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COP28 and its impact on the shared socioeconomic pathways

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COP28 aimed to make essential progress on the climate transition following a year marked by unparalleled climatic extremities. A spectrum of extreme weather phenomena, including droughts, floods, and wildfires, inflicted considerable devastation across various global locales. 2023 was identified as the warmest on record, with mean global temperatures surpassing those of the pre-industrial era by 1.4°C by the WMO. Given the current trajectory of temperature escalation, it is projected that global temperatures will surpass the preindustrial baseline by 1.5°C circa 2026, significantly ahead of the target year 2100 established during the 21st Conference of the Parties (COP21) in Paris, 8 years prior according to UNEP. The progress made during COP28 will need to be operationalized along pathways that enable the commitments to be turned into outcomes.

KEYWORDS

COP28, shared social economic pathways (SSP), climate change, Paris agreement, environment

The shared socioeconomic pathways as a gauge of COP28's impact

The outcomes achieved at COP28 can be assessed in light of the 6th Assessment Report from the UN's Intergovernmental Panel on Climate Change (IPCC), which depicted a grim future if current climate trends continue (Pörtner et al., 2022). The report emphasized the need for substantial and immediate reductions in greenhouse gas emissions to limit global warming to 2°C or less. Even if these limits are maintained, the world is still likely to experience more frequent extreme heat, increased species losses, land degradation, and rising sea levels (Pörtner et al., 2022).

For the first time the report also drew on the Shared Socioeconomic Pathways (SSPs), scenarios of projected socioeconomic global changes up to 2100 developed by experts across various (IPCC, 2021). These models incorporate a range of factors including population growth, economic trends, technology, and geopolitics, marking the first time social and economic factors have been used to derive greenhouse gas emissions scenarios with different climate policies. The SSPs serve as valuable guides for policymakers, businesses, and civil society. They point to the potential long-term global impacts of current decisions, enriching our understanding of how human and economic activities intersect with climate policies and impacts.

This paper offers an overview of whether COP28 has advanced the global climate change agenda sufficiently to impact the world's trajectory with regards to the five SSPs.

Since its founding in 1988, the Intergovernmental Panel on Climate Change (IPCC) has been a key source of scientific information on climate change, guiding international policy decisions such as the Kyoto Protocol and the Paris Agreement. The Sixth Assessment Report released in stages between 2021 and 2023 reiterates the urgency of the climate crisis and finds that the world's current trajectory is set to significantly overshoot the Paris Agreement goal to limit the global temperature increase to 1.5°C above

pre-industrial levels. The report also adds a new dimension by incorporating geopolitics and socioeconomics into its climate projections. Unlike earlier reports that mainly focused on emission trajectories, the latest report includes five Shared Socioeconomic Pathways (SSPs) that outline potential global futures based on various social, demographic, and economic factors. These SSPs point to a range of climate outcomes, enriching our understanding of the interconnectedness of climate change, society, and geopolitics (IPCC, 2021).

The five SSPs contain both narratives and quantitative information and each makes different assumptions of how population, education, energy and land use, and technology may change over the next century. These assumptions drive potential climate impacts which lead to very different worlds at the end of the century, ranging from worlds in which the Paris Agreement goals are met to ones in which increasing parts of the globe are rendered uninhabitable for humankind. Importantly the SSPs are "reference" pathways in that they assume no climate change or climate impacts, and no new climate policies, instead providing the baseline worlds in which any policies will be implemented (Kriegler et al., 2014). The IPCC Sixth Assessment Report states that: "Each pathway is an internally consistent, plausible and integrated description of a socio-economic future, but these socio-economic futures do not account for the effects of climate change, and no new climate policies are assumed" (IPCC, 2021).

Five potential scenarios facing the world

The SSPs provide an insightful tool for both climate scientists and policymakers. They offer insights into the implications of the potential trade-offs between economic growth, security, social justice, and environmental protection and also of the choices made in vital areas like global trade, migration, and technological innovation. Therefore, they offer a way to judge the extent to which policy and international agreements made in forums like COP27 might impact on the scenarios the world faces.

