = 57), assessing the knowledge base of international-national PMs, perceptions of scenarios' policy relevance, and plausible improvements. Results highlight a significant regional knowledge gap, with lower scenario familiarity for PMs representing low- and middle-income countries. Furthermore, policymakers request more straightforward scenario communication and more detail. To improve scenario relevance (credibility and legitimacy)⁴, we recommend more actively disseminating scenario knowledge (enhancing institutional capacity) in the Global South and providing more policy-relevant detail into global scenarios and national extensions (linking scenarios to on-the-ground policy action). This also means reassessing the IPCC's cautiousness concerning being policy-neutral.

For over three decades, model-based climate scenarios have been instrumental in evaluating emissions trajectories^{5,6} and guiding international climate policy^{1,7,8}. Introduced in the first IPCC Assessment Report (1990)⁹, these scenarios have served as boundary objects^{10,11,12}, shaping UNFCCC negotiations and influencing global temperature targets, including the Paris Agreement's goals^{7,8,13}. Despite their widespread use in scientific assessments, their real-world policy relevance remains underexplored. This gap raises pressing questions about their usability in real-life decision-making.

Effective boundary work that informs multiple audiences requires scientific information to be credible (scientifically robust), legitimate (perceived as fair and inclusive), and salient (relevant to decision-makers' needs)^{4,14}. The boundary between science and policy is just one of many. Managing boundaries between different knowledge systems is equally critical for ensuring that information is not only produced but also effectively transferred and utilized. The scenario literature has focused on credibility

and legitimacy, with less attention to salience¹⁵. Existing studies have examined stakeholder perspectives in local scenario planning^{16,17}, yet direct engagement with policymakers on their use and perception of scenarios is rare¹⁵. Recognizing this gap, the 2023 IPCC Scenario Expert Workshop highlighted a need to improve understanding of stakeholder and policy users' perspectives¹⁸, enhancing their applicability.

This study responds to these concerns by assessing the extent to which degree scenarios link science with decision-making, focusing on how policymakers perceive emission, climate, and impact scenarios. We surveyed 57 UNFCCC National Focal Points (UNFCCC-NFPs), comprising government representatives responsible for climate policy coordination, to explore their familiarity with scenarios, their views on their practical utility, and recommendations for enhancing their policy effectiveness. Given their formal role and year-round engagement in climate negotiations, their insights provide a critical perspective on how to bridge the science and

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policy spheres. Notably, given the small population (283 NFPs), results may not be generalizable to the larger global climate policymaker population.

To assess decision-makers' perceptions of the scientific scenario tool, we apply the credibility, salience, and legitimacy (CSL) framework, useful to examine how scientific knowledge is constructed, perceived, and applied in decision-making. Credibility concerns the quality and trustworthiness of information^{4,19}, e.g., data accuracy and user trust^{4,20}. Legitimacy concerns that knowledge production processes are unbiased or impartial by including diverse perspectives of all relevant groups (e.g., author team composition, scientific fields, and regional belonging)⁴. Thus, it also supports that the knowledge produced is perceived as credible and trustworthy, e.g., that scenarios obtain broad acceptance outside the modeling community^{4,19}. Finally, salience refers to the relevance of the information produced, considering the specific needs of decision-makers or other users. Knowledge is considered salient when relevant to policy or geared toward real-world decisions²¹, e.g., aligned with the priorities, needs, and concerns of decision-makers, delivered in a timely manner, and provides advice that can be converted into policies^{4,10,19}.

By applying this framework, we identify barriers to scenario usability and explore how scenario development can be better aligned with the needs of policymakers, strengthening their role as a decision-making tool. Before presenting the results, we provide a context section for non-scenario experts.

Scenarios in a broader historical and societal context

Since 1990, scenario planning^{22–24} has been an organizing principle and a backbone in the three IPCC Working Groups (WGs)^{9,25}. Literature about socioeconomic emission scenarios primarily informs IPCC WGIII (mitigation), climate scenarios inform WGI (physical climate change), and impact scenarios inform WGII (adaptation)^{6,15}. The first three scenario generations (SA90⁹, IS92²⁶, SRES²⁷) were developed between 1989 and 2000 under IPCC mandates⁶. The most recent scenario framework (SSP-SPA-RCP) is coordinated by but developed outside the IPCC²⁸. It informs the IPCC's 5th, 6th and 7th Assessment Reports (AR5–7). This SSP-SPA-RCP framework integrates three key components: the Shared Socioeconomic Pathways (SSPs)²², Shared Policy Assumptions (SPAs)²⁹, and Representative Concentration Pathways (RCPs)²³. The SSPs outline alternative global socioeconomic trajectories (SSP1–5), the RCPs describe corresponding emissions and radiative forcing levels by 2100 (RCP1.9–8.5), and the SPAs bridge the two by providing policy dimensions ranging from strong global cooperation and high ambitions (SPA0) to fragmented climate policy efforts (SPA5). SPA0 is often connected to the sustainability scenario narrative of SSP1, while SPA5 fits well the regional rivalry SSP3 narrative or the fossil fuel-driven economic growth narrative of SSP5^{29,30}. The SPAs differentiate mitigation strategy ambitions via general variables like global-regional carbon pricing, land-use legislation, and technological transitions.

For the AR6²⁵, the SSP-RCP scenarios were used as part of ScenarioMIP and mostly used in WGI. They provide a range from stringent mitigation in SSP1-1.9 and SSP1-2.6 (SPA0), the middle-of-the-road mitigation in SSP4-3.4 and SSP2-4.5 (SPA2/3), to weak institutions and control measures in SSP3-7.0 and the high climate change scenario SSP5-8.5 (SPA5)²⁴. The original RCPs were mainly used for the WGII literature (with impact assessment often being the latest to be developed^{15,31}). For WGIII, a system was set up to categorize a much wider set of scenarios consistent with the SSP-RCPs used in WGI^{32,33}.

Beyond long-term projections, expressed in the SA90, IS92, SRES, and SSP-RCPs, short-term policy scenarios represent a key tool to evaluate the effect of the Paris Agreement. They assess national climate policies and Nationally Determined Contributions of the Paris Agreement (NDCs), identifying gaps between pathways exploring existing mitigation strategies and the emissions reductions required to meet the Paris Agreement^{34–36}. While these evaluate real-world policies and NDC targets, they are not explicit about the (national) emission reduction strategies required to reach the Paris temperature goals, e.g., hypothetical suggested implementation roadmaps.

Scenarios in the science-policy interface

From the beginning, the IPCC sought to establish itself as a reputable source of scientific data^{37,38}, cultivating trust among scientific and non-scientific audiences^{39,40}. To uphold credibility, the panel implemented strong organizational structures and processes⁴¹, ensuring reliability³⁹. After the first assessment, the US and Russian delegations succeeded in excluding climate policy assumptions from scenario assumptions⁴², weakening scientific credibility. After the second assessment, Global South-based researchers⁴³ and IPCC delegates raised concerns about the lack of Global South perspectives in the IS92 narratives, potentially compromising scenario legitimacy^{43,44}. Within the IPCC, the critique led to mandating significant changes in the author team for developing the 3rd scenario generation (SRES). This aimed to include a larger range of values, concerns, and viewpoints in scenario developments⁴¹. After the 3rd and 4th assessments (informed by the SRES^{15,44,45}), successive and increasing credibility and legitimacy critiques forced the IPCC to move scenario developments outside⁴⁶ to the research community without any formal IPCC mandates. This enforced scenario credibility and legitimacy, e.g., inclusion of climate policy assumptions in the SSP-SPA-RCP framework²⁰. Still, IPCC delegates find current scenarios to lack implementation of Global South perspectives⁴⁷, compromising legitimacy and user trust¹⁸.

In the context of international climate negotiations and UNFCCC scenario use, global scenario-based analysis introduced the 2 °C threshold as a relatively safe limit in 1991⁴⁸, which was later incorporated into COP negotiations but not formally adopted by all parties until 2009^{7,13,49}. To enhance science-policy dialog, the COP established the Structured Expert Dialogue (SED) in 2012⁵⁰, laying the foundation for integrating the 1.5 °C and 2 °C targets into the Paris Agreement^{7,8}. Subsequently, the UNFCCC COP mandated scenario analysis to track Paris Agreement progress via annual periodic reviews^{2,51}. The IPCC's Special Report on 1.5 °C Pathways (SR1.5) refined the framework by presenting Paris-Compliant Pathways aligned with the Agreement's goals⁵². While welcomed by the UNFCCC Secretariat¹, the SR1.5s were criticized by some governments with less interest in mitigation¹⁵. The United Nations Environment Programme (UNEP) and Climate Action Tracker (CAT) have consistently released annual short-term policy scenario updates^{35,36}, timed strategically to provide critical insights for the UNFCCC COPs^{10,53}.

Implications for salience

Global scenarios typically aim to inform strategic decisions regarding international treaties. In addition, global models are sometimes used as a reference for domestic policies, e.g., impact assessment of EU climate policy or for the timing of emission reductions and overall strategy⁵⁴. Scenario extensions (of the global scenarios) aim to assist policymakers by investigating the implications of local policy options, prior to their implementation in real-world policy^{53,55}.

In some cases, downscaled global model results are used for countries lacking detailed domestic models. Some governments have developed scenarios linked to mitigation roadmaps, outlining the phased implementation of actions required to achieve policy goals within a specific timeframe⁵⁶. Finally, other scenario models provide tools to inform national governments and sectors in aligning corporate emissions reductions with global emissions budgets^{57,58}, e.g., Science-based Targets⁵⁹.

