



Communicating climate futures: a multi-country study of how the media portray the IPCC scenarios in the 2021/2 Working Group reports

James Painter¹ · Suzie Marshall^{2,3} · Katherine Leitzell^{2,3}

Received: 1 September 2023 / Accepted: 30 April 2024
© The Author(s) 2024

Abstract

The way governments and policy makers think about climate futures has a wide-ranging impact on how they formulate policy and plan for climate change impacts. In the lead-up to the Sixth Assessment Report (AR6), the IPCC adopted a new scenarios framework that aimed to provide a fuller picture of the interacting elements and policy choices that affect climate change. However, these scenarios, known as Shared Socioeconomic Pathways (SSPs), are complex and difficult to communicate. Most audiences, including policy makers, receive much of their information about climate change from mainstream media, and particularly online news sites. We therefore examined the five most popular online news sites in the UK and the USA, five popular English-language news sites in India, English-language news media from a wide range of African countries, and the Reuters News agency. Based on manual content analysis to assess 252 articles, we identify several important findings, amongst them: in all countries, the media provide little detailed explanation of how scenarios are developed, very little mention of SSPs, and virtually no detailed explanations of them; generally, journalists use the words ‘projections’, ‘futures’, and ‘pathways’ when talking about the IPCC scenarios, although some usage of ‘predictions’ or ‘forecasts’ is apparent; contrary to previous research, there were very few doomsday narratives such as ‘only 12 years to act’. We conclude by drawing out some implications for more effective communication of the IPCC scenarios.

Keywords Climate change · IPCC · News media · Scenarios · Communication

✉ James Painter
james.painter@politics.ox.ac.uk

¹ Reuters Institute for the Study of Journalism, University of Oxford, 13 Norham Gardens, Oxford OX2 6PS, UK

² IPCC Sixth Assessment Report, Working Group I TSU, Université Paris Saclay, 3 rue Joliot Curie, Gif-sur-Yvette, Paris, France 91190

³ CGIAR, 1000 Av. Agropolis, 34394 Montpellier cedex 5, France

1 Introduction

The IPCC is widely regarded as the most authoritative source on the physical science of climate change, its impacts in different geographical regions, and the options for tackling rising emissions. (O'Neill and Pidcock 2021) IPCC reports play a central role in summarizing and presenting the available science to policy makers and the wider public, creating media coverage, and raising public awareness of the risks and solutions. (Sanford et al. 2021) The IPCC has been a major contributor to national and international policy responses to the climate challenge, such as the Kyoto Protocol in 1997 and the Paris agreement in 2015, as a result of its mandate to provide scientific input to the UN Framework Convention on Climate Change (UNFCCC). (Sundqvist et al. 2018).

For its Sixth Assessment Report (AR6), which was published in 2021–23, the IPCC adopted a new scenarios framework that underpinned the Working Group (WG) reports. These scenarios were designed to provide plausible descriptions about how the future may develop, and according to the IPCC, are a vital part of the scientific literature on climate change, and an important part of the IPCC's work. (IPCC 2023) In the Sixth Assessment cycle, the IPCC included much more information about socioeconomic futures than previous emission scenarios, and featured 'multiple baseline worlds because underlying factors, such as population, technological, and economic growth, could lead to very different future emissions and warming outcomes, even without climate policy'. (Carbon Brief 2018, p. 1) At an IPCC workshop on scenarios in April 2023, the communication imperative was recognized as one of the most important issues facing scientists in their efforts to inform decision makers. (IPCC 2023, p. 10) However, these scenarios, known as Shared Socioeconomic Pathways (SSPs), are complex and difficult to communicate, and are often simply ignored or mentioned as an afterthought in communicating key findings on climate change.

There is little published scholarship on the communication of the scenarios. However, a survey of climate scientists in 2022 found that in the respondents' view, scientists do poorly in explaining scenarios, whilst the media do even worse.¹ Although the survey was limited in scope, it clearly illustrated the main communication challenges: making clear the difference between the concepts of projection and prediction, and explaining uncertainty, complexity, and the timescale of scenarios, in simple, clear messages. For the media, the issues were i) a misunderstanding of predictions and projections, and what-if investigations; ii) an assumption that scenarios are recommendations or truth; iii) an (over) focus on high-impact/worst-case, apocalyptic scenarios; and iv) the lack of coverage of uncertainty, agency, and policy choices.

As in other areas of life such as military planning or financial investments, projections are statements or observations about what could happen and not predictions or forecasts of what will happen. The IPCC too uses projections based on scenarios of what could happen if certain assumed conditions prevail in the future – it is neither a prediction nor a forecast of what will happen independent of future conditions. As one climate scientist has summarized the difference, (MacCracken 2001, p.1):

'A *prediction* is a probabilistic statement that something will happen in the future based on what is known today. A prediction generally assumes that future changes in related conditions will not have a significant influence. For decision makers, a prediction is a statement about an event that is likely to occur no matter what they do.

¹ The survey was carried out by an IPCC TSU employee in June 2022. 10 climate scientists took part.

In contrast to a prediction, a *projection* specifically allows for significant changes in the set of "boundary conditions" that might influence the prediction, creating "if this, then that" types of statements. The set of boundary conditions that is used in conjunction with making a projection is often called a scenario, and each scenario is based on assumptions about how the future will develop. For a decision maker, a projection is an indication of a possibility, and normally of one that could be influenced by the actions of the decision maker.⁷

Most audiences, including policy makers, receive much of their information about climate change from mainstream media (Amdt 2020). Online news sites from major news organizations are the second most common source of climate information after television news and documentaries in many countries of the world. For this reason, we analyzed a wide range of popular news sites in a selected number of countries from the Global North and Global South. As far as we are aware, no previous study has focused on the reporting of IPCC scenarios, in part because the media in general have not discussed them or the concepts underpinning them in great detail, except in a few cases of specialist coverage.²

1.1 Climate scenarios and the IPCC

To project how the climate will respond to rising greenhouse gases (GHGs), climate models need projections of future emissions. These scenarios have evolved significantly since the inception of the IPCC in 1988, driven in large part by the needs of the IPCC and the climate science community. (IPCC 2000) While emissions scenarios in the first IPCC reports were comparatively simple projections of possible trajectories of GHGs, based on simple narratives and the output of energy systems models (IPCC 1992), today's scenarios were developed with the aim of enabling a more complete assessment of not just temperature rise, but also the effectiveness of adaptation and mitigation strategies, possible tradeoffs, and synergies. (Van Vuuren et al. 2014) Developed by an international, interdisciplinary cohort of scientists, the SSPs are narratives of possible future worlds that include demographics, human development, economy and lifestyle, policies and institutions, technology, and environment and natural resources. (O'Neill et al. 2017).

The IPCC's Sixth Assessment Report was the first to use the SSPs framework, but these climate scenarios and pathways were used differently across the three working groups. (Pirani et al. 2024) The WGI report, published in August 2021, used a combination of SSPs and Representative Concentration Pathways (RCPs), to define five illustrative emissions trajectories that were meant to cover the full range of possible emissions, including more detailed inputs of air pollution, land use change, and others, and these were used in the modeling exercises that fed into the report. (IPCC 2021) According to the IPCC, the 'Emissions vary between scenarios depending on socio-economic assumptions, levels of climate change mitigation and, for aerosols and non-methane ozone precursors, air pollution controls.' (ibid., p. 12) The five scenarios included two low-emissions scenarios (SSP1-1.9 and SSP1-2.6) in line with temperature targets of the Paris Agreement, a middle-of-the-road one (SSP2-4.5), a scenario with no additional climate policy (SSP3-7.0),

² See for example, <https://www.carbonbrief.org/guest-post-how-not-to-interpret-the-emissions-scenarios-in-the-ipcc-report/> (March 2022); <https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change/> (April 2018); <https://qz.com/2043909/ipcc-our-climate-change-future-will-be-determined-by-politics/>; and <https://www.reuters.com/business/environment/un-climate-reports-five-futures-decoded-2021-08-09/>

Table 1 The IPCC SSPs in WGI

SPP	Emissions	Net zero	Temperature rise	Assumptions
1—1.9	Very low	by 2050	1.4C by end of century	Societies switch to more sustainable practices, with focus shifting from economic growth to overall well-being. Investments in education and health go up. Inequality falls
1—2.6	Low	after 2050	1.8C by end of century	The same socioeconomic shifts towards sustainability as SSP#1. Global CO2 emissions are cut severely, but not as fast
2—4.5	Intermediate—current levels	by 2100	2.7C by end of century	Socioeconomic factors follow their historic trends, with no notable shifts. Progress toward sustainability is slow, with development and income growing unevenly
3—7.0	High—roughly double by 2100	Not known	3.6C by end of century	Countries become more competitive with one another, shifting toward national security and ensuring their own food supplies
5—8.5	Very high—roughly double by 2050	Not known	4.4C by end of century	The global economy grows quickly, but this growth is fuelled by exploiting fossil fuels and energy-intensive lifestyles

Sources: IPCC 2021, *Cross Chapter Box 1.4*; <https://www.reuters.com/business/environment/un-climate-reports-five-futures-decoded-2021-08-09/>

and a high-emissions scenario intended to cover the highest possible emissions pathways (SSP5-8.5). (See Table 1 and Figure S2 in the Supplementary Material).