Treating the SSPs as a set of choices the world could make allows the implications of the decisions made at events like COP27 to be better understood. The SSPs and their implications can be summarized as follows:

i. SSP1 taking the green road – Is highly ambitious, and highly challenging to achieve: SSP1 envisions an ideal, sustainable, and equitable low-carbon future that may be overly optimistic. It assumes a significant shift in human nature toward altruism, inclusivity, and wellbeing over short-term material growth. While some may argue the world is moving (slowly)in this direction, the scenario overlooks the challenges posed by over 6.6 billion people in middle- and low-income countries, whose populations are unlikely to give up aspiring to the consumption patterns and living standards that have been prevalent in advanced industrialized nations.

ii. SSP2 the middle of the road – continuing the trend line derails the world off that path**:** SSP2 is based on the extension of historical trends and serves as a 'business as usual' model, providing middle-ground outcomes for climate and economy compared to the other SSPs. However, the unpredictability of real-world events, such as the recent global pandemic, economic downturn, and a war in Europe, challenge the idea that the future will align with past trends. These shocks indicate that without proactive measures, the world will be at risks veering toward less favorable scenarios like SSP3, which represents a worst-case situation in both economic and environmental terms.

iii. SSP3 regional rivalry - highlights the limits of the 'limits to growth' idea. SSP3 portrays a world marked by division and competition and serves as a warning for policymakers. It underscores the fact that climate challenges can't be effectively addressed without economic growth. Despite having the lowest economic growth of all five pathways, SSP3 leads to the second highest levels of GHG emissions, undermining the "limits to growth" approach to sustainability. The scenario suggests that managing climate change isn't simply about limiting growth; it would also require drastic reductions in living standards or population size, options that seem unfeasible on a global scale.

iv. SSP4 inequality – a road divided – warns of the danger of national populists: SSP4, which portrays high economic growth with low global cooperation, is potentially appealing to current national populist sentiments like "America First" and "Taking Back Control." It points to domestic prosperity for advanced industrialized countries through investment in both capital and knowledge-intensive sectors and employs a mix of high and low carbon energies. However, the assumption of a less integrated global landscape makes this pathway an unrealistic one in practice, as economic and security shocks have global consequences, disrupting supply chains and exacerbating migration, with potentially negative impacts on domestic prosperity. SSP4's lack of global coordination also makes it vulnerable to sliding into the far less desirable SSP3 scenario, characterized by division and failure to meet environmental goals.

v. *SSP5 Fossil-fuelled development – a high risk gamble on timely breakthrough innovation*. SSP5 presents an optimistic future with rising living standards, improved health and education, and the financial resources to combat climate change. It also points to the possibility of limiting global temperature rises to below 2°C, even with continued carbon resource exploitation. Unlike SSP1 which focuses on near-term mitigation, however, SSP5 relies on both adaptation and mitigation, relying on continued fossil fuelled growth in the near term to fund innovation into energy efficiency and cleaner technologies. However, the scenario relies on a of global cooperation that appears to be unlikely today and is a risky bet on significant technological breakthroughs that have not yet been made. Failing to achieve these advances could easily result in the worst-case climate scenario given the certainty of the near-term environmental costs the pathway implies, making SSP5 a high-risk gamble (Bhattarai et al., 2024).

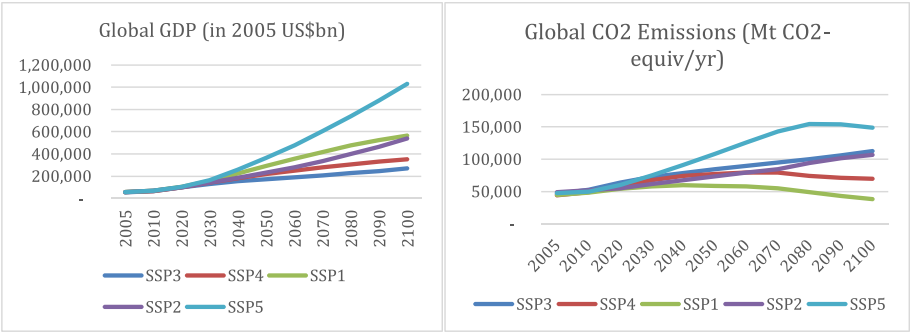

FIGURE 1
Left: Global GDP divergence predicted by shared socioeconomic pathways (Riahi et al., 2017; IIASA, 2024). **Right**: Global greenhouse gas emissions projections by SSP (Riahi et al., 2017; IIASA, 2024).