Since scenarios play a central role in science, it may be easy to reproduce a perception within the scientific field that scenarios play a key role in policy. However, their value for policy is not always straightforward. First, scenarios applicability in policy is more abundant in Global North jurisdictions^{60–63}. Second, differences between the science and policy fields, such as climate researchers' long-term focus versus policymakers' short-term electoral priorities, might create misalignments. Moreover, researchers' ability to identify problems is not always placed in a context of timely and feasible policy solutions⁶⁴. Finally, policymakers must balance the overall global paradigm worshipping economic growth with climate mitigation strategies, national interests with global needs and targets⁶⁵. Thus, public interests, stakeholder pressures (e.g., from fossil fuel⁶⁶ and cement

industries⁶⁷), economic competitiveness, job creation, etc., may conflict with public climate objectives.

Results

Population and sample

A survey was distributed among 278 UNFCCC National Focal Points (UNFCCC-NFPs)⁶⁸. Forty completed the survey, and 17 partially completed it, implying a 21% response rate. UNFCCC-NFPs comprise a group of all year-round delegates engaged, and thus a valid population to examine central policymakers and delegates engaged in the UNFCCC⁶⁸. On the contrary, COP party delegates comprise a diverse group of ever-changing policy advisors, negotiators, scientists, and industry stakeholders⁶⁹.

Out of 196 UNFCCC member states, our sample presents 63% non-Annex-I (38) and 37% Annex-I representatives (19) from different 22 non-Annex-I and 15 Annex-I countries. The sample has a higher Annex-I representation compared to the distribution of the UNFCCC-NFP population (80% non-Annex-I/20% Annex-I).

The 57 informants were between 24 and 72 years ($M = 44$). The informants' UNFCCC experience ranged between 1 and 30 years ($M = 8$ years). Twenty-five percent had participated since before 2014 (the final publication of AR5). Seventy percent had experience as UNFCCC negotiators, and 86% had national policymaking experience. Forty-four out of 57 informants (44/57) identified their principal occupational role as policy-maker (77%), 11% (6/57) as researcher, and 12% (7/57) as stakeholder (see "Methods" section, Table 5). On average, the respondents find it highly important to anticipate climate change (4.8 out of 5) and biodiversity loss (4.7), while pandemics (4.5) and terror (4.2) are perceived as a bit less important.

Analytical categories

The world has changed since the UNFCCC's Annex-structure was defined in 1992, comprising 42 Annex-I countries as highly developed and 154 non-Annex-I developing countries⁷⁰. In 2023, the UN classified 46 as Least Developed Countries (LDCs)⁷¹, while the World Bank categorizes 28 as low-income, 108 as middle-income, and 76 as high-income countries^{72,73}.

As illustrated in Table 1, our analytical categories distinguish between Least (LDCs), Medium (MDCs), and Highly Developed Countries (HDCs), based on income levels. The term "developed" primarily reflects economic growth rather than sustainability, considering high-income countries' high emission levels. The LDC category includes the UN-defined LDCs, which include some middle-income countries. Table 1 shows that our sample aligns with the real-world UNFCCC population for LDCs, while MDCs are underrepresented and HDCs are overrepresented.

Overall, the regional distribution of informants reflects quite well the actual distribution of UNFCCC parties. However, the sample has an overrepresentation of European High-income and African Low-income countries, and a significantly lower Middle East representation (see "Methods" section Table 7).

As illustrated in Table 2, 51% of the survey participants have a contributing role (Policy Contributors), while 49% have a coordinating or leading role in policymaking (Policy Enablers). In the paper's citations, we use the *LDC-MDC-HDC* and *policy contributor-enabler* categories to label informants' representation and policy role (open-ended questions).

Regional variations in scenario familiarity. We examined the participants' self-reported familiarity with the emission scenario tool to create a foundation for the analysis. Participants who are familiar with (know) the scenario tool are more reliable in evaluating its policy relevance and plausible improvements. Figure 1 shows the distribution of delegates with low (yellow) and high (green) familiarity with the emission scenario concept. Seventy-three percent (32 out of 44 informants (32/44)) express high familiarity with emission scenarios (answers 4–6). Of these, 41% (18/44) have seen them and think they know what the scenario variables express (answer 4), and 32% (14/44) know them very well (answers 5–6). Over 25% of the examined UNFCCC-NFPs are unaware of the scenario

Table 1 | Analytical classifications of participants grouped by the development and income levels

Paper categories for analysis	Definition	Informants	Share of sample	UNFCCC-NFP population (share of countries)	Annex group belonging
LDC Least Developed Countries	UN LDC definition	16	28%	46 (23%)	Non-Annex-I
MDC Medium Developed Countries	Middle-income countries (excl. UN LDCs)	19	33%	90 (46%)	Non-Annex-I
HDC Highly Developed Countries	High-income countries	22	39%	60 (31%)	Non-Annex-I & Annex-I
Total		57	100%	196 (100%)	

An overview of the measures and categories is available as dataset⁷⁴. High-, Middle-, and Low-income countries are based on World Bank definitions⁷⁵. Given the significant pollution by high-income countries, "developed" refers primarily to economic, and not sustainable, development.

concept. They have either heard about them but are unsure what they express (20%; 9/44) or don't know them (7%; 3/44).

Interestingly, scenario familiarity varies significantly across income regions, with 84% (16/19) HDC representatives being familiar with the scenario concept (answers 4–6), compared to 64% (16/25) of the MDC/LDC representatives. Of these, 55% (10/19) HDCs, 38% (9/25) MDCs, and only 13% (3/11) LDCs report knowing the scenarios very well (answers 5–6).

The open-ended responses reveal two distinct knowledge bases. HDC participants often reference advanced concepts related to scenario models (e.g., IAMs, downscaling) and specify variables (e.g., CDR, AFOLU, BECCS). Their requests for scenario improvements are more sophisticated, such as addressing specific variables (e.g., negative emissions, CDR). In contrast, MDC and LDC participants use more general terms, requesting scenarios to be “displayed simpler and more understandable” (MDC policy enabler, Africa) or “transmittable to a national policy context” (MDC policy enabler, Oceanian Island).

How policymakers perceive scenario relevance. Defining the concept, policy relevance (or salience) pertains to information’s usability for policymakers and decision-makers in guiding decisions or achieving political goals^{4,19,74}. Since UNFCCC-NFPs often engage in national policymaking and both global scenarios and local scenario extensions assess and inform about national policies^{16,36}, we investigated the perceived policy relevance by examining the informants’ perspective of various scientific tools’ usefulness in designing national mitigation policies and facilitating UNFCCC treaties.

In national policymaking, governments may benefit from scenarios to set emission reduction targets, develop strategies, and assess the potential impacts of policy measures⁷⁵. Within the UNFCCC, emission scenarios may support assessing safe emissions limits and potential future impacts⁵⁰. Global scenarios aid negotiators in setting reduction targets and outlining

strategies to achieve them. The short-term policy scenarios^{36,76}, in contrast, may support transparency and feasibility of national commitments (NDCs).

Our survey participants generally found the emission, climate, and impact scenarios policy-relevant. On a 1–5 scale (1–2: not relevant; 4–5: relevant for facilitating international climate treaties), impact scenarios scored highest (4.4), followed by climate (4.3) and emission scenarios (4.2). In comparison, economic assessments of impacts, mitigation vs. no mitigation, and policy roadmaps averaged 4.05. Despite policy roadmaps, all tools were on average perceived as less relevant in a national policy context (Table 3).

Figure 2a displays the percentage of participants who rated the three scenario types as relevant (Dark red, answers 4–5) for facilitating international treaties (bottom rows of panel a & b) and designing national mitigation policies (top rows). Emission scenarios are perceived as most relevant for national contexts and least relevant in the UNFCCC contexts of the three scenario types. The results suggest that UNFCCC policymakers generally find scenarios most relevant at the international level. This could be because detailed scenario knowledge is less critical in international negotiations than in shaping specific national policies.

We expect participants with high scenario familiarity to be better equipped to evaluate salience. Figure 2b illustrates the relationship between scenario familiarity and perceived policy relevance, grouped by country income level. It reveals that policymakers familiar with scenarios rate scenarios as more useful compared to those with low familiarity.

Table 4 and Fig. 3 present the perceived policy relevance of three long-term and three short-term scenario series. Interestingly, the SR1.5s⁵² (aiming to support the UNFCCC Paris Agreement implementation⁷⁷) are viewed as the most policy relevant for both national policy and international treaties. Long-term scenarios overall are rated slightly more relevant for international policymaking. Among short-term scenarios, UNEP Emission Gap report and CAT scenarios are considered most relevant for international use. IEA scores lowest across both contexts. While long-term scenarios slightly outperform short-term ones internationally, the overall relevance of both is comparable, highlighting their importance in both national and international policymaking.

Figure 3a illustrates the examined UNFCCC-NFPs’ perceptions of the national policy relevance of the recent scenario series. Participants with high scenario awareness identified the RCPs, SR1.5, and UNEP scenarios as the most relevant for designing national mitigation policies. The lower relevance of the SSP-RCP series may be attributed to the survey timing, as AR6 had not yet been published. However, it may also be due to higher complexity compared to the RCPs. One participant noted that: “The UNEP emissions Gap report and the IPCC report and their presented scenarios have been used for the Paris Agreement for the mitigation and climate goals” (HDC Policy Contributor, EU).

