Beyond the Limits

New IPCC Working Group II Report Highlights How Gambling on Overshoot is Pushing the Planet Past a Point of No Return

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The latest report of the Intergovernmental Panel on Climate Change (IPCC) regarding Climate Change Impacts, Adaptation and Vulnerability (Working Group II Contribution to the IPCC Sixth Assessment Report) confirms that climate change is already causing severe and permanent loss and damage to human and natural systems, that exceeding 1.5°C warming–even temporarily–would result in further irreversible harm, and that strategies premised on the possibility of returning from such overshoot through the use of solar radiation modification (SRM) or technological carbon dioxide removal (CDR) court grave danger.

The IPCC finds that warming above 1.5°C would cause extensive human and ecological damage, including irreversible impacts from which recovery or adaptation would be difficult if not impossible. The Sixth Assessment Report explicitly considers the risks introduced not just by climate change, but by human responses to it. Working Group II recognizes that such measures can have significant adverse impacts, compounding climate damage, eroding resilience, and exacerbating vulnerabilities. This is critical because a growing majority of climate scenarios—and the climate plans and policies being adopted by nations and companies alike—rely heavily on technologies and strategies not expected to make meaningful contributions to climate mitigation for decades. Two categories of such strategies—large-scale CDR and deployment of SRM—have emerged as the primary approaches for returning to 1.5°C in the event of temperature overshoot. These strategies have gained increasing prominence in climate discourse, in national climate commitments, and in government funding decisions. These strategies may not only prove ineffective in reversing warming and impotent against its consequences, such as sea level rise, but also cause significant adverse impacts of their own, such as rainfall disruption, termination shock, water depletion, and erosion of human and ecological resilience.

In affirming that climate change is already causing, and will continue to cause, severe loss and damage, with disproportionate impacts on the most vulnerable human and ecological systems, the IPCC's findings support growing calls for financing commitments to address those mounting impacts. While the Working Group II (WGII) report does not directly discuss climate change mitigation measures, its findings fundamentally underscore the need for urgent action and near-term emissions reductions, including a halt to all oil and gas expansion and the phaseout of fossil fuels—not strategies that assume overshoot and hope for return to 1.5°C or below by relying on risky and unproven technologies. More than any preceding IPCC publication, this report emphasizes that social justice and equity are critical to such urgent action. The IPCC concludes that to

effectively reduce vulnerability and enhance adaptation, responses to the climate crisis must involve participatory decision-making processes and integrate considerations of justice and equity, Indigenous and local community knowledge, and the gender dimensions of climate change and climate actions.

The WG II report must be read against the background of the IPCC's prior reports, such as the Working Group I Contribution to the Sixth Assessment Report (2021) and the Special Report on Global Warming of 1.5°C (2018).[1] Collectively these volumes signal an unambiguous warning—dangerous climate change is already unfolding, its impacts will worsen, and failure to limit warming to 1.5°C risks irreparable consequences including grave threats to human rights.

The following analysis examines the WG II report in this context and with specific attention to its findings and significance for: overshoot scenarios, technologies and approaches common to those scenarios, and the implications of climate change and responses to it for human rights, Indigenous Peoples' rights, and social justice. It highlights three critical messages and themes that emerge from the WG II report:

1) Even temporary overshoot of 1.5°C is exceptionally dangerous and would result in adverse impacts irreversible on time-scales from centuries to millennia, or in the case of species extinctions, simply irreversible;
2) Approaches that deploy unproven technologies to reverse or mask overshoot may prove ineffective and risk further disaster;
3) Climate responses, including adaptation, must integrate social justice and equity and center Indigenous and local knowledge.

A recognition of these critical messages is important both to a proper understanding of the WGII report itself and to evaluating the mitigation options to be discussed in the forthcoming report of IPCC Working Group III.

Some of Working Group II's most sobering findings were diluted or deleted from the final Summary for Policymakers approved by State Parties. But Parties cannot negotiate away the science. The underlying chapters of the WGII report, including the technical summary, leave no doubt: surpassing 1.5°C will lead to irreparable harm, whether or not return to lower temperatures is even possible. Technologies like SRM and large-scale CDR that purport to enable such return may not only fail to deliver their claimed climate benefits, they also may trigger significant adverse impacts of their own. Policy choices that lock the world into overshooting 1.5°C and gambling on return, rather than immediately and drastically slashing emissions—including through rapid phaseout of fossil fuel production and use and a halt to deforestation—invite permanent loss and irreversible damage to humans and ecosystems around the world. In the face of this latest IPCC report, such choices are indefensible.