In contrast, the WGII report on Impacts and Adaptation (IPCC 2022a), published in March 2022, used scenarios inconsistently across its chapters – largely because the SSPs had not yet been taken up by much of the research assessed in that report.

The WGIII report on Mitigation (IPCC 2022b), published in April 2022, examined over a thousand scenarios for possible mitigation futures and their consequences for global temperatures, produced by the research community. These scenarios differ from the WGI scenarios in that they provide a ‘pathway’ by which a particular temperature goal may be reached. Like the WGI scenarios, these emissions pathways are described as illustrative and not policy prescriptive, but their detailed nature have opened them up to criticism for being unrealistic, not comprehensive, or biased, and led some to argue that they are less authoritative than WGI scenarios.³ The scenario development process for the WGIII report was also criticized for being insufficiently inclusive of scientists in the Global South.⁴

Indeed, IPCC climate scenarios in general have faced a variety of criticisms, which have also informed their continued evolution. These range from methodological, to process, to transparency, to policy relevance. (Pedersen et al. 2022; Carton 2020) There are also a variety of technical points of contention around scenarios, such as the reliance in very low emissions scenarios on negative emissions technologies which have not yet been proven at scale. (Hilaire et al. 2019) Finally, it has also been pointed out that ‘knowledge-making about future pathways is never neutral, but is instead inescapably political’. (Beck and Mahoney 2018, p. 5).

1.2 The IPCC, policy makers and climate scenarios

A body of research shows how IPCC reports are a very important source of reliable climate information to policy makers of distinct types in different parts of the world. (Hermansen et al. 2021; Howarth and Painter 2016; O’Neill and Pidcock 2021; Pathak et al. 2021) However, the reports have been criticized for not including practitioner-based evidence, which would make the reports a more relevant source of information for decision-making (Viner and Howarth 2014), for not exploring sufficiently the possibilities of co-produced knowledge (Howarth et al. 2022), and for not using language and Figures more understandable by policy makers (Barkemeyer et al. 2016; Budescu et al. 2009; Hutchins 2020; Morelli et al. 2021, de Bruine et al. 2024). There is also a considerable amount of scholarly literature on the effective communication of climate science in general to different audiences (e.g. Dahlstrom 2014, Smith et al. 2014), the better communication of IPCC reports (Shaw et al. 2018; O’Neill and Pidcock 2021), and the advantages of locally-relevant narratives or storytelling for engagement with the IPCC reports by different audiences (Howarth et al. 2020).

However, there is only a limited amount of literature on the general communication of climate scenarios, such as the research by Sheppard et al. (2021), who studied the efficacy of the Local Climate Change Visioning Project in British Columbia, Canada. The researchers collaboratively visualized possible local climate change scenarios, including environmental impacts and community responses, and found considerable potential value in such

³ <https://theintercept.com/2022/11/17/climate-un-ipcc-inequality/>

⁴ Ibid.

activities to enhance engagement and learning. Liguori et al. (2021) concluded that in the DRY (Drought Risk and You) project in the UK, by co-designing and facilitating storyboarding workshops with local stakeholders and scientists, scenarios could be developed that were not only scientifically accurate, but also reflected local interests, aspirations, and practices.

As far as we are aware, no research has been published on how the specific IPCC scenarios can be conceptualized and operationalized in practice to aid effective communication and practice by different types of policy makers, the private sector, NGOs, the media, and the wide range of publics. There are some practical guides, toolkits and scenario simulators available for scenario communication, particularly to non-specialist audiences, such as those produced by the Senses project⁵ and Climate Interactive,⁶ and talks given by science communication experts such as Susan Hassol.⁷ Moreover, the IPCC has published a list of recommendations for better scenario communication (IPCC 2023, p. 4):

- Conduct a targeted survey on perception and use of scenarios from the AR6 cycle.
- Develop and provide accessible IPCC explainers on scenarios.
- Develop a guidance note on inclusive, co-developed scenario elaboration.
- Build and cultivate a network of trusted intermediaries to communicate scenarios.
- Strengthen institutionalized science communication experts throughout the IPCC process.

These will be discussed in more detail in the Conclusions.

1.3 IPCC communication and the media

In general, the news media remain essential for individuals, policy makers and society in general to understand, critically evaluate, and act on tackling climate change (Metag et al. 2017). Legacy media are (still) seen as the most important sources of information about climate change for many members of the public (Amdi 2020, Guenther et al. 2022). IPCC reports are international policy events which drive a large amount of media attention, and climate coverage often peaks around their publication dates. (Painter, 2013) For example, coverage of the IPCC's Special Report on 1.5°C (SR15 report) in October 2018 contributed to an overall increase in climate change stories by 43% throughout the world from September 2018. (Boykoff and Pearman 2019) However, the amount of coverage can vary from country to country, with some research showing, for example, that there was more coverage of the IPCC reports in Germany than Australia and India in the period 1996 to 2010. (Schäfer et al 2014).

The IPCC uses a variety of methods to communicate its main findings. (O'Neill and Pidcock 2021) Of particular importance are the summaries for policy makers (SPMs) for each IPCC report, which play a key role in transferring knowledge from experts in one field to policy makers and experts in other fields (Barkemeyer et al. 2016). They have a central task of communicating the headline scientific messages from the IPCC to policy makers

⁵ <https://www.youtube.com/watch?v=r-yeAjMNPwU>

⁶ <https://www.climateinteractive.org/the-en-roads-climate-workshop/>

⁷ <https://www.nationalacademies.org/event/09-22-2020/communicating-climate-change-scenarios-to-the-public>

and publics around the world, particularly via the news media (Kunelius et al. 2017). Previous research shows that journalists (normally) closely follow these IPCC prompts, and in particular they quote the SPMs, press releases, the IPCC representatives at the media launch, and social media posts and tweets. (Sanford et al. 2021) Although most journalists follow such prompts, they also shape or frame the way IPCC reports are presented and received by audiences and policy makers (Hulme 2009; Painter 2013, 2014; Pearce et al. 2014; O'Neill et al. 2015; Painter et al. 2023).

A common framing of the IPCC reports journalists have used in the past has been a predominance of apocalyptic, doom-based, or worst-case scenarios. Specific studies of the 2007 AR4 and 2013/4 AR5 reports show that print and/or broadcast media coverage of the IPCC's 2007 was notable for the language of catastrophe, fear, and disaster (Hulme 2009; O'Neill et al. 2015; Painter 2017). More recently, analysis of the media response to the IPCC's SR1.5 report of October 2018 showed that numerous articles chose to cite 2030 as a deadline for action,⁸ which was a headline-driven interpretation of the IPCC's statement that global emissions had to be reduced by 45% from 2010 levels by 2030 in order to avoid passing 1.5 °C (Boykoff and Pearman 2019). The so-called '12-year deadline' narrative is an example of a 'binary framing' by which stark alternatives are presented as the only options or likely outcomes. It became a clarion call for some politicians and climate activist groups like Extinction Rebellion to urge rapid and radical action,⁹ but prompted push back from some IPCC authors as a misinterpretation of the presentation of scenarios in the 1.5 report.¹⁰

Given the importance of scenarios to the IPCC reports, journalists covering them face a number of challenges: understanding them, explaining them accurately to their audiences, and making them relevant and urgent both for policy makers and for the general public alike. Across the media in the Global North and South, research has shown that common frames are used to portray climate futures, some focusing on the distant threats, whilst others emphasize solutions and opportunities. (Guenther et al. 2023) So another challenge is to get the balance right between reporting the possible negative impacts but not to resort to too much doom-mongering - instead, emphasize the array of possible solutions available.