Table 2 | Participants role in policymaking

Role in policymaking	Count	Share	Paper categories for analysis
Lead	20	35%	28 Policy enablers (49%)
Coordinating	8	14%	
Advisory	20	35%	29 Policy contributors (51%)
Informing	2	4%	
Following	2	4%	
“No role” or “other role”	5	9%	
Total	57	100%	

Fig. 1 | UNFCCC national focal points’ familiarity with the emission scenario concept. The share of UNFCCC national focal points having a high scenario familiarity & knowledge base (green colors), and low scenario familiarity (yellow colors) grouped by Highly Developed Country (HDC), Medium Developed Country (MDC), and Least Developed Country representatives (LDC), and all examined delegates (All), *n* = 57.

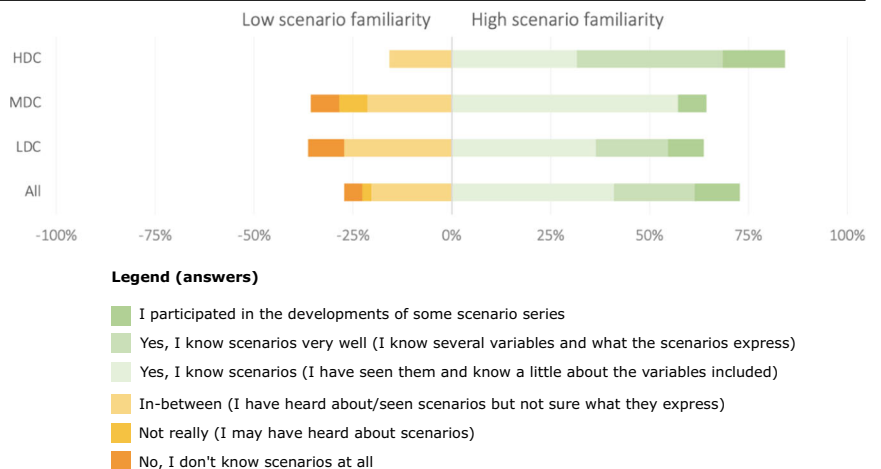
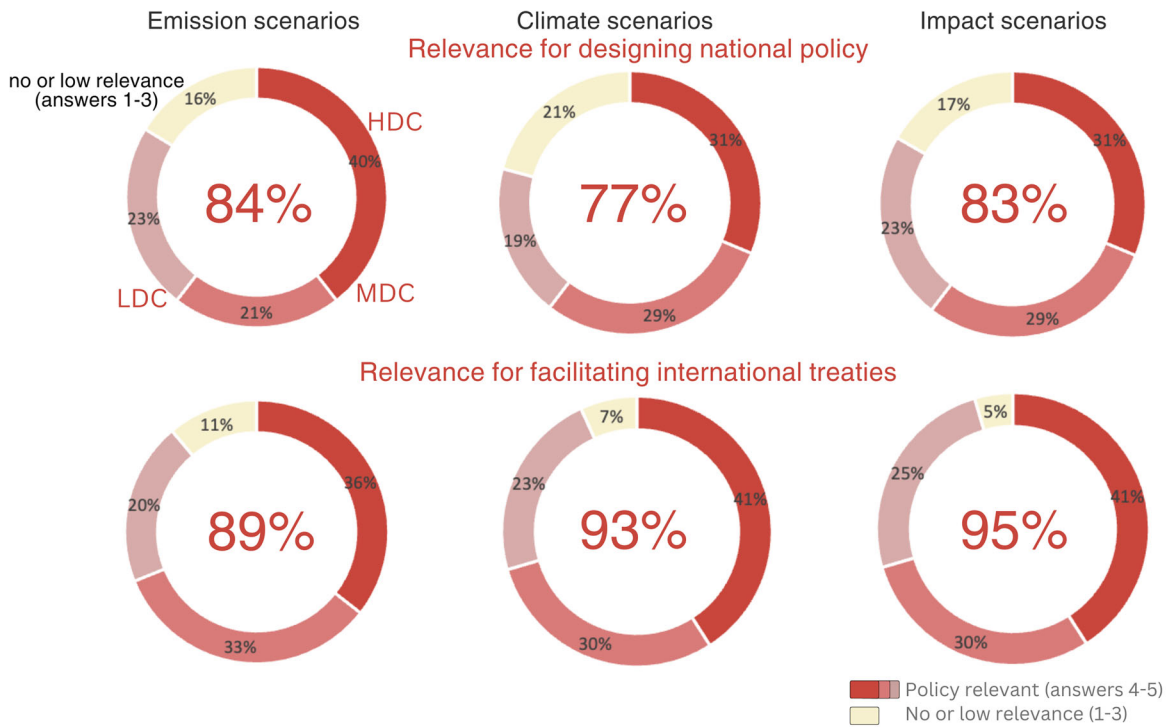


Table 3 | Perceived policy relevance of six scientific tools (sample means), Answer categories: 1–2 (not policy relevant), 3 (in-between), 4–5 (policy relevant)

	Emission scenarios	Climate scenarios	Impact scenarios	Policy roadmaps	Econ. Assessment of	
					Future climate-related impacts	Mitigation action vs. no action
Designing national policy	4.00	3.95	4.09	4.12	3.91	3.86
Facilitating international treaties	4.23	4.31	4.36	4.05	4.03	4.05

a The share of participants finding emission, climate & impact scenarios policy-relevant



b The distribution of HDC & MDC/LDC participants finding scenarios policy-relevant

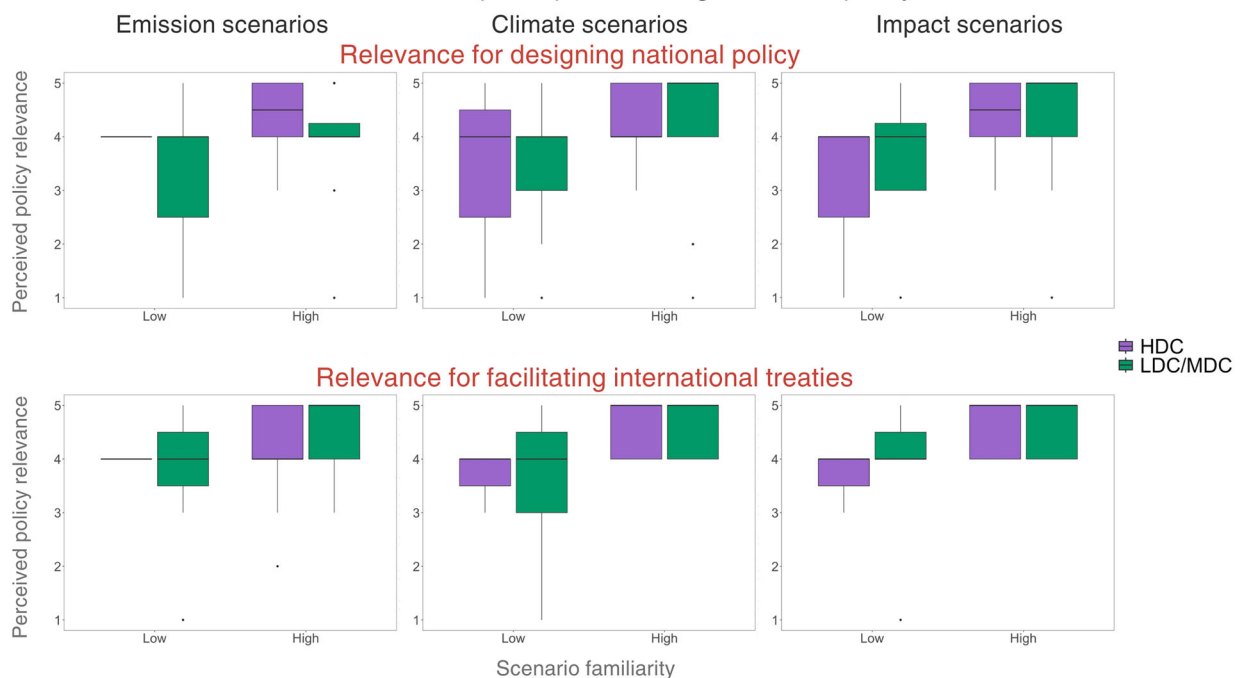


Fig. 2 | Perceived relevance of long-term emission, climate, and impact scenarios for national and international policy design, stratified by country development level.

The policy relevance of scenarios in designing national policy (top rows) and facilitating international UNFCCC treaties (bottom rows), as perceived by UNFCCC National Focal Point delegates, grouped by Highly Developed Country (HDC), Medium Developed Country (MDC), and Least Developed Country representatives (LDC). **a** Share of participants perceiving scenarios as policy relevant (answer 4) or highly policy relevant (5) (process (red colors (answers 4–5; grouped by HDC, MDC, and LDCs))), and participants finding those scenarios are less or not relevant (white color (in-between (3) & not relevant (1–2))). **b** Distribution of answers/participants perceiving scenarios as policy relevant, neutral, or not relevant, grouped by Highly (HDC) (purple box) and medium/least developed country representations (LDC/MDC) (green box). In **(b)**, policy relevance is grouped by informants’ scenario familiarity. Low familiarity (answers 1–3:

“I do not know them” to “I have heard about them but not sure what they express”), High familiarity (answers 4–6: “I know emissions scenarios a little,” to “I participated in developing scenarios”). The survey comprises 22 national Focal Point representatives from HDC (High-income) and 19/16 from MDC/LDC (medium and least developed) countries. Bar plot explanation **(b)**: Median (line) and variability/standard deviation (colored area). The box plot shows the ‘middle 50%’ of the answers, the interquartile range covering the 25% percentile to the 75% percentile (purple/green boxes), and the median (horizontal black line) representing the middle answer. In comparison, the box-ends represent the 25% quartile and 75% quartile (comprising 50% of the data responses). Each of the whiskers (vertical black lines) extends up to about 1.5 times the box size (the whiskers extend to the most extreme responses, which are within the range of the upper and lower ends of the box plus or minus 1.5 times the interquartile range (IQR - the box length)). Outliers (dots) express low or high responses outside the whisker ranges.