[1] IPCC, Working Group I Contribution to the IPCC's Sixth Assessment Report on The Physical Science Basis (2021) and component chapters [WGI], available at: https://www.ipcc.ch/report/ar6/wg1/; IPCC, Global Warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (2018) [SR 1.5], available at https://www.ipcc.ch/sr15/.

I. Exceeding 1.5°C will lead to irreversible impacts.

Overshoot poses grave dangers. The IPCC warns that exceeding 1.5°C warming will result in severe and irreversible adverse impacts, limiting the capacity for adaptation and severely threatening human rights. [WGII SPM.B.6, B.6.1 at SPM-20] The permanent impacts of overshoot on human and natural systems would include, for example, sea level rise, inundation of small islands and other coastal areas, loss of large ice masses, loss of certain marine and coastal ecosystems and associated livelihoods and food security, and loss of human lives due to heat. [WGII TS.C.2.5 at TS-26, TS.C.4.2 at TS-30, TS.C.13 & C.13.1 at TS-42; WGII Ch. 16, at 16-8][2] Coral reefs and kelp forests, which are at "high risk" this century, will suffer irreversible impacts beyond 1.5°C. [WGII TS.C.2.1 at TS-25] "Threats to species and ecosystems in oceans, coastal regions, and on land, particularly in biodiversity hotspots, present a global risk that will increase with every additional tenth of a degree of warming *(high confidence)*." [WGII TS.C.1 at TS-23]

Overshoot also increases the chances of triggering climate "tipping points" and self-reinforcing feedback loops, such as permafrost thawing and forest ecosystem collapse, which would greatly amplify warming and associated adverse impacts [WGII TS.C.13.2 at TS-43; *see also* WGI SPM C.3.2 at 27], and make "return to a given global warming level or below … more challenging." [WGII SPM.B.6.2 at SPM-20] Impacts on marine ecosystems of exceeding 1.5°C likewise contribute to negative feedback loops, reducing carbon storage and biological carbon pump functions: "In coastal areas beyond 1.5 C warming, blue carbon storage by mangroves, marshes, and seagrass habitats are increasingly threatened by rising sea levels and the intensity, duration and extent of marine heat waves, as well as adaptation options (including coastal development) *(high confidence)*. Changes in ocean stratification are projected to reduce nutrient supply and alter the magnitude and efficiency of the biological carbon pump *(medium confidence)*." [WGII TS.C.1.4 at TS-24-25]

Even if temperatures could be returned to below 1.5°C following overshoot—and there is no certainty that they can—some impacts and losses will be permanent. [WGII SPM B.6, B.6.1 at SPM-20; WGII TS.C.2.5 at TS-26, TS.C.12.1 at TS-42, TS C.13 & C.13.1 at TS-42] "Even if the Paris temperature goal is still reached by 2100," after warming exceeds 1.5°C or 2°C around mid-century, "this 'overshoot' entails severe risks and irreversible impacts to many natural and human systems (e.g. glacier melt, loss of coral reefs, loss of human lives due to heat) *(high confidence)*." [WGII TS.C.13.1 at TS-42] Regardless of whether temperatures could subsequently decline, some impacts that occur during overshoot cannot be undone but would continue for centuries to millennia, like sea level rise [WGI SPM D.1.6 at 30], threatening the existence of Small Island States and low-lying coastal areas, and the millions of people located in those regions.

[2] Unless otherwise noted, bracketed citations in this analysis refer to the final published versions of the IPCC's reports from the Working Group II Contribution to the IPCC Sixth Assessment Report on Climate Change Impacts, Adaptation and Vulnerability, abbreviated as follows: AR6 Working Group II Summary for Policymakers [WGII SPM]; Working Group II Technical Summary [WGII TS]; Working Group II Chapter 16: Key risks across sectors and regions [WGII Ch. 16], available at: https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/.