Audience reception can be obfuscated by the various forms of contestation the IPCC reports often attract. For example, O'Neill et al. (2015) found that in television and print reporting in the US and UK, the WGI of the IPCC's Fifth Assessment Report (AR5) in 2013 was often contested and politicized. Painter et al. (2023) concluded that this had changed for the coverage of the AR6's WGI in 2021. Whereas skepticism about the science of climate change was still prevalent in right-wing television channels in Australia, Brazil, Sweden, the UK and the USA, this was largely absent from mainstream channels with large audiences such as the ABC in Australia, and the BBC in the UK.

Moreover, organized skeptical groups have often attacked the IPCC and its reports for what they call 'climate alarmism', or exaggerating the potential impacts of climate change in their scenarios. This has been described as a form of climate obstructionism that can either take the form of downplaying the impacts ('climate impacts are not bad') or of

⁸ E.g. <https://www.theguardian.com/environment/2018/oct/08/global-warming-must-not-exceed-15c-warns-landmark-un-report>

⁹ E.g. <https://www.theguardian.com/environment/2018/oct/26/we-have-a-duty-to-act-hundreds-ready-to-go-to-jail-over-climate-crisis>

¹⁰ E.g. <https://theconversation.com/why-protesters-should-be-wary-of-12-years-to-climate-breakdown-rhetoric-115489>

accusing the ‘climate movement’ (made up of the media, environmentalists or scientists) of being unreliable due to their alleged alarmism or bias. (Coan et al. 2021) An example of this is the commentary by the American Enterprise Institute published in September 2021 which started with the sentence ‘The sixth Assessment Report (AR6) of the <...> (IPCC) continues a long history of alarmist predictions (*emphasis added*) with the deeply dubious statement that human-caused climate change has now become “irreversible”.’ (Wallison and Zycher 2021) In the specific case of scenarios, some niche right-leaning publications have criticized the assumptions behind the SSP5-8.5 (RCP 8.5),¹¹ based on analysis by Pielke et al. (2022), or attacked the ‘dire forecasts’ in the use of SSPs found in the UK Met Office report of January 2022.¹²

1.4 Research questions:

Given this context, we devised the following research questions:

1. Does media coverage of the IPCC reports refer to the scenarios considered by the IPCC?
2. How does the media describe or characterize different scenarios, and what words do they use to talk about them?
3. Do the media report the range of scenarios and possible futures, or are they using a more binary framing (such as deadline narratives)?
4. Are scenarios being discredited in the media, and/or used by skeptical voices to question the IPCC science for alleged climate alarmism?
5. Do the media mention and/or describe accurately the uncertainty in the scenarios?

2 Materials and method

We first chose the five most popular online news sites in two countries, the UK and the USA. The sites were selected according to online survey results found in the 2022 Reuters Institute’s *Digital News Report* (Newman 2022). The two countries were chosen as their legacy media organizations have a strong worldwide presence in English (particularly online); US and UK media titles are influential amongst policy makers outside of their home countries; and the two countries are major players in international climate change negotiations. (Kristiansen et al. 2020) The ten titles were the BBC news online, the Guardian, Sky news online, the Telegraph and the Mail (for the UK), and the New York Times, the Washington Post, CNN online, the Wall Street Journal and Fox News online (for the USA). This also gave us a variety of media types (broadsheet, tabloid, and broadcast) and political orientation (left-leaning, right-leaning, neutral/impartial). We then added the Reuters news agency as it is known to cover the IPCC reports extensively, and many media outlets around the world rely on the service for their coverage.

¹¹ <https://reason.com/2022/02/09/worst-case-climate-change-scenarios-are-highly-implausible-argues-new-study/>

¹² <https://www.dailymail.co.uk/news/article-10406521/Met-Office-predicts-collapse-society-following-climate-disaster.html#article-10406521>; <https://www.spectator.co.uk/article/the-met-office-s-bizarre-forecasts>

In order to widen the geographical base of our sample, we added coverage in the English-language press in Africa, and five popular English-language news online sites in India according to the same 2022 *Digital News Report*, namely *India Today*, *Times of India*, *Hindustan Times*, *The Hindu*, and the *Indian Express/New Indian Express*. The Factiva search in ‘Africa by region’ gave us a wide range of African titles (28) in English covering the IPCC reports, which we did not reduce in number in order to maintain a good representation of Africa in our results. Tables 1S and 2S in the Supplementary Material show the titles and distribution of articles in all four countries or regions, and the Reuters news agency.

We looked at the period of 48 to 72 h after the publication of each WG report, which in this case meant 9th and 10th August 2021 for WGI, 28th February and 1st March 2022 for WGII, and 4th, 5th, and 6th April 2022 for WGIII. The search words were ‘IPCC’ OR ‘UN’ AND ‘Climate’ for the UK and US sample, and ‘IPCC’ for the African and Indian sample. The search engine Factiva was used. These searches yielded a large corpus of 120 articles for the US, UK, Reuters, and 132 articles for Africa and India (after several articles had been discarded for being repeats, trails, video reports, or insufficiently focused on the IPCC reports). Table 2 summarizes the distribution of the 252 articles by country, region and Reuters.

A detailed code book with 32 variables was devised to provide answers to the research questions (RQs) outlined above—first deductively from the literature and RQs, and then inductively from the sample. Manual content analysis was then applied to each article (see SM for code book). The code book was divided into three main sections: the presence of scenarios and the language used; explaining scenarios; and other issues such as the presence of binary framing or criticism from skeptic groups or individuals. One researcher coded all the articles from the US, UK and Reuters. The second researcher coded Africa and India. Coder reliability was established between the two coders by the joint coding of an initial six articles from the UK sample. Of the 32 variables being coded, 24 showed 100% agreement. Using the website <http://dfreelon.org/recal/recal2.php>, of the remaining variables, four showed 83.3% agreement, and four showed 66.7% agreement. Because of these high scores for agreement, no more joint coding was carried out. The scores for Cohen’s Kappa ranged between 0 (three variables), 0.4 (three variables) and 0.571 (two variables). The score of 0 for three of the variables was explained by the first coder coding all six articles as 0 and the second coder coding one or two of them as 1. Some of the coding differences were due to one coder including the text around graphics, whilst the other did not, and others due to differences over whether to code all mentions of ‘projections’ as in ‘sea level rise projections’, or just projections related to temperature increases. Discrepancies were ironed out or the text of the code book was discussed, clarified and re-written to ensure less ambiguity in its interpretation.

The limitations to this study are that firstly, we only coded for presence, not salience (i.e. when scenarios appear in headlines or opening sentences) or dominance (i.e. how much does the discussion of scenarios dominate an article), which would have given a greater sense of how much prominence journalists assigned to the reporting of scenarios. Secondly, despite the coder reliability testing, there may have been different interpretations of the code book and articles by the two coders. Thirdly, the inclusion of more countries and languages for the selection of media analysis would have provided more complete results. Finally, we only assessed the media coverage of scenarios at the launch of the WG reports, but outside of those dates IPCC scenarios are occasionally used and discussed at length by

the mainstream media, such as by the prominent climate author and commentator, David Wallace-Wells, in a long feature in the *New York Times* of 26 October 2022.¹³

3 Results and discussion

3.1 Press releases

Given the importance of the IPCC media outreach work mentioned above, we first examined the text of three press releases publicizing the WG reports. The WGI press release¹⁴ did not mention ‘scenarios’ or SSPs in the main body of the text, but ‘project[x]’ did appear a couple of times. In contrast, SSPs (175 times), scenarios (115 times), futures (31), pathways (7 times), and projections (17 times) were featured strongly throughout the SPM, particularly in Box SPM.1.¹⁵ There was no mention of predictions or forecasts.

In similar fashion, the WGII press release¹⁶ did not mention ‘scenarios’ or SSPs in the main body of the text, but the word ‘projected’ did appear once. Scenarios (36 times), pathways and futures (27 each), projections (12 times), and SSPs (25 times) appeared in the WGII SPM, and particularly in Box SPM.1.¹⁷ There was no mention of predictions or forecasts.

The press release for WGIII¹⁸ mentioned scenarios once, but not SSPs. Scenarios were mentioned 111 times and SSPs 26 times in the SPM, and particularly in Box SPM.1, called ‘Assessment of Modelled Global Emission Scenarios’.¹⁹ Projections (85) and pathways (243) were also mentioned frequently, projections (8) and futures (3) less so. Predictions or forecasts did not appear except in the statement within Box SPM.1 that [these are] ‘quantitative projections and are neither predictions nor forecasts’. (p.25).