Table 4 | Perceived policy relevance of three long-term scenario series informing IPCC’s fifth and sixth assessment reports and three short-term policy scenarios (sample means, all participants)

	RCP (2011)	SR1.5 (2018)	SSP-RCP (2019)	IEA (since 2006)	CAT (since 2009)	UNEP (since 2010)
Designing national policy	3.88	3.95	3.58	3.45	3.70	3.80
Facilitating international treaties	4.10	4.23	4.00	3.74	3.87	4.03

Answer categories: 1–2 (not policy relevant), 3 (in-between), 4–5 (policy relevant).

Enhancing policy relevance. Figure 4 illustrates the relationship between policymakers’ scenario awareness and their perception of five potential scenario improvements, drawing on historical critiques and recommendations for scenarios¹⁵. These comprise simpler communication⁷⁸, best-guess scenarios^{79,80}, and science-policy co-creation^{81,82}. While some researchers have advocated for including a best-guess scenario as a way to communicate scenarios in less complicated ways to stakeholders and policymakers^{78,79}, such a method conflicts with the historical and current scenario approach of exploring a range of possible futures^{15,83,84}. A best-guess typically aims to reflect the “most probable” pathway in a series, e.g., combining median assumptions about socioeconomic drivers, policy choices, and technological progress⁸⁵ or based on qualitative assessments⁸⁰.

The top rows of Fig. 4a, b display three aspects concerning policymakers’ perceived need to reduce scenario complexity: (1) more simple knowledge communication, (2) minimize reliance on expert translation, and (3) less complex scenario data, making scenario data easier to process and apply in policy analysis. Notably, scenarios are developed as frameworks for exploring potential futures and informing decisions, and not prescriptive tools to be directly implemented into policy^{6,22,23,45}. Figure 4a and b, bottom rows address changes in scenario content and development, whether scenarios should feature a “best-guess” or most likely scenario, and whether policymakers should be included in the scenario development process. Both aspects were suggested by academic scenario critics to improve scenarios’ policy relevance¹⁵.

According to policymakers with high scenario familiarity (Fig. 4b), the high complexity of scenarios appears to hinder scenarios’ policy relevance for MDC/LDC representatives. The examined policymakers express a consistent preference for scenarios that are less complex to interpret and easier to apply in policy settings. In particular, those that require less expert knowledge and computing capacity to process and use effectively. As shown in Fig. 4b, a substantial share of LDC/MDC policymakers with high scenario familiarity indicated that emission scenarios would be more policy relevant if they were communicated more simply, required less analytical expertise, and could be processed with limited computational resources. HDC policymakers with high familiarity agree on communicating scenarios in a more simple manner, while the complexity of output data is not a problem. The latter may indicate that HDC policymakers have more access to technical support and computer power, than LDC/MDC policymakers. It

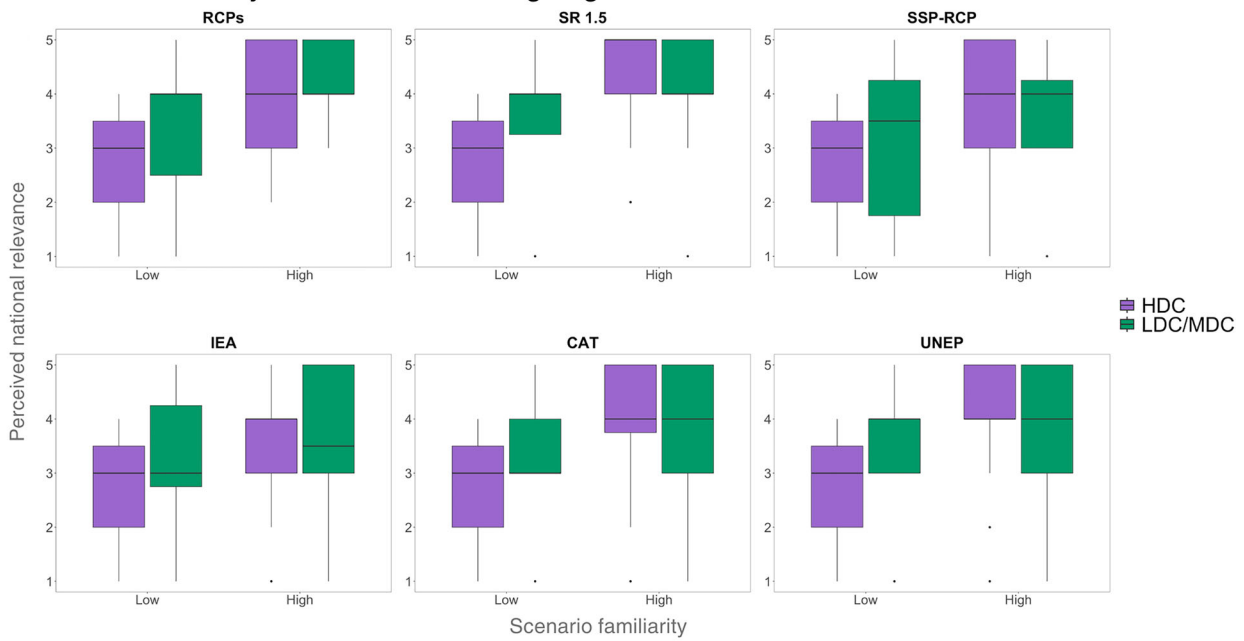
highlights a challenge that policymakers, particularly in MDCs and LDCs, report difficulties in utilizing scenarios, emphasizing a need for more accessible and actionable scenario outputs.

Although HDC representatives generally consider complex output data to be less of a barrier to salience, one HDC participant noted during pre-interviews that their country relied on the older SRES scenarios (published in 2000) to develop national carbon-neutral pathways: “We used the SRES to create our national carbon-neutral scenarios because the SSP data was too complex” (HDC policy enabler, EU).

Adding a best-guess scenario to a series may simplify scenario communication. As displayed in Fig. 4b, this is less relevant for HDC representatives with high scenario familiarity but highly useful according to the examined MDC/LDCs (in particular LDCs). Interestingly, the examined policymakers do not generally perceive policymaker inclusion in scenario development (e.g., science-policy co-creation) as a crucial adjustment to improve scenario salience. Delegates with low scenario awareness favor policymaker inclusion, while those with high awareness are less supportive. Some respondents noted in open-ended questions and pre-interviews that involving policymakers who are not committed to mitigation efforts could risk obstructing scenario development. Notably, the examined policymakers may not distinguish between global scenarios and local extensions. Development of the latter has included various types of stakeholder inclusion in the development processes^{16,55,86}.

Tailored communication and capacity building to enhance the science-policy link. The questions displayed in Fig. 4 aimed to open up informant reflections on how to increase scenario salience. The related open-ended questions reveal two potentially opposing requests for improving salience on the national level: simpler communication and greater detail. Eleven participants commented on science-policy communication. Four found scenarios overly complex, e.g., “reduce the complexity of scenarios” (LDC policy contributor, SIDS Africa), while ten emphasized the need for simpler communication, e.g., “simpler communication of emission scenarios to policymakers” (HDC policy contributor, EU) and “use reader-friendly, simpler language” (MDC policy enabler, Middle East). These comments highlight the challenge of translating complex scientific information into accessible formats: “The challenge is to communicate complex science to make it understandable for everyone” (HDC policy contributor, EU). Another noted, “Scenarios

a Perceived Policy Relevance for Designing National Climate Policies



b Perceived Policy Relevance for Facilitating International Climate Treaties

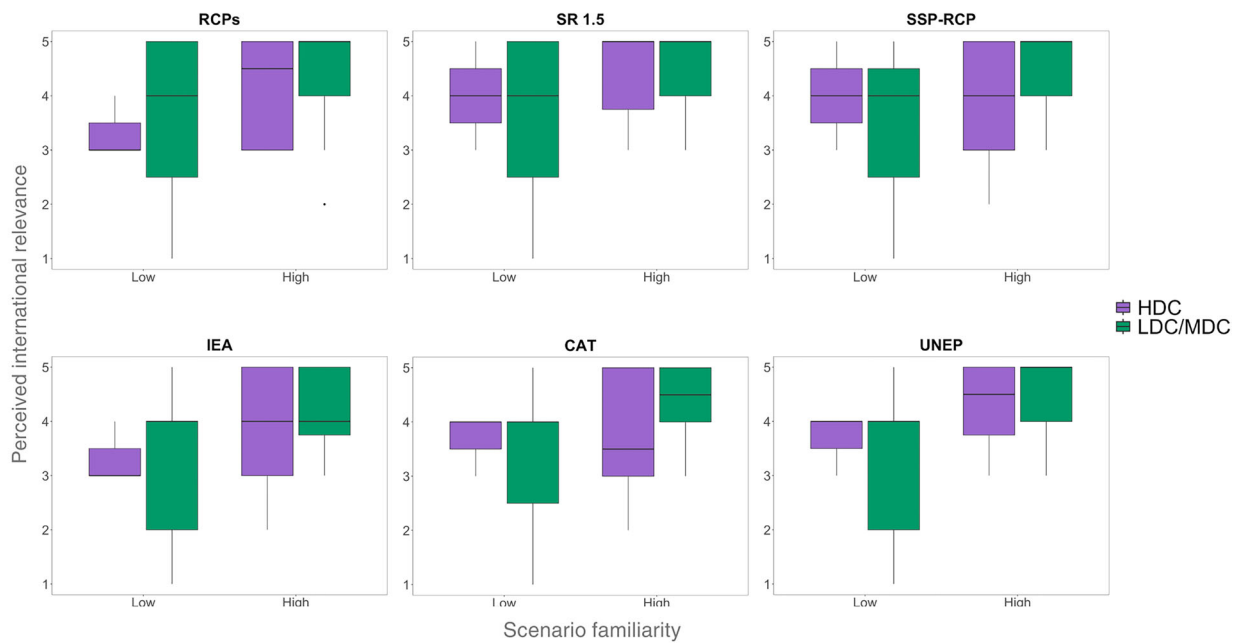


Fig. 3 | Perceived relevance of long-term and short-term emission scenarios for national and international policy design, stratified by country development level. Disparities in perceived scenario relevance for national (a) and international (b) policymaking across HDC and MDC/LDC representatives of long-term scenarios

informing the IPCC (top row) and short-term policy scenarios assessing energy futures and policies and targets related to the Paris Agreement (bottom row). Answers are grouped by Highly (HDC), Medium (MDC) & Least Developed Country (LDC) representatives.