Economic activity and global greenhouse gases

The relationship between economic activity and global greenhouse gases (GHGs) is an important one (Figure 1). The five SSPs offer distinct future scenarios based on varying assumptions about economic development, demographics, energy demands and resource use. Initially, the differences between the pathways are minor, but they grow significantly over the long term, leading to vastly different global conditions by the end of the century. For example, while all SSPs predict substantial growth in global GDP—projected to increase by at least five times over the twenty first century—the range between the highest and lowest growth pathways is nearly 4-fold by the century's end.

Economic growth is a fundamental factor influencing future CO_2 emissions. However, the relationship between GDP growth and emissions varies significantly across different Shared Socioeconomic Pathways (SSPs) due to differing assumptions about energy intensity, decarbonization, and technology. While most pathways predict a positive correlation between GDP growth and emissions, the levels vary widely. Only the most optimistic scenario, SSP1, anticipates a decrease in emissions below current levels, and that is projected to occur only in the final decade of this century.

COP28 and its outcomes

COP28 in Abu Dhabi was the biggest ever conference of parties, attracting some 85,000 participants, including more than 150 heads of state or governments heading the 198 national delegations (UNFCCC, 2024). Among these participants however were also a record number of fossil fuel industry lobbyists, who with nearly 2,500 attendees, more than four times the number at COP27, would have represented the third largest country delegation of the conference (Guardian News and Media, 2023). Tellingly, perhaps the conference was hosted in the capitol of the United Arab Emirates, of the world's ten largest oil producers. Rather than being an anomaly, this increasing lobbyist presence looks set to be a feature of future COPs, with this year's COP29 being held in Azerbaijan, another major oil and gas producing country.

The need for COP28 to deliver tangible outcomes was urgent. A UNEP report released earlier in the year (UNEP, 2023) estimated than global emissions in 2030 will need to be cut by 42% to limit warming to the 1.5°C target agreed in the Paris climate accords. As with many of its predecessors, the conference outcomes however drew both praise for its achievements as well as condemnation for its shortcomings. The major outcomes include heralding the end of fossil fuels, renewable investment commitments, agreement on a loss and damage fund.

The beginning of the end of fossil fuels

COP28 marked the first "global stocktake" to assess the global response to the climate crisis, as agreed in the Paris Climate Accords. This stock take concluded that progress across all areas of climate action has been too slow, including in greenhouse gas emissions reduction, strengthening resilience to climate impacts, and securing finance and support for developing nations to address the crisis. In response to these findings, countries agreed a decision on how to accelerate action across all areas by 2030 in order to keep alive the global goal of limiting temperature rise to 1.5 degrees C. The conference's final text called for "transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner" to achieve net-zero emissions by 2050 (UNFCCC, 2023).

The positive impact is that this year's conference acknowledged that fossil fuels were the cause of the warming climate for the first time. In fact, this was first ever reference to "fossil fuels" in a COP decision text. While the scientific consensus on the link between fossil fuels and climate change has been well established for nearly 30 years (IPCC, 1995), the inclusion of fossil fuels in the conference decision text was seen as a major step, particularly given that the final text is subject to a unanimous vote by all attending countries.

On the other hand, several critics noted that the phrase "transitioning away" was a softening of the original language which called for the "phase out" of fossil fuels, a phrase that was rejected by major oil producing countries despite the support by a majority of attendees (Nature, 2023; USIP, 2023; World Economic Forum, 2023). Further, the final text lacked concrete emission reduction targets and a clear timeline for explicit actions.

Significant renewable capacity commitments

While COP28 may have lacked concrete emission reduction targets (other than by exception)[1], it included new investment commitments in renewables and other decarbonization technologies. A total of 130 countries signed the Global Renewables and Energy Efficiency Pledge, with a goal to triple global renewable energy capacity, including wind and solar, and to double the rate of energy efficiency improvements by 2030, as well as to make significant investments in carbon capture technologies (COP28, 2023b). Further, a subset of 22 countries including the US, the United Kingdom, and Japan pledged to triple nuclear energy capacity globally by 2050, (which received a mixed response, with some observers pointing out this was impossible to achieve) (U.S. Dept. of Energy, 2023), methane reduction commitments (IEA, 2024b), and new climate funding (COP28, 2023a).