3.2 Presence of the word ‘scenario’ and idea of multiple futures or scenarios

We then examined the content of the 252 articles. The word ‘scenario’ and the concept or idea of a range of scenarios does appear regularly across our sample, particularly in the reporting of WGI. The word ‘scenario’ sometimes appeared just in phrases like ‘worst-case scenario’, rather than in the context of any detailed explanation. The concept or idea of a range of scenarios could be present explicitly or strongly implicitly, without necessarily mentioning the number of scenarios. Figure 1 gives the results for each WG report, and shows how nearly half (48.5%) of the articles covering WGI included the word, which dropped to 22% for WGII and III.

In similar fashion, the idea or concept of scenarios was present in 55% of articles covering WGI, which dropped to 38% for WGII and 19.5% for WGIII (see Fig. 2). The high

¹³ <https://www.nytimes.com/interactive/2022/10/26/magazine/climate-change-warming-world.html>

¹⁴ https://www.ipcc.ch/site/assets/uploads/2021/08/IPCC_WGI-AR6-Press-Release_en.pdf

¹⁵ https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf, p. 12.

¹⁶ <https://www.ipcc.ch/report/ar6/wg2/resources/press/press-release/>

¹⁷ https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf, pp 7–8.

¹⁸ <https://www.ipcc.ch/report/ar6/wg3/resources/press/press-release/>

¹⁹ https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf, p. 21.

Table 2 Distribution of articles by country and WG report

	UK	USA	Reuters	Africa	India	Total
WGI	24	25	7	19	28	103
WGII	13	8	8	19	19	67
WGIII	16	13	6	22	25	82
Totals	53	46	21	60	72	252

figure for WGII was mostly due to the reporting from Africa including climate change impacts at a range of temperatures. For example: ‘Up to 18% of all those species assessed on land will be at high risk of extinction if the world warms 2°C by 2100. If the world warms up to 4°C, roughly every second plant or animal species assessed will be threatened’²⁰ or ‘The report found: up to 3 billion people are projected to experience chronic water scarcity due to droughts at 2°C warming, and up to 4 billion at 4°C warming, mostly across the subtropics to mid-latitudes; projected flood damages may be up to two times higher at 2°C warming and up to 3.9 times higher at 3°C, when compared with damages at 1.5°C’.²¹

3.3 Explanation of scenarios and SSPs

Right across our sample, there was little detailed explanation of how scenarios are calculated, very little mention of the specific term ‘SSPs’, and virtually no detailed explanations of the SSPs. Moreover, there was only one example in our sample (in *The Hindustan Times*) of how SSPs are different to previous calculations of pathways (RCPs).²² The few times in which detailed explanations did appear usually occurred in background or ‘explainer’ articles, and not in general reporting.

For example, SSPs are mentioned in only four articles from the WGI sample from US/UK/Reuters and an explanation of them appears only in two; three of the four mentions are found in graphs, and one in a detailed ‘explainer’ from Reuters with the headline ‘The U.N. climate report’s five futures – decoded’.²³ None appear in the reporting of WGII and WGIII from this sample. SSPs are not mentioned at all in the African corpus, and only in three articles in the Indian sample, two of which are found in the WGI coverage, with the description of them both times as ‘possible paths of growth human societies could follow over the next century’, and one in the WGII coverage to explain some accompanying graphics.

Two examples of a detailed explanation of scenarios/SSPs can be found on the day of the release of the WGI report (9 August) in Fox News online (based on an Associated Press article by climate correspondent Seth Borenstein), in which he writes that.

‘The report described five different future scenarios based on how much the world reduces carbon emissions. They are: a future with incredibly large and quick pol-

²⁰ <https://allafrica.com/stories/202203010069.html>

²¹ <https://allafrica.com/stories/202203010069.html>

²² <https://www.hindustantimes.com/india-news/india-stares-at-water-scarcity-extreme-heat-stress-report-101646070934296.html>

²³ <https://www.reuters.com/business/environment/un-climate-reports-five-futures-decoded-2021-08-09/>

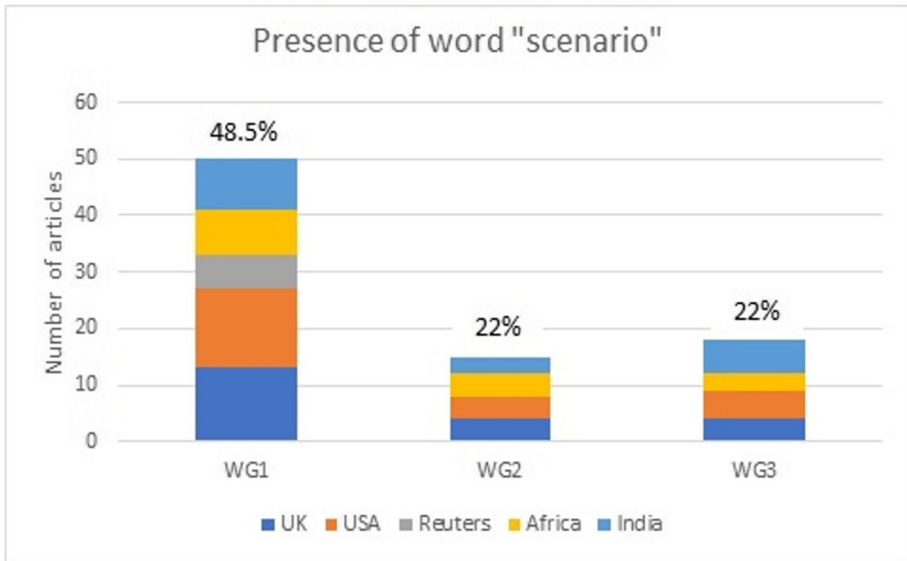


Fig. 1 Presence of word 'scenario'

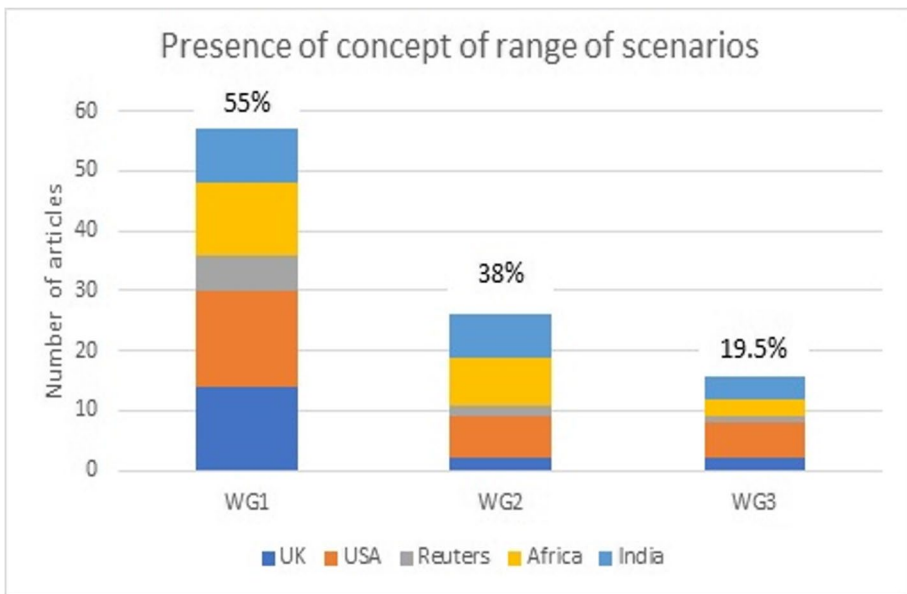


Fig. 2 Presence of concept of range of scenarios

lution cuts; another with intense pollution cuts but not quite as massive; a scenario with moderate emissions; a fourth scenario where current plans to make small pollution reductions continue; and a fifth possible future involving continued increases in carbon pollution.²⁴

Or ii) in the Reuters explainer mentioned above,

‘The scenarios are the result of complex calculations that depend on how quickly humans curb greenhouse gas emissions. But the calculations are also meant to capture socioeconomic changes in areas such as population, urban density, education, land use and wealth. [...] Each scenario is labeled to identify both the emissions level and the so-called Shared Socioeconomic Pathway, or SSP, used in those calculations. Here’s how to understand each one: FIVE FUTURES – DECODED: SSP1-1.9: The IPCC’s most optimistic scenario, this describes a world where global CO₂ emissions are cut to net zero around 2050.’