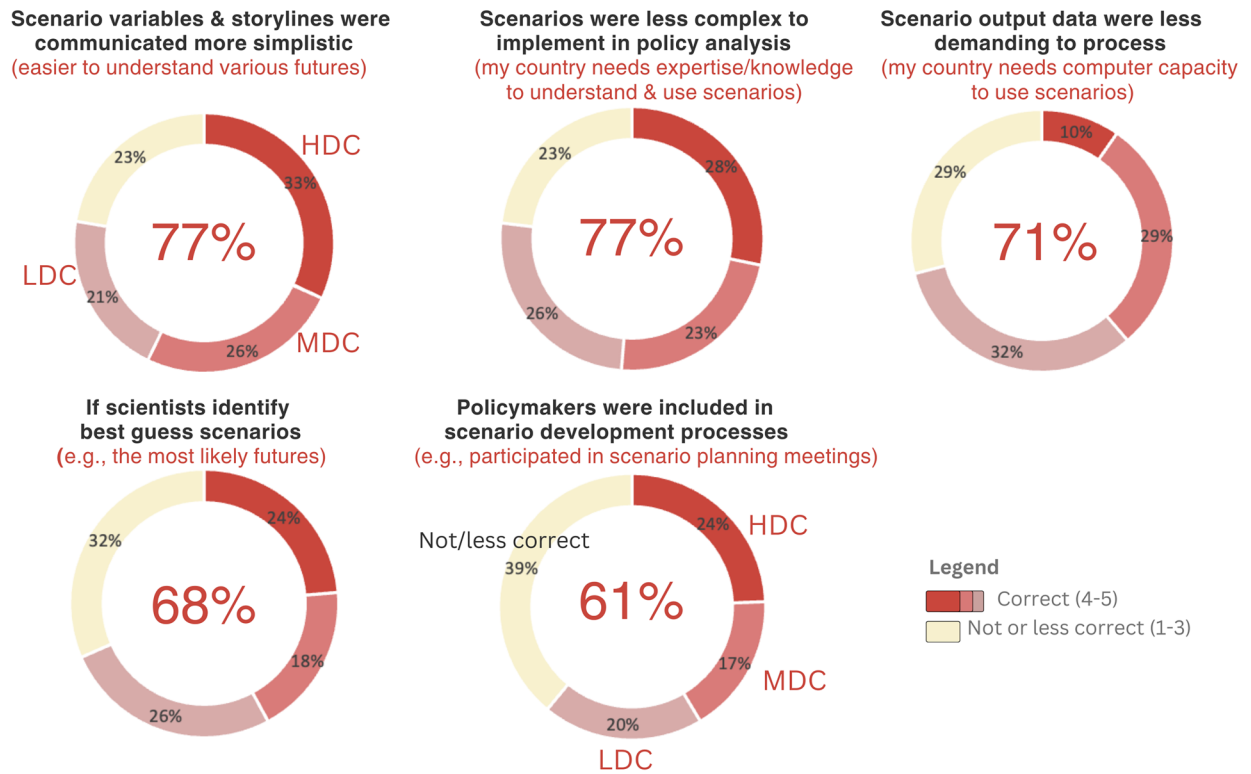
can become more relevant if they are better understood and explained using simpler information” (MDC policy contributor, Latin America).

Unlike HDC representatives, MDC/LDC policymakers often highlight the need for additional scientific and technical staff. For example, one MDC policy enabler from an Oceanian Small Island Developing State (SIDS) stated: “We require the input or presence of technical experts to assist in creating relevant tools, methodologies, and policies to address climate change issues.” Policymakers from low- and middle-income countries may use scenarios less frequently than their HDC counterparts, due to limited technical support, including institutional, academic, and technological capacities. In the survey, MDC and LDC representatives frequently cite

insufficient computing power and human resources to process complex scenario data, emphasizing the need for expert guidance to understand model variables, interpret results, and analyze data for policymaking.

Nine respondents (seven LDCs and two MDCs) requested capacity building and scenario training for policymakers and technical staff. Examples include: “Support capacity building & technology transfers & financial support for research, climate change observations, and modeling” (MDC policy enabler, SIDS Oceania), “Present scenarios in a more simplistic language and include capacity building and training when presenting them” (MDC policy contributor, Africa), and “Our country lacks the technical capacity to create scientific knowledge. We require technical

a The share of participants finding that emission scenarios would become more policy relevant if ...



b Distribution of answers grouped by HDC and MDC/LDC

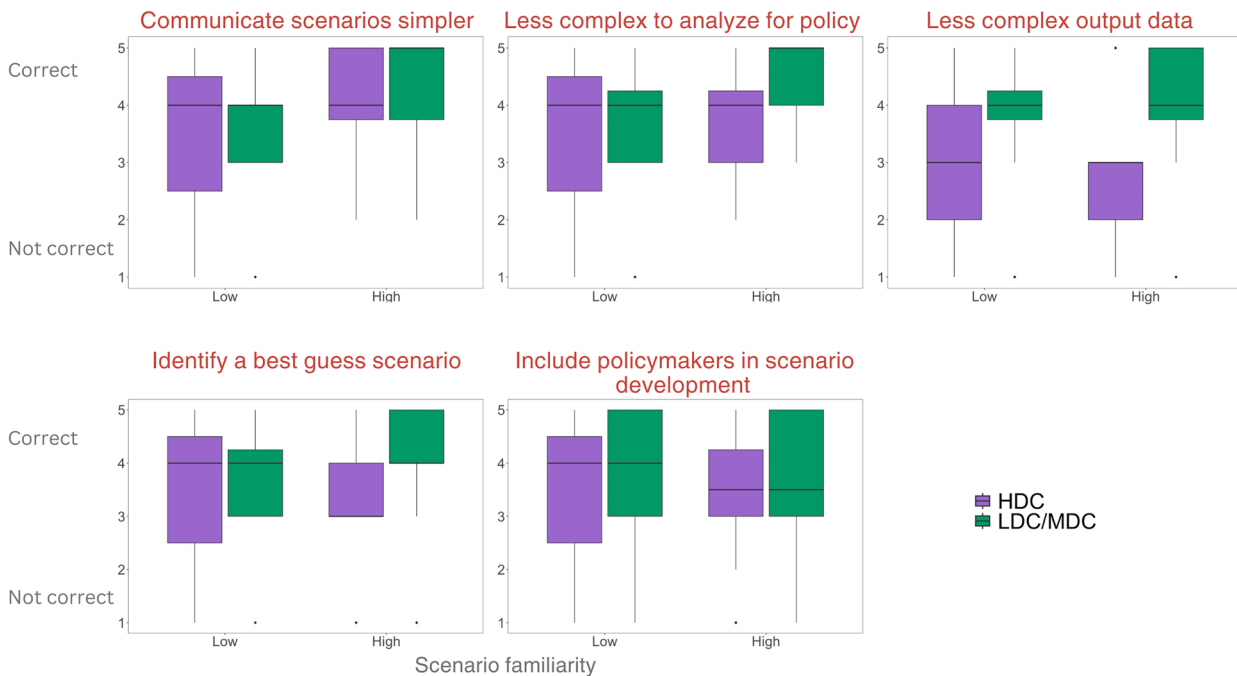


Fig. 4 | Policymakers’ perspective of plausible changes to improve policy relevance of emission scenarios. **a** The share of participants finding that it is correct that scenarios would become more policy relevant if specific changes are added to scenario designs or processes (red colors (answers 4–5); grouped by HDC, MDC, and LDCs), and participants finding it is neutral or not correct (white color (in-between (3) & not relevant (1–2))). Answers are grouped by Highly Developed Country

(HDC), Medium Developed Country (MDC), and Least Developed Country representatives (LDC). **b** Distribution of answers/participants grouped by Highly (HDC, purple box) and medium/least developed country representation (LDC/MDC, green box). The horizontal axis reflects participants’ scenario familiarity (Low vs. High). The vertical axis reflects informants’ opinions on whether specific scenario changes would increase the policy relevance of emission scenarios.

experts to assist with tools, methodologies, and policies for climate change” (MDC policy enabler, SIDS Oceania). Solutions to overcome LDC/MDC capacity challenges included “Exchanges of learnings” (LDC policy enabler, Asia), “Support for setting up inventories” (LDC policy enabler, Africa), and “More capacity building to understand climate models” (LDC policy enabler, Asia).