While the pledges and commitments above are both welcome and necessary, absolute reductions in fossil fuel production are critical. Cumulatively, the carbon reduction pledges at COP28 as they stand today only amount to 30% of what the world needs to limit a global temperature rise of 1.5°C, with the balance dependent on a phase out of fossil fuels· (IEA, 2024a). Further, many countries reference 'transitional fuels' in their decarbonization pledges, which is commonly understood to include natural gas, itself a fossil fuel (albeit one that produces c.25% CO_2 than the equivalent amount of oil) (EIA, 2024).

Loss and damage fund agreed

Following several years of failed breakthroughs on the issue[2], COP28 began with a definitive agreement on a loss and damage fund for developing countries to cope with the effects of climate change. A group of wealthy nations including the US, Germany, Britain, Japan and the UAE, have pledged US$700 m to compensate especially vulnerable countries for encapsulate climate change impacts that cannot be addressed by mitigation or adaptation efforts (WEF, 2023). Following the in-principle agreement for such a fund's establishment at COP27, the commitments at COP28 have operationalized the "Loss and Damage Fund."

While welcome and needed, the sums committed to the Loss and Damage Fund falls well short of estimates of the true damage suffered by developing countries from climate change, which is placed at between $290 billion and $580 billion *annually*, several orders of magnitude larger than the Fund (Markandya, 2019). Moreover, the Fund is meant to cover only existing destruction, rather than preventative measures like adaptation and mitigation. Effectively limiting climate-inflicted loss and damage will require significantly increasing funding for preventative measures in the developing world, where funding commitments by wealthy nations have consistently failed to have been met (Könneke and Adolphsen, 2024).

Methane reduction commitments

Methane is a greenhouse gas whose annual emissions are dwarfed by CO_2, it is responsible for over a quarter of the total temperature rise since preindustrial times due to it having 80 times the warming power as carbon dioxide (European Union, 2024). Over 150 countries have signed the Global Methane Pledge, which includes national actions and catalytic grant targeting a 30% reduction in anthropogenic methane emissions by 2030 (vs. 2020 levels) (Global methane pledge, 2023). Global Methane Pledge partners also announced over US$1 billion in new grant funding for methane action mobilized since COP27, more than triple current levels (Global methane pledge, 2023).

Further methane commitments were made by the energy sector, with a group of 50 major oil and gas companies pledging to reduce methane emissions from oil and drilling activities by 80% by 2030. The clear positive from these commitments is that cutting methane emissions is the fastest way to reduce near-term global warming and critical to meeting the temperature limits set out in the Paris Climate Accords.

Climate finance target

While countries reaffirmed their general commitment to climate finance during COP28, actual hard dollar commitments were comparatively small. The largest funding commitments came from the host United Arab Emirates' newly announced fund mobilizing US$250 billion in private investment in global climate solutions by 2030 (COP28, 2024). In addition, the World Bank Group pledged to allocate US$40 billion, or nearly half of its total financing, to climate funding by 2025, split equally between mitigation and adaptation projects (Gombar, 2024). Also, the world's largest multilateral climate fund, the Green Climate Fund (GCF), received a substantial boost in its funding, receiving ~$12.8 billion, with six countries pledging new funding for climate change mitigation and adaptation efforts (Green Climate Fund, 2023).

COP28 represents an advancement in the global drive to secure appropriate funding for climate-related initiatives. Although financial contributions have increased, it is widely recognized that further efforts are necessary. The path to a sustainable, resilient future involves not just meeting current targets, but setting new, more ambitious ones.

Discussion and conclusion: how far did COP28 go and what next

The United Nations Secretary General, Antonio Guterres, said in December 2020, "Humanity is waging war on nature. Nature always strikes back – and it is already doing so with growing force and fury. The fallout of the assault on our planet is impeding our efforts to eliminate poverty and imperiling food security.