It is worth pointing out that Figures at times appeared in the news online coverage that depicted either the five scenarios or SSPs in visual detail. One example can be found in Fig. 1S in the SM which is an example of the *BBC* news website on 9 August 2021 adapting material from the WGI’s SPM to reduce the amount of information presented and make the five scenarios under different temperature increases relatively easy to follow.²⁵ A different example (see Fig. 2S) can be found in the Mail online coverage on 8 August 2021 where the Figure they publish depicting future emissions²⁶ contains the acronym SSPs and is an exact reproduction of the IPCC’s Figure found in the SPM, Box SPM.1, p. 13.²⁷

We then looked at the presence of any explanation of how the different scenarios or SSPs are calculated. This could range from a general, short explanation (such as *Sky News* reporting that ‘The IPCC investigated five future scenarios based on how much carbon dioxide the world continues to emit and what we do to compensate’²⁸), to a very detailed explanation of the different SSPs. An example of the latter can be found in *the Hindustan Times*,²⁹ which explained both RCPs and SSPs in the following manner:

“RCP stands for representative correction pathway, which is a trajectory of greenhouse gases assumed by IPCC for modelling. RCP 2.6, 4.5 and RCP 8.5 represent three futures, based on the magnitude of greenhouse gas emissions. The numbers themselves are in units of watt/square metre. The numbers are the difference between the incoming and outgoing energy on Earth; a high level of greenhouse gases means higher incoming energy. SSP stands for Shared Socioeconomic Pathways. SSP 1 is a scenario for sustainability focused growth and equality; SSP 2 is status quo; SSP 3 is where every country does its own thing; SSP4 is a scenario where inequality spikes; and SSP5 is one where there is rapid and uncontrolled growth in energy use. The SSPs are used in consonance with RCPs to represent different possible futures.”

²⁴ <https://www.foxbusiness.com/lifestyle/un-report-global-warming-is-likely-to-blow-past-paris-limit>

²⁵ <https://www.bbc.co.uk/news/science-environment-58138714>

²⁶ <https://www.dailymail.co.uk/news/article-9875079/Planet-likely-warm-far-quickly-expected-bombshell-report-warns.html>

²⁷ https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

²⁸ <https://news.sky.com/story/climate-change-global-warming-limit-of-1-5c-to-be-hit-in-next-20-years-landmark-un-report-warns-12376737>

²⁹ <https://www.hindustantimes.com/india-news/india-stares-at-water-scarcity-extreme-heat-stress-report-101646070934296.html>

Finally, an explanation for the calculations behind the scenarios was present in a weak or strong form in a total of 18 articles (only 7% of the total sample), with all but one of them found in the coverage of WGI, and the other in WGII. None was found in the WGIII reporting.

3.4 Use of language: predictions/forecasts compared to futures/pathways/projections

Figure 3 shows the results from the coding of the presence of different words to describe or accompany the scenarios for each of the WG reports. We coded for the presence of the word ‘Path(ways)’, ‘Futures’, ‘Forecasts’, ‘Predictions’, ‘Projections’, ‘Visions’, and ‘Other’ (when used in reference to climate scenarios). Given the frequent presence of the words ‘projections’, ‘pathways’, and ‘futures’ in the SPMs (see Sect. 1 above), it is not surprising that these feature strongly in the reporting. But ‘predictions’ and ‘forecasts’ also appear relatively frequently in WGI and II reporting (24% and 18%, respectively), and particularly in the WGI coverage in the UK and USA. For example a *Guardian* article of 9 August³⁰ says that ‘Under the high and very high emissions scenarios outlined in the report, global heating is *predicted* (*emphasis added*) to reach 3.6C and 4.4C above pre-industrial levels respectively, by the end of the century’, or *Sky News* on 10 August reports that ‘the IPCC *predicts* (*emphasis added*)—even under the best case scenario—warming will continue for several years to come’.³¹

It is worth adding that there was no use of the word ‘visions’ anywhere in the sample. Other phrases that did appear occasionally about the future scenarios included ‘we are on track/course for’, ‘outcomes’, and ‘options’/‘choices’ particularly in the reporting of WGIII.

3.5 Descriptors for the scenarios

We looked at a variety of descriptors used in conjunction with the scenarios. The first category was phrases describing the different scenarios such as low/medium/high-range emission scenarios, worst/best (case) scenarios, and pessimistic/optimistic. As can be seen from Fig. 4, WGI reporting covered a range of such descriptors, with low/medium/high the most frequently present (23%), and pessimistic/optimistic the least (13%). In WGII reporting, low/medium/high was also the most present, but for WGIII it was the worst/best (case) scenario. Pessimistic/optimistic were not present in WGIII, and hardly present in WGII.

We then looked at the number of scenarios that were discussed, if they were mentioned at all. As might be expected, WGI coverage often (21 times) presented five scenarios, frequently in a figure. The number of scenarios was left vaguer in WGII and WGIII reportage: an article may outline one, two, or three scenarios, but an overall number of calculated scenarios was seldom given.

Finally, we coded for the timelines used in conjunction with the presence of scenarios, such as 2030, 2050/mid-century, or end of century. In general, for the UK/US/Reuters sample and Africa, there was more mention of time phrases in the coverage of the WGI report

³⁰ <https://www.theguardian.com/world/2021/aug/10/ipcc-report-shows-possible-loss-of-entire-countries-within-the-century>

³¹ <https://news.sky.com/story/climate-change-seven-key-takeaways-from-the-ipcc-climate-change-report-12377264>

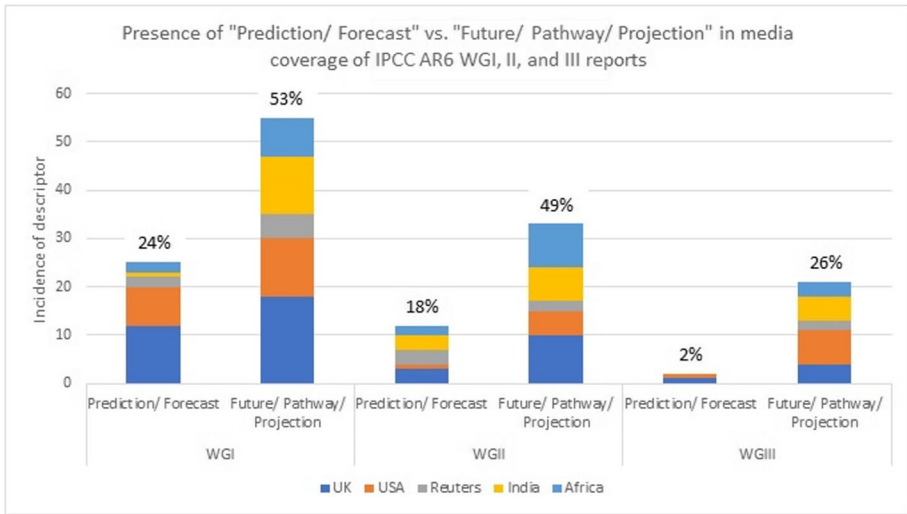


Fig. 3 Presence of ‘prediction/forecast’ vs. ‘future/pathway/projection’

such as mid-century and end of century. There was much less in WGII and III, and with a few exceptions, most reports in the US and UK sample of WGIII did not clarify the timeline for the various scenarios. So, readers might have been left in confusion regarding the timing by which these various scenarios could be reached (e.g., warming of 3 °C by the end of the century was often discussed as ‘warming of 3C’).

3.6 Binary framing

We divided our coding into articles which clearly mentioned a hard deadline narrative and those describing a softer binary framing. We defined the first as including i) mention of a specific year as a deadline (e.g. 2030) or a specific number of years to go before a deadline for action is reached together with ii) mention of such phrases as doom, catastrophe, climate disaster, or ‘end of the world as we know it’ etc. Examples would be ‘The world is about 18 years away from global warming of 1.5 °C, the line that must not be crossed if catastrophic changes in climate and damage to ecosystems are to be averted³², or (by way of rejection of the concept), ‘The 1.5C threshold is an important threshold politically, of course, but from a climatic point of view, it is not a cliff edge—that once we go over 1.5C, suddenly everything will become very catastrophic,’ explained Dr Amanda Maycock, from the University of Leeds, and one of the authors of the new report.’³³

We defined the second as a softer presentation of two alternatives, such as: ‘Any further delay in concerted anticipatory global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all’ (a direct quote from WGII’s SPM, paragraph D.5.3), or ‘It’s now or never if we want to

³² Business Day (South Africa) 2022. A decade of difficult decisions on climate. 22 March.