Nearly half of the examined policymakers (25) requested specific additional detail in scenarios, with 21 (35%) seeking greater national-level detail (3 LDCs, 7 MDCs, and 11 HDCs). General requests included assessments of present and future mitigation options, cost estimates, missing scenarios, and connections to other policy objectives like biodiversity, as well as the complexity of intergovernmental climate policy. National-level requests focused on supporting adaptation and mitigation actions: “Developing countries need localized scientific knowledge so national policies can be appropriately developed using relevant national scenarios” (MDC policy enabler, SIDS Oceania). Another noted, “Scenarios’ policy relevance will improve if they provide data applicable to national policymaking” (MDC policy enabler, SIDS Oceania).

Some participants suggested exploring policy options and addressing missing scenario aspects, particularly appropriate and effective mitigation options: “Unpack Paris-compatible scenarios to identify socioeconomic changes needed now and highlight missing options. For example, the policy need for phasing out internal combustion engines is well-understood, but this is not the case for domestic heating systems driven by natural gas or heating oil” (HDC policy contributor, EU). Similarly, “Modeling should explore policy mixes that achieve specific emission reduction levels at sectoral and societal costs. Current emission scenarios work at a higher global level and do not directly inform national policymaking” (HDC Policy Contributor, EU). Other participants suggested revealing economic assessments: “National policymaking is based mostly on economic analysis of current and future costs of action, burden on society and the anticipated level of public and private investments required. Science would be helpful if focused on those economic aspects.” (HDC policy contributor, EU) or “Policy relevance will improve if analyzed scenarios correlate with economic and political data” (HDC policy contributor, Latin America).

Improving scenario salience may involve including policy options and economic assessments, but these may also be assessed and disseminated to policymakers in parallel with scenario developments. However, supporting policymakers and their technical staff to better understand and use scenarios in policymaking may be achieved by tailoring scenario communication of global scenarios (and local extensions) to policymakers needs, knowledge bases, and institutional capacities. This includes ensuring the knowledge communicated is transferable to policy needs and objectives in the UNFCCC or national policymaking contexts.

Discussion

Based on the results, the discussion examines three identified boundaries for scenario’s policy relevance and applicability for climate action: scenarios’ connection to policy objectives, scenario communication, and unequal regional knowledge bases.

First, it is relevant to reshape scenarios’ connection to policy objectives. Our data shows that the examined policymakers find scenarios applicable to designing national policies and international treaties (Figs. 2 and 3). Simultaneously, they question their applicability to real-world problems, e.g., some request more detail about policy options (e.g., cost-effectiveness of mitigation strategies) and development of local scenarios for low- and middle-income countries. To be salient, scenario information needs to be connected to policymakers’ needs and objectives^{39,64}. Thus, it is relevant to specify scenario types, specific purposes, and their connection to specific policy objectives that the scenarios aim to support. Based on survey answers and contemporary literature^{76,87,88}, we identify at least three overall policy objectives relevant to current decision-making: (1) mitigation objectives (e.g., temperature goals), (2) long-term socioeconomic drivers’ effect on emission levels²², and (3) the need for adaptation^{87,89}.

Concerning the third, the long-term scenarios informing the IPCC provide high-impact scenarios (e.g., SSP3-7.0 and SSP5-8.5) relevant as input for vulnerability analyses to inform adaptation policies and strategies⁸⁹. For the second policy objective, the long-term scenarios aim to evaluate specific energy and socioeconomic futures, informing about plausible relationships between drivers and emissions.

Concerning the first policy objective, the SSP-SPA-RCPs framework includes abstract variables, such as international cooperation, carbon taxes^{29,30}, and energy transition⁸⁸. Avoiding policy analysis keeps the scenarios and the IPCC within a safe limit from being policy prescriptive. However, it may constrain the IPCC’s objective of being policy-relevant. On the contrary, the first generation of IPCC scenarios (SA90s) introduced three quite specific policy scenarios. Because of IPCC’s intergovernmental nature, the 2nd and 3rd generations were mandated to exclude policy scenarios^{30,42}, preventing critiques of being policy prescriptive. Avoiding mitigation detail and options contrasts with requests expressed by the examined policymakers. Notably, the global scenarios do not explicitly aim to support governments in planning policy, but they can provide a better understanding of what is needed on a global level to stay within “safe limits”. Here, it appears important that local scenario extensions continue to be developed to inform domestic policymaking^{16,55,86}, in particular for Global South countries.

The short-term policy scenarios partly inform the first objective, i.e., assessing current policy and NDC pathways, and their gaps in achieving the Paris Agreement’s temperature targets^{36,76}. However, they do not provide information about how to close the gap. Their Paris-compliant scenarios are also abstract trajectories without socioeconomic detail or strategy suggestions. A way to increase the policy relevance of, e.g., CAT scenarios, might be to accompany national Paris-Compliant Pathways with policy roadmaps, detailing the stepwise adoption of renewable energy, phased-out reliance on fossil fuels, or sector-specific interventions (e.g., transportation electrification or industrial decarbonization). This may allow policymakers to explore specific policy options within their unique contexts, simulating potential outcomes before real-world implementation.

Second, clearer and less technical communication of scientific knowledge may soften science-policy boundaries. With 77% of survey participants indicating a preference for simpler scenario communication, suggesting that current scientific materials are overly technical and complex for policy audiences (UNFCCC-NFPs). This finding aligns with prior studies^{19,90}, highlighting that the technical terminology common in IPCC reports¹² may limit accessibility for a wider audience and hinder practical application^{19,90}. For example, one global North government opted for the earlier and simpler SRES scenarios over the most recent SSP scenarios when developing local extensions (mitigation pathways) of the global scenario. Thus, future scenario updates should prioritize more accessible and easier-to-understand data formats and communication approaches, closely tailored to policymakers’ requirements.

The boundaries between scientific and policy fields remain sensitive. Only 61% of surveyed policymakers believe that involving them in scenario development enhances salience. This highlights a need for a precautionary integration (or separation) of co-creation between the science and policy fields⁸¹. The survey highlighted mitigation as a topic of vested interests, with some NFPs expressing skepticism about policymakers’ genuine commitment to mitigation efforts. Similarly, the literature reflects this concern, as some scientists also question the underlying motives behind policymakers’ mitigation strategies⁹¹, or mistakenly question scientific results for being science-policy biased⁸². Skepticism toward science-policy co-creation suggests that such processes focus on enhanced scientific communication rather than the development of scientific content. According to the survey, enhanced dissemination would imply simplifying scenario descriptions (e.g., outlining plausible futures, identifying key drivers) and tailoring them to policy needs (e.g., cost-effectiveness of mitigation strategies).

Third, our findings underscore significant regional disparities in scenario familiarity and knowledge among UNFCCC-NFPs. Approximately 27% of all respondents, and notably 36% from Low- and Middle-income

countries representatives, demonstrating low scenario familiarity compared to 16% of high-income counterparts (Fig. 1). Additionally, high scenario familiarity strongly correlates with perceived policy relevance (Figs. 2 and 3). This uneven knowledge distribution aligns with existing scholarship stressing the dominance of Global North institutions in climate change research^{31,92–94} and scenario modeling^{22,95–98}. Such disparities indicate that limited institutional capacity and unequal knowledge dissemination could constrain evidence-based climate policymaking in low- and middle-income countries.

Lower institutional capacities may limit academic and technical support for policymakers and evidence-based policy designs in Low- and Middle-Income countries. Furthermore, the predominance of scenario development in the Global North^{22,36} may unintentionally overlook regional perspectives¹⁸, jeopardizing scenario credibility (e.g., the effect of institutional capacities needed to enforce policy⁴⁷). Finally, low scenario legitimacy might affect user trust, making IPCC reports irrelevant to some Global South countries. Capacity building, primarily requested by LDC participants, highlights that scenarios policy relevance may increase if scenario knowledge dissemination is accompanied by training of LDC (and MDC) policymakers and technical staff. While real-world capacity-building falls outside the scope of scenarios, it is relevant to scenario assumptions and variables (credibility). Here, varying regional institutional capacities are not yet accounted for in the RCP-SPA-SSPs^{15,99}. Additionally, as scenarios are primarily developed in the Global North^{22,36}, they may inadvertently overlook regional perspectives from other parts of the world^{43,100}. Improving the dissemination of scenario knowledge and implementing capacity-building initiatives across UNFCCC Member States may reinforce mitigation efforts in the Global South. Such support may include anticipating future emissions trajectories for low-emitting countries and facilitating a just transition to low-carbon societies, e.g., organized under the IPCC or established as a fourth financing pillar under the UNFCCC Paris Agreement framework.

Finally, a synthesis of our results highlights significant regional disparities in knowledge bases. Policymakers across regions express a need for both simpler communication and more policy-relevant detail, especially at the national level. Although the simultaneous demand for simpler scenarios and greater detail may seem contradictory, it underscores the need for tailored communication that balances clarity with actionable insights. Simplifying scenario outputs to emphasize policy-relevant information while strengthening connections to mitigation strategies may bridge the gap between complex scientific models and practical policy needs.

Current emission scenarios address at least three policy objectives: mitigation goals, understanding emission drivers, and adaptation needs. While short-term policy scenarios partially assess current pathways for mitigation, they could become more policy-relevant by assessing specific national strategy pathways for closing the gap. Similar to adaptation, more national extensions are needed, particularly for low- and middle-income regions. To better understand emission drivers for policy use, the long-term scenarios could more explicitly analyze the effect of specific mitigation strategies.