1 Among the new initiatives are Canada's plans to cut emissions by 38% by 2030.

2 The formal concept of Loss and Damage originated in 2013 at COP19 in Warsaw, Poland, with the establishment of the Warsaw International Mechanism for Loss and Damage.

And it is making our work for peace even more difficult, as the disruptions drive instability, displacement, and conflict." COP28 made important steps in the right direction, in particular the signaling of the end of the fossil fuel eras as well as the commitment to loss and damage funding. This was a credit to the oil nation as the host. However, the financial commitments did not follow the political agreements made in 2015 as part of the Paris agreements. The political agreement to meet the scientific agreement that the IPCC reports have captured did not materialize, as subsequent analysis shows (Könneke and Adolphsen, 2024).

The dilemma of clean progress is a difficult one. A study of the multiple variables driving progress and climate and the environment warns of the long-term connections between the positives of technology adoption, financial inclusion, and environmental impact, showing that while financial inclusion can worsen carbon emissions, it also amplifies technology's effectiveness in reducing them, alongside finding that energy efficiency and innovation are crucial for environmental improvement, but GDP growth and trade openness exacerbate emissions (Gao et al., 2024).

So, what does this mean for the path ahead for the world? The SSPs provide a way to understand the implications of various paths the world might follow toward the future. Given that the middle paths SSP2, SSP3, and SSP4 are all divisive to differing extents, the two "end-posts" - the sustainable green road (SSP1) and the riskier high growth through innovation approach (SSP5) - appear to be the two choices to plot a path toward, or a combination if that were possible. The path the world has been on to date has placed it in a mediocre position, pointing to an unsustainable way ahead that is susceptible to event risk, which can derail the world onto a path of regional and national rivalry, creating sharp divisions both between and within countries across the Global North and South. Despite making encouraging progress in some important areas, COP28 does not appear to have shifted the world away from the current "mediocre" path, having failed to deliver critical outcomes necessary to transition the world onto either the safer path of SSP1's sustainable green road or the riskier path of SSP5's high growth through innovation, albeit a mitigated one given how risky SSP5 is.

There has been a re-examination of the shift in the light of COP28 on the pathway to reality. Policy, regulation and international agreements are identified as essential ingredients in placing strict controls over activities that exacerbate the challenges of climate change, as well as mitigation of past transgressions are supported by research (Marchiori and Friel, 2024) In addition, public investments and taxes are also seen to be essential government levers, alongside international agreements on matters such as climate and energy security, and private sector actions such as corporate responsibility to implement large-scale changes to realize a just transition (Sending et al., 2024). A direct and strategic focus on carbon dioxide removal is identified as an important factor that needs far more attention given it provides the "net" in Net Zero (Adun et al., 2024), and this may counterbalance the belief that carbon trading is the major solution to emissions. Further, analysis reveals that addressing country level debt is crucial in the climate change challenge since severe economic repercussions and global financial instability are shown to result from climate-induced debt crises (Martin et al., 2024).

However, fundamentally, despite the important initiatives committed to, COP28 did not change the equation between the pursuit of global economy growth objectives and global decarbonization, evidenced by the following shortfalls:

1. New emissions-reduction commitments: The lack of new emissions-reduction commitments from attending countries jeopardized the goal of limiting global warming to 1.5°C above pre-industrial levels.
2. Lack of swift action: There was a failure to rapidly move toward reducing global emissions.
3. Holding major emitters accountable: High emission developing countries like China, India, Brazil, and Indonesia were not held to new commitments, which also means they will not contribute to the loss and damage fund.
4. Continuing financing gaps: It remains unclear how the world will pay for the massive clean energy transition it's now committed to
5. Key climate sensitive factors left unaddressed: COP28 failed to achieve meaningful decarbonization progress across key GHG emitting sectors, such as the defense industry (Khadka, 2024), or other major sources of carbon, such as urban environments more generally (Zhang et al., 2024).
6. Adaptation targets lacked detail: While COP28 established a framework for global adaptation goals for the first time, it continues to lack quantified targets and timescales, as well as the necessary financial and other support for developing countries.
7. Lack of clarity on the most vulnerable: The structure of the new loss and damage fund lacks clarity on focusing on the most vulnerable countries, raising questions about how the funds will be used.
8. Energy security over climate action: The Russian war in Ukraine and the resulting energy crisis diverted attention away from long-term climate concerns, diminishing the urgency of the conference's outcomes relative to COP26.
9. Fossil-fuel geopolitics: Europe's diversification of Russian oil and gas to Africa, Latin America, and the Middle East, at the time seemed to compromise Western efforts to reduce oil and gas dependency overall.