³³ <https://www.bbc.co.uk/news/science-environment-58138714>

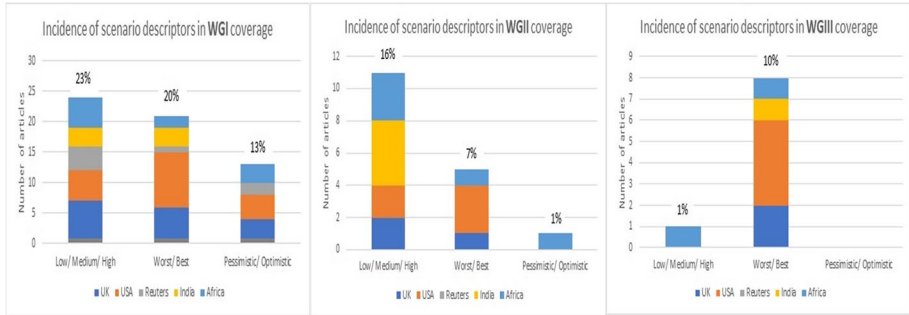


Fig. 4 Incidence of scenario descriptors in the coverage of WGI, WGII and WGIII

limit global warming to 1.5 °C’, contained in a quote from WGIII Co-Chair Jim Skea in the accompanying press release. A third example would be the phrase found in the reporting of the WGIII report in the *BBC* and *Guardian* (but not much elsewhere) that ‘global emissions of CO₂ would need to peak within three years (at the latest by 2025) to stave off the worst impacts’.³⁴

Our key finding is that the hard deadline narrative was present in less than 10% of our sample, and much less than we thought given the reporting of the IPCC’s 1.5 2018 report, and the frequent mention there of variants on ‘12 years to go before catastrophe’. For example, in the UK/US/Reuters sample, the deadline narrative was present in only four articles in the WGI coverage, in each case to be rejected; it was present in three articles in the WGII coverage, such as in the phrase ‘delay means death’ (a quote from the UN Secretary General), and not at all in WGIII reporting. For the African and Indian sample, it was present in 15 articles across the three reports. However, in several cases, the mention of the hard deadline was present only to reject it or debunk it, such as in the quote above from IPCC author Dr. Maycock. If we remove the cases of rejection, then the total presence of the deadline narrative drops to only 15 articles, or 6% of the total sample.

In contrast, the soft binary framing was present in 15 of the total sample of 103 articles in the WGI coverage, but for WGII this rose to 29 (out of 67 articles) and for WGIII 26 articles (out of 82). For WGII, the binary framing was mostly variations on the ‘disappearing window’, and for WGIII it was often the ‘now or never’ quote (present in six articles). For example, the *Guardian* headline of 4 April 2022 was ‘IPCC report: ‘now or never’ if world is to stave off climate disaster’, which is a clear binary narrative with its own added description of a ‘climate disaster’. Figure 5 shows the breakdown for the presence of a binary narrative across the entire sample, broken down by country and WG report.

3.7 Contestation

There was no criticism or questioning of the scenarios in any of the articles we monitored. This included the absence of organized skeptical or denialist groups who may have sought to criticize the scenarios as part of a broader strategy of undermining the credibility of the

³⁴ This was later clarified in a BBC article that emissions needed to start being reduced now. <https://www.bbc.co.uk/news/science-environment-61110406>

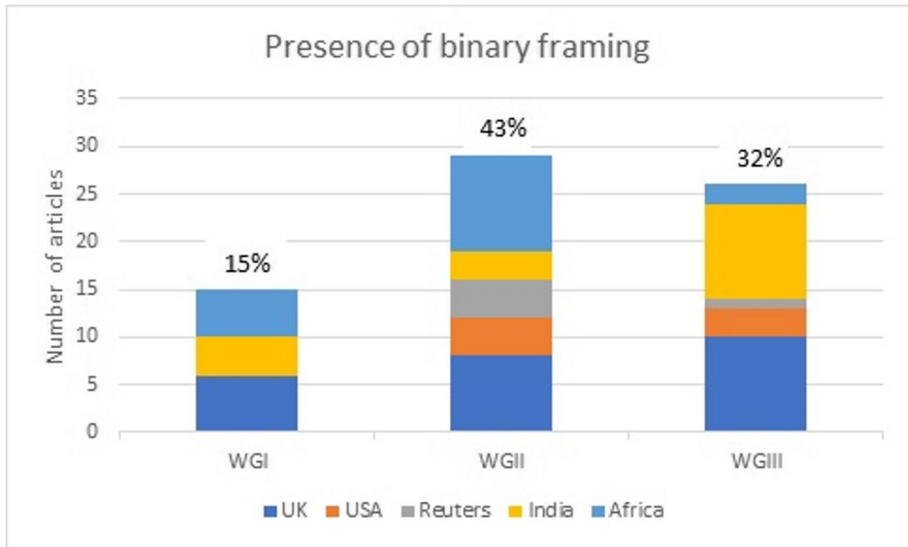


Fig. 5 Presence of binary framing

IPCC. This is in line with other research looking at broader coverage of the media reporting of the AR6 WG reports, which shows little presence of evidence skeptics (who dispute the science) on mainstream television channels' coverage of WGI (Painter et al. 2023).

There was very little doubting of the credibility of the IPCC in our sample, except for one article in the Indian media, which questioned the use of the 1980 baseline and the choice of scenarios that do not 'consider global equity and regionally differentiated mitigation based on principles of equity and common but differentiated responsibilities'.³⁵

3.8 Uncertainty

The word 'uncertain', 'uncertainty' or 'uncertainties' in association with the models or scenarios very rarely appeared in our sample, and the concept was equally rarely described or even mentioned. However, there are many other indicators of a framing of uncertainty, such as the presence of words like 'may', 'suggest', 'likely', 'could' and 'possible'; uncertainty parameters or a range of projections; the shortcomings of computer models; or the presence of 'dueling experts' suggesting contestation (see Painter 2013, Appendix 1 and 2). We did not code for these other indicators, except we did note the regular presence of words depicting likelihood ('likely' or 'very likely') in the articles.

³⁵ <https://www.hindustantimes.com/india-news/households-in-top-10-contribute-largest-share-to-ghg-emissions-ipcc-101649268993271.html>.

3.9 Other

We coded for the presence of the word ‘must’ to see if there was any strong picture emerging of the more frequent use of a more prescriptive tone to the coverage in WGIII as to the solutions that need to be adopted, or for the need for action, as in the phrase for example, ‘the world must cut energy emissions between 38 and 52 percent in the next eight years’. In the reporting of the WGIII report in the UK and US sample, the use of the ancillary verb ‘must’ did appear frequently (26 times) as in the phrase, ‘global emissions must peak by 2025 to stave off the worst impacts of the climate crisis’.

However, when we compared the usage across the WG reports, we found that in the African sample, the word ‘must’ appeared the most in WGIII (14 articles), but this was not noticeably higher than its appearance in WGII (12 articles) or WGI (11 articles). Likewise, no clear picture emerged from the Indian sample, as the word appeared in six articles in WGIII, but also in six articles in WGI and in four articles for WGII.

With some exceptions noted above, no strong differences were apparent between the country samples. There were however, some differences in the use of terms between media outlets: for example, in the Reuters articles about WGI, the word ‘scenario’ was present in 6 out of 7 articles, in the *BBC* sample it was in 4 out of 8, and in the *Guardian* only 2 out of 9. It is not possible to ascertain if these differences were a result of an editorial policy, without carrying out additional interview work.

4 Conclusions and recommendations

In answer to our five sets of research questions above, the media in our sample do use the word ‘scenario’ and the concept of a range of scenarios regularly, particularly in the reporting of WGI, where they both appear in around half of our sample. The concept and brief labelling of the five scenarios are also often found in the graphs and Figures accompanying the text. In general, journalists do use more accurate words like ‘projections’, ‘futures’, and ‘pathways’ when talking about the IPCC scenarios, although some usage of ‘predictions’ or ‘forecasts’ is apparent. Contrary to previous research about the coverage of IPCC reports, there were very few doomsday narratives such as ‘only 12 years to act’. There was very little contestation around the scenarios and models, with no presence of any organized skeptical group or their representatives challenging the scenarios. Finally, the uncertainty surrounding scenarios was rarely spelt out by the use of the word ‘uncertain’, ‘uncertainty’ or ‘uncertainties’, although other ways of depicting uncertainty was present.

However, in all countries, the media in our sample provided little detailed explanation of how scenarios are developed, very little mention of SSPs, and virtually no detailed descriptions of them. Such explanations tend to appear in specialist coverage. In part, this can be explained by journalists in general finding it difficult to report on the complexity and uncertainty inherent in climate science (Painter 2013), the primacy of journalistic norms of personalization, dramatization, and novelty driving a lot of climate coverage (Boykoff and Boykoff 2007), and the lack of editorial space necessary to explain scenarios when journalists have to think of short phrases, headlines or images designed to improve shareability on social media (Dwyer and Martin 2017). It may well take another round of IPCC reports highlighting the importance of scenarios for there to be more detailed coverage or discussion in the media.