We underscore the need to balance process-oriented concerns of credibility and legitimacy, ensuring transparency and inclusivity, with outcome-oriented salience, ensuring scenarios are usable for policymakers in real-world decision-making. IPCC has positioned itself within a sensitive science-policy interface. It navigates the tension between a two-world perspective, which emphasizes policy neutrality and structured scientific assessments, and a one-world perspective, advocating for knowledge co-production and stronger integration of diverse policymaker needs⁸¹.

While the IPCC seeks to remain neutral, the concept of neutrality may be further explored. Among the four stylized IPCC reform agendas¹⁰¹, this paper resonates with orchestrating broad knowledge generation, highlighting disparities in scenario use across regions, and advocating for greater Global South inclusion in scenario development. It also intersects with tailored broadcasting, given its emphasis on simplifying scenario communication to enhance usability. On the contrary, this study highlights potential limitations of the back-to-basics approach, suggesting that the

IPCC's historical reluctance to offer prescriptive policy recommendations may reduce its practical relevance. Our findings support calls for reflexive learning, where scenario frameworks (or the dissemination of them) evolve dynamically based on policymaker feedback, bridging the gap between abstract model outputs and actionable policy pathways.

We recommend that the scientific community engage in science-policy dialogues to better understand policymakers' objectives and the needs of Global South institutions, supporting the development of SSP-SPA-RCP elaborations and national extensions relevant for successive COPs. This involves:

1. Tailoring scenario communication to address policy-relevant knowledge and consider policymakers' knowledge levels (and communicating in non-technical terms). This may be supported by ethnographic analysis and a global policymaker survey targeting a broader UNFCCC population, exploring what types of knowledge they rely on when designing policies.
2. Improve knowledge dissemination and use in the Global South, e.g., via document analysis and ethnographic participatory studies of scenario use in practical processes of policymaking.
3. Connecting international and national policy contexts via scenario analysis on implementing the Paris Agreement, e.g., showcasing diverse policy mixes for achieving global mitigation goals
 - a. To better support UNFCCC negotiations and actions, the global SSP-SPA-RCP framework could be strengthened by incorporating more specific policy assumptions beyond abstract variables, i.e., refining the Shared Policy Assumptions (SPAs) and improving their practical application within the framework.
 - b. The Climate Action Tracker (CAT), UNEP Emission Gap, and other scenarios assessing current policies and targets against pathways to meet Paris Agreement goals could be improved by connecting scenarios with roadmaps detailing plausible stepwise mitigation actions to reach national carbon neutrality targets, providing clearer guidance for plausible implementation steps.
4. The integration of justice into scenarios necessitates further exploration. Ignoring a justice perspective now risks deferring critical issues such as just transitions, energy transitions, and loss and damage, which will inevitably need to be addressed to ensure fair and transparent UNFCCC COP negotiations. While some scenarios address equitable carbon budget sharing^{102,103}, they could also incorporate effort-sharing for stranded asset risks. Additionally, scenarios should evaluate the cost-efficiency of mitigation strategies, scrutinize GDP assumptions¹⁰⁴ for compatibility with emission reductions, and ensure transparency in normative values and assumptions.

Methods

The study explored a well-defined group of policymakers' perception of scientific tools and their relevance for policy, focusing on the four generations of long-term scenarios informing the IPCC (a crucial scientific tool cutting across the three IPCC Working Groups (WGs))⁶ and short-term policy scenarios assessing mitigation policy, NDC targets and Paris-Compliant Pathways^{35,36}.

We gathered perspectives from a clearly defined population on scenario perceptions concerning international (UNFCCC) and national policymaking processes. UNFCCC National Focal Points (UNFCCC-NFPs) are officially designated by their respective parties within the UNFCCC framework. This makes them relevant for understanding how parties interact and engage with knowledge and expertise. Surveying NFPs provides a manageable and targeted approach to gathering insights from key individuals responsible for coordinating their parties' engagement. On the contrary, surveying the entire population of UNFCCC COP delegates would be logistically challenging and resource-intensive, given the dynamic nature of delegate participation and the absence of contact information. The entire population of UNFCCC COP delegates has grown yearly with a potentially ever-changing composition of policymakers, researchers, and stakeholders¹⁰⁵. The NFP representation is expected to be more stable, e.g., with commitments to participate in several annual meetings (e.g., in Bonn).

Definitions

Emission scenarios are hypothetical trajectories of future greenhouse gas emissions based on assumptions about factors such as population growth, economic development, and technological advances²². Designed to help scientists and policymakers assess future consequences, policy relevance reflects a scenario's usefulness in guiding climate change mitigation and adaptation decisions.

We determine “scenario familiarity” by the self-reported level of informants' knowledge and awareness of the tool of emission scenarios. This concept encapsulates individuals' degree of information and awareness with emission scenarios, providing a comprehensive perspective that includes both knowledge and awareness. Emission scenario familiarity refers to being well-acquainted or knowledgeable about the content of scenarios^{106,107}, encompassing variables, narratives, and potential future greenhouse gas (GHG) emission trajectories. An individual with a heightened awareness of emission scenarios is likely to understand better diverse pathways, including the influencing factors such as economic growth, population dynamics, technological advancements, risks, and mitigation opportunities. This understanding is crucial for making well-informed decisions.

Research is considered policy-relevant when it guides informed decisions or develops effective policies, providing actionable information that policymakers can use to design and implement policies that achieve desired outcomes⁷⁴. Salience pertains to information's usability for policymakers and decision-makers in achieving political goals^{4,19} and can be converted into laws or decisions by decision-makers^{4,10,19}.

Research design and methods

The analysis is based on a quantitative survey. The survey used a five-point (11), six-point (1), and seven-point Likert scale (3), open-ended questions (9), and social variables (e.g., age, policy role, and intergovernmental IPCC and/or UNFCCC experience). In some cases, the wording of the open-ended answers is modified to increase readability (keeping the core message/content). Regarding scenario familiarity, we asked the participants about their knowledge of emission scenarios (*Honestly, how well do you know the scientific tool of emission scenarios?*). The reasoning was to provide a starting point for the analysis, identifying the participants' knowledge base. We termed this high or low “scenario familiarity” in the study. Low familiarity (awareness) is comprised of “I have heard about them but not sure what they express” and “not knowing them” (answers 1–3). High familiarity constitutes knowing emissions scenarios “a little” to “a high degree” to “participated in developing scenarios” (answers 4–6).

Pre-interviews were made to improve the survey design, e.g., the overall scope, covering challenges and aspects relevant to policymakers and researchers (interview question guide is available in the supplementary information of Pedersen⁴⁷). The questions were tested by researchers (3) and UNFCCC delegates (2) to ensure non-ambiguous, simple, and neutral questions were communicated in easy-to-understand language to improve reliability (answer consistency). We have obtained informed consent from all participants.

The survey is replicable. The Survey data are available in the Open Science Framework repository (<https://osf.io/5qctp/>), and the survey's question guide is available in the supplementary information of Pedersen⁴⁷. The quantitative data were processed in R and Excel, and the open-ended questions were analyzed via ATLAS.ti (<https://atlasti.com/>).

We analyzed if the sample means were statistically different (between Annex groups) via sample one- and two-tailed *t*-tests. Significant differences were defined via Equal Variances when the ratio of standard deviations was below 2:1. Correlational analyses were performed using R. The “cor.test” command calculated the correlation coefficient and conducted the test of significance simultaneously using Pearson's product-moment correlation (Table 9). The open-ended answers were coded into three overall scenario communication categories (simpler communication), reduced complexity, capacity building (training, technology, human resources), and more scenario detail (national detail, mitigation, missing scenarios). They were coded for quantitative analysis to count the most common responses (to adjust for

repetitions, each category could not be counted more than once per respondent). All quotes in the paper are based on survey answers unless otherwise expressed. Sometimes, we modify quotations to increase readability without compromising the meaning.

Finally, the survey themes and questions were designed based on literature reviews of scenario critiques, semi-structured interviews with modelers and scenario developers (6), researchers and IPCC authors (5), and national policymakers (5). Some of the interviewed policymakers also had experience in research (3). Of the 16 interviewees, nine and five had UNFCCC and IPCC intergovernmental experiences, respectively. The informal interviewees comprised ministers and UNFCCC delegates from Europe, Africa, Asia, North America, and South America, including Small Island states.

Population and sample

We surveyed a population of 278 UNFCCC national focal points (UNFCCC-NFP). These focal points were identified from a list of 299 UNFCCC-NFP from 196 parties during COP25⁶⁸. The participants^{68,73} were invited via email, including two reminder emails between October 2020 and November 2021. Twenty-one email invitations did not reach their destination (returned to sender). Fifty-seven answered the survey partially or entirely, resulting in a response rate of 21%. Specific implications relate to the small population. The response rate is considered relatively high, considering the busy schedules of UNFCCC delegates. The COVID-19 COP delays provided a unique opportunity to access these typically busy policymakers.

The selection of national focal points was carefully considered and justified by their official role, representativeness, stability in representation, the likelihood of persistent views on policymaking needs, and practical considerations.