Arguably, any individual COP is but one of a series of steps toward a more sustainable path for the world. Therefore, it may be too much to expect one COP to achieve too much. However, the warning from the IPCC and the UN Secretary General point to both increasing challenges and time running out to address them, meaning that each COP needs to deliver leaps rather than incremental steps of progress. Every shortfall places a greater burden on the next COP, deferring decisions that are too difficult until a potentially far more radical, and costly solution is required. The priorities for COP29 and beyond are therefore increasingly clear.

COP29 will primarily need to be the 'finance' the climate goals that successive COP events have failed to do so far. Given the shortening window and the rising costs of the Paris Climate Accord targets, currently estimated at US$5 trillion annually by 2030, only a fraction is currently being met each year so far (Black et al., 2023). The need to secure funding mechanisms at scale is particularly critical given that nearly 90% of the world's

US$450 trillion in liquid assets is held by financial institutions, whose appetite for climate finance (particularly in the US where the largest pools of capital are located), has cooled recently in response to the politicization of ESG and climate action (Force for Good, 2024). During the first quarter of 2024 for example, JPMorgan Chase, world's largest bank by market capitalization, State Street, the world's largest custodian bank, and Pimco, the largest actively managed bond fund in the world have all exited Climate Action 100+, an international investor coalition that pushes big companies to address global warming (Climate Action 100+, 2024). Similarly, the UN-backed Glasgow Financial Alliance for Net Zero (GFANZ), the world's largest coalition of financial institutions committed to Net Zero, whose member at one point represented US$130 trillion in financial assets, has seen several high-profile departures, particularly in its insurance industry organization, which has seen membership contract from 28 in May 2022 to 11 as of March 2024 (FNLondon, 2024; UNEPI, 2024).

The top five priorities for COP29 flow from the shortcomings of the COP28, with a resulting heavy emphasis on financing:

1. Energy transition: Despite making significant decarbonization pledges at COP28, only a small number of countries have committed to enhanced nationally determined contributions. To turn their good intentions and goals into reality, countries at COP29 will need to translate these into significantly enhanced targets for their nationally determined contributions, which are due in 2025.
2. Net Zero Finance. Securing the trillions capital required for the energy transition, industrial decarbonization, and global climate adaptation to the inevitable impacts of climate change will require creating funding pathways and mechanisms that allow private sector participation and unlock private capital flows.
3. Global policy coordination: Managing the shift to Net Zero will require significant global policy coordination on issues like environmental standards and regulations, financial incentives (including taxes and subsidies), and trade (Bashir et al., 2024; Hassan et al., 2024).
4. Climate funding support: The US$100 billion annual climate funding goal for developing countries has been repeatedly missed and scrapped accordingly. While a new (more ambitious) has been put in its place, it lacks the financing and funding pathways required for capital to flow from industrialized to developing and least developed countries where it is most needed.
5. Loss And Damage fund enhancement: The recently agreed Loss and Damage fund will need to be operationalized with processes and policies that allow funding to flow where it is most needed. Equally importantly however will be the mobilization of much larger pools of capital to support climate-related liabilities in developing countries, with industrialized nations needing to unlock innovative source of public sector funding to meet these needs.
6. Global goal on adaptation: While the original Paris Agreement in 2015 has included a Global Goal on Adaptation, focusing on increased resilience and adaptative capacity in the face of climate change, this goal to date has lacked including clear targets or how they would be measured. To address the gaps, countries will need to agree quantifiable adaptation targets at COP28, as well as to develop indicators for measuring and assessing progress toward them.

In this sense, while COP28 did achieve some important advances, the pressure is on COP29 to make a far bigger contribution to putting the world on a much needed and safer path.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

KP: Writing – review & editing, Writing – original draft. CH: Writing – review & editing, Writing – original draft.

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