As mentioned above, journalists closely follow the IPCC prompts found in press releases, SPMs, press conference, and posts or tweets on social media. So, spelling out simple, repeated messages (e.g. that scenarios are not predictions or forecasts but projections, or that scenarios do not depict ‘cliff-edge narratives’, or that ‘scenarios are helpful for illustrating the urgent choices we face’) would aid effective communication of what IPCC scenarios are and what they are not. It is worth speculating why the use of ‘prediction’ or ‘forecast’ was much lower in the WGIII sample (2%). This may in part be related to the statement in the Box SPM.1 in the WGIII SPM (in contrast to the WGI and WGII SPMs) on scenarios that [these are] ‘quantitative projections and are neither predictions nor forecasts’. (p.25).³⁶

The IPCC Figures and Charts found in the Boxes describing scenarios in the SPMs and provided in the IPCC slide decks were not widely used by the media in our sample, so it may be worth thinking through what appropriately simplified, but never inaccurate, charts, figures and animations based on IPCC findings will aid the depiction in the media of the variety of scenarios, and the assumptions behind them, without overloading the non-expert audience with too much information. In this context, the work by Morelli et al. (2021) is particularly apposite, as they emphasize certain elements in the co-designing of the IPCC’s visual information including practical tools, a flexible method, and social science expertise to understand the needs of users, in order to recognize the value of a visual story, whilst retaining scientific integrity. The IPCC itself stresses the importance of ‘using simple storylines, where possible supported by clear and easy to understand graphics, to effectively communicate scenarios about a range of possible futures’. (IPCC 2023, p. 44).

Calling on the expertise of journalists and designers from reputable media organizations to seek their advice on effective graphics could help the design process, particularly as data visualizations are now such an important part of the work of media organizations, partly because good visuals help the virality and shareability of articles on social media (Newman et al. 2015). Indeed, in general, experienced climate and environment correspondents could be part of the network of ‘trusted intermediaries’ identified by the IPCC 2023 expert workshop on scenarios to aid effective communication. (IPCC 2023) The niche climate site Carbon Brief³⁷ is mentioned in the same workshop report, in the context of scenario explainers being co-developed by stakeholders, scenario experts and IPCC WG communication experts. For example, Carbon Brief puts particular editorial emphasis on explaining complex climate science and using appropriate diagrams to aid understanding by specialist and general audiences (Painter et al. 2024), including special features on scenarios (Carbon Brief 2018).

Even though there are many factors, actors and interests other than IPCC reports which influence policy makers, we have already seen that there is evidence that with important caveats, these reports are used extensively by policy makers around the world to help provide scientific context to their decisions. In this context, all five recommendations put forward by the IPCC workshop report and mentioned above (IPCC 2023) are a useful starting point for aiding effective communication in the future. Additional recommendations mentioned elsewhere in the report (Section 3.5) such as i) using storylines to complement graphs and tables, and to illustrate how a scenario evolves over time, ii) selecting authors equipped with strong communication skills, and iii) the co-production of scenarios are also

³⁶ <https://news.sky.com/story/climate-change-seven-key-takeaways-from-the-ipcc-climate-change-report-12377264>

³⁷ <https://www.carbonbrief.org/>

helpful. However, at the time of writing, none of these recommendations have been implemented or assessed, and adequate resources will be needed for their implementation.

Given the challenges mentioned above which journalists face in reporting accurately on scenarios, and making them relevant to people's lives, writing guidelines for them is increasingly important. In addition, testing how the IPCC scenarios are received and understood by media consumers could aid effective communication designed to provide knowledge and appropriate action. This could include an assessment of the most helpful language such as the greater use of the phrase 'options we face', which suggests agency and choice.³⁸

As climate-enhanced extreme weather events become more of a daily part of existence around the world rather than a problem far away in space and time, the concept of scenarios and multiple possible futures, and public agency in choosing trajectories, could become a powerful communications tool for climate science in general. Just as the scenarios underlie the understanding of our potential future, embedding scenarios in climate communication could help to change the narrative away from a doom-laden or tipping point narrative, to involving the public and stake holders more in the discussion and options for possible (better) futures.

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1007/s10584-024-03744-z>.

Author contributions JP: Conceptualization; project administration; resources; content analysis; writing original draft; writing review and editing. SM: content analysis; writing original draft; writing review and editing; data visualisation. KL: project administration, writing review and editing. All authors read and approved the final manuscript.

Funding This research was partly funded by the United Nations Foundation.

Data availability The datasets generated during and/or analysed during the current study are presented in the Tables and Figures found in the main text and Supplementary Material.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication All authors agreed with the content and all gave explicit consent to submit.

Competing interests James Painter has worked for the Intergovernmental Panel on Climate Change (IPCC) as an external consultant. Katherine Leitzell has worked as a communications manager at the IPCC. Suzie Marshall has worked as an intern at the IPCC.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

³⁸ See the talk by Susan Hassol in September 2020 at <https://www.nationalacademies.org/event/09-22-2020/communicating-climate-change-scenarios-to-the-public>

References

- Amdt S (2020) How people access news about climate change. In: Newman N (ed) Digital news report 2020. Reuters Institute for the Study of Journalism, Oxford. Available at <https://www.digitalnewsreport.org/survey/2020/how-people-access-news-about-climate-change/>
- Barkemeyer R, Dessai S, Monge-Sanz B et al (2016) Linguistic analysis of IPCC summaries for policymakers and associated coverage. *Nat Clim Change* 6:311–316. <https://doi.org/10.1038/nclimate2824>
- Boykoff MT, Boykoff JM (2007) Climate change and journalistic norms: a case-study of US mass-media coverage. *Geoforum* 38(6):1190–1204. <https://doi.org/10.1016/j.geoforum.2007.01.008>
- Boykoff M, Pearman A (2019) Now or never: how media coverage of the IPCC special report on 1.5C shaped climate-action deadlines. *One Earth* 1(3):285–288
- Bruin de Bruin W, Rabinovich L, Weber K et al (2024) Improving figures for climate change communications: insights from interviews with international policymakers and practitioners. *Clim Change* 177:57. <https://doi.org/10.1007/s10584-024-03704-7>
- Budescu DV, Broomell S, Por H-H (2009) Improving communication of uncertainty in the reports of the Intergovernmental Panel on Climate Change. *Psychol Sci* 20(3):299–308
- Carbon Brief (2018) Explainer: How ‘Shared Socioeconomic Pathways’ explore future climate change. 19 April. Available at: <https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change/>
- Carton W (2020) Carbon unicorns and fossil futures. Whose emission reduction pathways is the IPCC performing? In: Sapinski J, Buck H, Malm A (eds) Has it Come to This? The Promises and Perils of Geo-engineering on the Brink. Rutgers University Press, pp 34–49
- Coan TG, Boussalis C, Cook J, Nanko MO (2021) Computer-assisted classification of contrarian claims about climate change. *Sci Rep* 11(1):1–12. <https://doi.org/10.1038/s41598-021-01714-4>
- Dahlstrom MF (2014) Using narratives and storytelling to communicate science with nonexpert audiences. *Proc Natl Acad Sci U S A* 111(Supplement 4):13614–13620. <https://doi.org/10.1073/pnas.1320645111>
- Dwyer T, Martin F (2017) Sharing news online. *Digit Journal* 5(8):1080–1100. <https://doi.org/10.1080/21670811.2017.1338527>
- Guenther L, Brüggemann M, Elkobros S (2022) From global doom to sustainable solutions: international news magazines’ multimodal framing of our future with climate change. *Journal Stud* 23(1):131–148
- Guenther L, Meyer H, Kleinen-von Königsłow K, Brüggemann M (2023) A distant threat? The framing of climate futures across four countries. *Environ Comm* 17(7):775–793. <https://doi.org/10.1080/17524032.2023.2253500>
- Hermansen EAT, Lahn B, Sundqvist G et al (2021) Post-Paris policy relevance: lessons from the IPCC SR15 process. *Clim Change* 169:7. <https://doi.org/10.1007/s10584-021-03210-0>
- Hilaire J, Minx JC, Callaghan MW et al (2019) Negative emissions and international climate goals—learning from and about mitigation scenarios. *Clim Change* 157:189–219. <https://doi.org/10.1007/s10584-019-02516-4>
- Howarth C, Painter J (2016) The IPCC and local decision making on climate change: a robust science-policy interface? *Palgrave Commun* 2:16058
- Howarth C, Parsons L, Thew H (2020) Effectively communicating climate science beyond academia: harnessing the heterogeneity of climate knowledge. *One Earth* 2(4):320–324. <https://doi.org/10.1016/j.oneear.2020.04.001>
- Howarth C, Lane M, Morse-Jones S, Brooks K, Viner D (2022) The ‘co’ in co-production of climate action: challenging boundaries within and between science, policy and practice. *Glob Environ Chang* 72. <https://doi.org/10.1016/j.gloenvcha.2021.10244>
- Hulme M (2009) Mediated messages about climate change. In: Boyce T, Lewis J (eds) Climate Change and the Media. Peter Lang, New York NY
- Hutchins JA (2020) Tailoring scientific communications for audience and research narrative. *Curr Protoc Essent Lab Tech* 20(1):e40. <https://doi.org/10.1002/cpet.40>. (Epub 2020)
- IPCC (1992) Climate Change: The IPCC Response Strategies, Report prepared for Intergovernmental Panel on Climate Change by Working Group III. Chapter 2: Emissions Scenarios. Available at: https://archive.ipcc.ch/ipccreports/far/wg_III/ipcc_far_wg_III_chapter_02.pdf
- IPCC (2000) Special Report of IPCC Working Group III, Emission Scenarios. Available at: <https://www.ipcc.ch/site/assets/uploads/2018/03/sres-en.pdf>
- IPCC (2021) Climate Change 2021: The Physical Basis. Summary for Policy Makers. Available at: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf
- IPCC (2022a) Climate Change 2022: Impacts, Adaptation and Vulnerability. Summary for Policy Makers. Available at: https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