Respondents included 38 participants from least, semi, and newly industrializing (or developing) non-Annex-I countries (63%) and 19 from industrialized (or developed) Annex-I countries⁷⁰ (37%), representative of the examined population. Eleven out of 37 countries have more than one representative (some have several focal points listed). The UNFCCC-NFP population comprised 240 non-Annex-I focal points (80%) and 59 (20%) Annex-I focal points. The UNFCCC parties contain 151 non-Annex-I (78%) and 42 Annex-I (22%), making the sample's country representation of countries slightly biased towards Annex-I representation. The share of Annex-I focal points in the population is lower than the sample Annex-I share to a statistically significant degree on a 1% level ($P = 0.0045$), meaning that a larger percentage of Annex-I focal points joined the survey. We acknowledge that since the sample and population are relatively small, our statistical findings may not precisely represent the entire population of UNFCCC and national policymakers. Still, we believe the sample is representative enough of UNFCCC focal points regarding country representation and that our results highlight UNFCCC focal point perspectives. Of the Annex-I representatives, seventeen informants represented High-income countries and two Middle-income countries.

Analytical categories

The world has changed since the UNFCCC's establishment in 1992. Thus, it is relevant to distinguish between income levels and countries' present respective financial capabilities to implement mitigation actions and prepare for UNFCCC negotiations, e.g., human resources and institutional capacity. For the analysis, we grouped informants into three groups: LDC (UNFCCC definition), Medium Developed Countries (MDC, WB Middle-Income excluding UN LDCs), and Highly Developed Countries (HDC; WB High-Income) (Table 1). Our sample comprises 16 participants from LDCs (UN definition), 19 from MDCs (World Bank defined “Middle-Income countries” excluding UN LDCs), and 22 from HDCs (World Bank “High-Income Countries”)^{72,73}. The real-life distribution of UNFCCC member states comprises 46 LDCs, 90 MDCs, and 60 HDCs.

Given the massive pollution caused by high-income countries, the term developed covers primarily economic development rather than sustainable development.

The participants identified their primary work role as either policy-maker (77%), researcher (11%), or stakeholder/other (12%) (Table 5).

Regional distributions

Tables 6 and 7 show that most HDC survey participants represented European countries (16), with fewer responses from Latin America (3), the United States (1), and Australia (2). However, this is a logical consequence of the methodological choice of examining the national focal point population, i.e., with UNFCCC parties comprising 48 European and 2 North American countries.

Table 5 | Primary work role concerning climate change

Category	Policy maker	Researcher	Stakeholder
All	44 (77%)	6 (11%)	7 (12%)
LDC	13 (23%)	2 (4%)	1 (2%)
MDC	17 (30%)	1 (2%)	1 (2%)
HDC	14 (25%)	3 (5%)	5 (9%)

Table 6 | Informants grouped by region (& island states (SIDS)) and country income level

Income level	Region	Count	Share of total	Total Count	
LDC	Africa	13	23%	16	
	(Island state)	(2)	(4%)		
MDC	Asia	6	11%	19	
	Latin America	5	9%		
33%	Oceania	4	7%	22	
	EU	2	4%		
	Africa	1	2%		
	Middle East	1	2%		
	(SIDS)	(5)	(9%)		
HDC	EU	15	26%	22	
	Latin America	3	5%		
	Oceania	2	4%		
	Europe (non-EU)	1	2%		
39%	North America	1	2%	57	
	Total		100%		

P-values: variable correlation and sample t-tests

Simple linear regression results (Table 8) indicate that high scenario familiarity is associated with higher perceived emission scenario relevance to a statistically significant level for national policymaking to the 5% level (p -value = 0.0389) and the UNFCCC context to the 10% level (0.095). LDC & MDC sample participants exhibit a statistically significant relationship between high scenario familiarity and perceived scenario relevance within the UNFCCC context to the 10% level. For HDC participants, no statistically significant relationships were found.

Considering Annex member states and UNFCCC-NFP distributions, the t -tests (Table 9) show no significant change between the population and sample groups (p -values = 0.0114 & 0.0324). However, they appear different considering the LDC-MDC-HDC distribution.

Test explanation. A two-sample t -test aims to compare the means of two independent groups or samples to determine if there is a statistically significant difference between them. The null hypothesis (H_0) states no difference between the means, while the alternative hypothesis (H_1) states a difference. In a one-tailed t -test, the alternative hypothesis is specific about the direction of the difference between the means. In a two-tailed (two-sided) t -test, the alternative hypothesis does not specify the direction of the difference, but states that if there is a difference between means. Two-tailed is appropriate to detect any difference between the groups, whether an increase or a decrease. The p -value obtained from a two-sided t -test represents the probability of observing a difference as extreme or more extreme than the one obtained if there were no differences between the means.

Ethics and inclusion statement

The research has been performed in accordance with the Declaration of Helsinki and participants are anonymized, adhering to General Data Protection Regulation (GDPR) guidelines¹⁰⁸, including freely given unambiguous consent. The information provided is potentially sensitive because of the nature of intergovernmental negotiations. Thus, the participants' identities and nationalities are excluded from the manuscript. The Production and Archive of Social Science Data (PASSDA) at the Institute of Social Sciences of the University of Lisbon (ICS-ULisboa, Portugal) provided guidelines for study procedures. The ICS Ethics Committee and cE3c office of the Faculty of Sciences, University of Lisbon (FC-UL) approved the study protocol. Upon reasonable request, more details about the different stages of the research are available from the corresponding author. Informed consent to participate in the study (and the possibility of withdrawing consent) was obtained from all survey and interview participants.

Table 7 | Numbers of sample informants and UNFCCC parties grouped by region & economic development level (share of total)

Region	Survey sample Representation (57 informants)				UNFCCC Party Distribution (196 Parties)			
	Total	LDC	MDC	HDC	Total	LDC	MDC	HDC
Africa	14 (25%)	13 (23%)	1 (2%)	0	53 (27%)	32 (16%)	20 (10%)	1 (1%)
Asia	9 (16%)	3 (5%)	6 (11%)	0	28 (14%)	7 (4%)	17 (9%)	4 (2%)
Europe	18 (32%)	0	2 (4%)	16 (28%)	48 (24%)	0	15 (8%)	33 (17%)
Latin America	8 (14%)	1 (2%)	4 (7%)	3 (5%)	33 (17%)	2 (1%)	23 (12%)	8 (4%)
Middle East	1 (2%)	0	1 (2%)	0	16 (8%)	2 (1%)	6 (3%)	8 (4%)
North America	1 (2%)	0	0	1 (2%)	2 (1%)	0	0	2 (1%)
Oceania	6 (11%)	0	4 (7%)	2 (4%)	16 (8%)	3 (2%)	9 (5%)	4 (2%)
Total	57	17 (30%)	18 (32%)	22 (39%)	196	46 (23%)	90 (46%)	60 (31%)
(Small Island Dev. States)	7 (12%)	2 (4%)	5 (9%)	0 (0%)	32 (16%)	7 (4%)	16 (8%)	9 (5%)

Small Island Developing States (SIDS) are included in the regional categories, e.g., the LDC category has 16 representatives (with 2 of these being SIDS).

Table 8 | Simple linear regression results (Pearson’s correlation coefficient)

Sample group	Y variable	X variable	Coefficient of X variable	P-value
All sample participants	Emissions Scenario relevance – National Policy Context	High Scenario familiarity Indicator	0.7330	0.0389
HDC sample participants	Emissions Scenario relevance – National Policy Context	High Scenario familiarity Indicator	0.3750	0.39
LDC & MDC sample participants	Emissions Scenario relevance – National Policy Context	High Scenario familiarity Indicator	0.7500	0.149
All sample participants	Emissions Scenario relevance – UNFCCC Policy Context	High Scenario familiarity Indicator	0.5437	0.095
HDC sample participants	Emissions Scenario relevance – UNFCCC Policy Context	High Scenario familiarity Indicator	0.1875	0.732
LDC & MDC sample participants	Emissions Scenario relevance – UNFCCC Policy Context	High Scenario familiarity Indicator	0.7857	0.0708

Table 9 | Two-sample t-test results

Sample Group; n = 57	Reference group	X variable	P-value (1-sided)	P-value (2-sided)
All sample participants	Population (invited UNFCCC Focal Points); N = 299	Annex-I, non-Annex-I distribution	0.0114	0.02288
All sample participants	Population (invited UNFCCC Focal Points); N = 299	LDC, MDC, HDC distribution	0.4681	0.9363
All sample participants	Distribution of UNFCCC Parties; 196 states	Annex-I, non-Annex-I distribution	0.0324	0.0648
All sample participants	Distribution of UNFCCC Parties; 196 states	LDC, MDC, HDC distribution	0.3828	0.7655

Data availability

The datasets generated during and/or analyzed during the current study are available in the Open Science Framework (OSF) repository: <https://osf.io/5qctp/>⁷³. The online dataset details country grouping, sources, answer scores, and open-question answers. Additional data analyses generated during and/or analyzed during the current study, coding, interview, and the survey questionnaire are available from the corresponding author at reasonable request. Identities and nationalities are anonymized. Besides that, no data availability restrictions exist. The survey is accessible on the SurveyXact platform (<https://www.survey-xact.dk>) and the question guide in the supplementary information of Pedersen⁴⁷.

Code availability

Statistical analyses were conducted using the R statistical computing platform. Codes or algorithms used during the current study are available from the corresponding author upon reasonable request.

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- reviewed the manuscript and provided literature recommendations. F.D.S. reviewed the manuscript and provided literature recommendations. J.G. provided conceptual framework input. RS reviewed the manuscript and provided conceptual framework input.

Competing interests

The authors declare no competing interests.

Additional information

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Author contributions

J.T.P. designed the study, conducted pre-interview and survey, wrote the manuscript, performed data analysis, designed figures, and designed the theoretical framework and discussion. P.O. reviewed the manuscript, performed data analysis, statistical correlations, and designed figures. D.V.V. reviewed the manuscript and provided conceptual framework input. C.G.