- IPCC (2022b). Climate Change 2022: Mitigation of Climate Change. Summary for Policy Makers. Available at: https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf
- IPCC (2023) IPCC Workshop on the Use of Scenarios in the Sixth Assessment Report and Subsequent Assessments. Available at: https://www.ipcc.ch/site/assets/uploads/2023/07/IPCC_2023_Workshop_Report_Scenarios.pdf
- Kristiansen S, Painter J, Shea M (2020) Animal agriculture and climate change in the US and UK elite media: volume, responsibilities, causes and solutions. *Environ Comm*. <https://doi.org/10.1080/17524032.2020.1805344>
- Kunelius R, Eide E, Tegelberg M, Yagodin D (eds) (2017) Media and global climate knowledge: Journalism and the IPCC. Palgrave Macmillan, New York, NY
- Liguori A, McEwen L, Blake J, Wilson M (2021) Towards ‘creative participatory science’: exploring future scenarios through specialist drought science and community storytelling. *Front Environ Sci* 8:589856. <https://doi.org/10.3389/fenvs.2020.589856>
- MacCracken M (2001) Prediction versus Projection – Forecast versus Possibility. *Weatherzine*, Edition number 26, February. <https://sciencepolicy.colorado.edu/zine/archives/1-29/26/guest.html>
- Metag J, Füchslin T, Schäfer MS (2017) Global warming’s five Germanys: a typology of Germans’ views on climate change and patterns of media use and information. *PUS* 26(4):434–451
- Morelli A, Johansen TG, Pidcock R et al (2021) Co-designing engaging and accessible data visualisations: a case study of the IPCC reports. *Clim Change* 168:26. <https://doi.org/10.1007/s10584-021-03171-4>
- Newman N (ed) (2015) Digital News Report 2015. Reuters Institute for the Study of Journalism, Oxford
- Newman N (ed) (2022) Digital News Report 2022. Reuters Institute for the Study of Journalism, Oxford
- O’Neill S, Pidcock R (2021) Climate change communication and the IPCC. *Clim Change* 169:19. <https://doi.org/10.1007/s10584-021-03253-3>
- O’Neill S, Williams HTP, Kurz T, Wiersma B, Boykoff M (2015) Dominant frames in legacy and social media coverage of the IPCC Fifth Assessment Report. *Nat Clim Change* 5:380–385. <https://doi.org/10.1038/nclimate2535>
- O’Neill B, Kriegler E, Ebi KL et al (2017) The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. *Glob Environ Change* 42. <https://doi.org/10.1016/j.gloenvcha.2015.01.004>
- Painter J (2013) Climate change in the media: reporting risk and uncertainty. Reuters Institute/IB Tauris, Oxford
- Painter J (2014) Disaster averted? television coverage of the 2013/14 IPCC’s climate change reports. Reuters Institute, Oxford
- Painter J (2017) Disaster, risk or opportunity? A ten-country comparison of themes in the coverage of the IPCC reports. In: Kunelius et al (eds) *Media and Global Climate Knowledge: Climate Journalism and the IPCC*. Palgrave Macmillan, New York
- Painter J, Ettinger J, Holmes D et al (2023) Climate delay discourses present in global mainstream television coverage of the IPCC’s 2021 report. *Commun Earth Environ* 4:118. <https://doi.org/10.1038/s43247-023-00760-2>
- Painter J, Kangas J, Kunelius R, Russell A (2024) The journalism in climate change websites: their distinct forms of specialism, content, and role perceptions. *Journalism Practice* 18(4):954–973. <https://doi.org/10.1080/17512786.2022.2065338>
- Pathak M, Roy J, Patel S et al (2021) Communicating climate change findings from IPCC reports: insights from outreach events in India. *Clim Change* 168:23. <https://doi.org/10.1007/s10584-021-03224-8>
- Pearce W, Holmberg K, Hellsten I, Nerlich B (2014) Climate change on Twitter: topics, communities and conversations about the 2013 IPCC Working Group 1 report. *PLoS One* 9(4):e94785. <https://doi.org/10.1371/journal.pone.0094785>
- Pedersen JTS, van Vuuren D, Gupta J et al (2022) IPCC emission scenarios: how did critiques affect their quality and relevance 1990–2022? *Glob Environ Chang* 75. <https://doi.org/10.1016/j.gloenvcha.2022.102538>
- Pielke R Jr et al (2022) Plausible 2005–2050 emissions scenarios project between 2 °C and 3 °C of warming by 2100. *Environ Res Lett* 17:024027. <https://doi.org/10.1088/1748-9326/ac4ebf>
- Pirani A, Fuglestedt JS, Byers E et al (2024) Scenarios in IPCC assessments: lessons from AR6 and opportunities for AR7. *npj Clim Action* 3:1. <https://doi.org/10.1038/s44168-023-00082-1>
- Sanford M, Painter J, Yasseri T et al (2021) Controversy around climate change reports: a case study of Twitter responses to the 2019 IPCC report on land. *Clim Change* 167:59. <https://doi.org/10.1007/s10584-021-03182-1>

- Schäfer MS, Ivanova A, Schmidt A (2014) What drives media attention for climate change? Explaining issue attention in Australian, German and Indian print media from 1996 to 2010. *Int Commun Gaz* 76(2):152–176
- Shaw C, Corner A et al (2018) Principles for effective communication and public engagement on climate change: A Handbook for IPCC authors. Available at: <https://climateoutreach.org/reports/ipcc-communications-handbook/>
- Sheppard SRJ et al (2011) Future visioning of local climate change: a framework for community engagement and planning with scenarios and visualisation. *Futures* 43(4):400–412. <https://doi.org/10.1016/j.futures.2011.01.009>
- Smith J, Tyszczuk R, Butler R eds (2014) *Culture and Climate Change: Narratives, Culture and Climate Change*, 2. Cambridge, UK: Shed. <http://www.open.ac.uk/researchcentres/osrc/files/osrc/NARRATIVES.pdf>
- Sundqvist G, Gasper D, LeraSt.Clair A et al (2018) One world or two? Science–policy interactions in the climate field. *Crit Policy Stud* 12(4):448–468. <https://doi.org/10.1080/19460171.2017.1374193>
- Van Vuuren DP, Kriegler E, O'Neill BC et al (2014) A new scenario framework for Climate Change Research: scenario matrix architecture. *Clim Change* 122:373–386. <https://doi.org/10.1007/s10584-013-0906-1>
- Viner D, Howarth C (2014) Practitioner's work and evidence in IPCC reports. *Nat Clim Chang* 4:848–849
- Wallison PJ, Zycher B (2021) *What We Really Know About Climate Change*. The American Enterprise Institute. Available at: <https://www.aei.org/articles/what-we-really-know-about-climate-change/>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.