The modeled pathways presented in prior IPCC reports, including the Special Report on 1.5°C, must be read in this context. Pursuing any of the scenarios that assume overshoot of 1.5°C, even if only temporarily, entails the knowing and willful acceptance of these irreversible impacts. The imperative to avoid irreparable harm requires greater research and investment of resources in modeling and planning for deep greenhouse gas (GHG) reduction pathways that avoid overshoot altogether. [Cf. SR1.5, 2.4.2.1 at 131[3]] Of the 222 total modeled scenarios analyzed by the IPCC in the Special Report on 1.5°C, only nine were non-overshoot scenarios (i.e. scenarios that did not envision any overshoot). [See SR1.5, Ch. 2, Table 2.1 at 100] The common denominator in these scenarios is the rapid and virtually complete phaseout of fossil fuel combustion, and limited or no reliance on CDR aside from afforestation and reforestation. [SR1.5, Figure SPM.3b at 14-15, D.4.2 at 19, Ch.2 ES at 95-97] By contrast, overshoot scenarios rely heavily on large-scale carbon dioxide removal to bring global GHG concentrations and temperatures down decades to centuries after critical thresholds have been exceeded. **Compared to pathways that never exceed 1.5°C, those that involve even temporary overshoot, in which warming exceeds 1.5°C for several decades and then returns to or below 1.5°C, "imply severe risks and irreversible impacts in many ecosystems *(high confidence)."*** [WGII TS.C.2.5 at TS-26]

Moreover, overshoot thwarts adaptation. The warmer it gets, the harder it becomes to adapt to a warming world. Every fraction of a degree makes matters worse, and adaptation becomes more difficult if temperature rise exceeds 1.5°C. [WGII SPM.B.6.2 at SPM-20] "Risks to ecosystem integrity, functioning and resilience are projected to escalate with every tenth of a degree increase in global warming *(very high confidence)*. Beginning at 1.5°C warming, **natural adaptation faces hard limits**, driving high risks of biodiversity decline, mortality, species extinction and **loss of related livelihoods** *(high confidence)*." [WGII TS.C.1.2 at TS-24] "Above 1.5C global warming level, some ecosystem-based adaptation measures will lose their effectiveness in providing benefits to people as these ecosystems will reach hard adaptation limits *(high confidence)*." [WGII SPM.C.3.3 at SPM-27] "Climate resilient development pathways are progressively constrained by every increment of warming, in particular beyond 1.5C." [WGII SPM.D.1.1 at SPM-30]

Cumulative stressors contribute to irreversible damage. The IPCC warns of the complex, compound, and cascading risks resulting from climate hazards. "Irreversible changes will occur from the interaction of stressors and the occurrence of extreme events *(very high confidence)*, such as the expansion of arid systems or total loss of stony coral and sea ice communities." [WGII TS.C.2 at TS-25] "Adverse impacts from climate hazards and resulting risks are cascading across sectors and regions *(high confidence)*," and "[t]hese hazards and cascading risks also trigger tipping points in sensitive ecosystems and in significantly and rapidly changing social-ecological

[3] The IPCC acknowledged in its Special Report on 1.5°C that there are other analyses in the literature that "explore in greater detail some options for deep reductions in GHG emissions" including "analyses of transitions to up to 100% renewable energy by 2050 (Creutzig et al., 2017; Jacobson et al., 2017), which describe what is entailed for a renewable energy share largely from solar and wind (and electrification) that is above the range of 1.5°C pathways available in the database." SR 1.5 2.4.2.1 at 131-32. "[P]rovided their assumptions prove plausible," the report noted, these analyses could "expand the range of 1.5°C pathways." *Id.*

systems impacted by ice melt, permafrost thaw and changing hydrology in polar regions *(high confidence)*." [WGII SPM B.5.2 at SPM-19]

These impacts threaten human rights. During periods of overshoot, "[r]isks to human systems will increase, including those to infrastructure, low-lying coastal settlements, some ecosystem-based adaptation measures, and associated livelihoods *(high confidence)*, cultural and spiritual values *(medium confidence)*." [WGII SPM.B.6.1 at SPM-20] The irreversible human and ecological impacts of warming above 1.5°C include, inter alia, excess deaths from heat waves, glacier melt, and loss of coral reefs, small islands, and cultural heritage. [WGII TS.C.12.1, TS.C.13, & TS.C.13.1 at TS-42] "Unavoidable sea level rise will bring cascading and compounding impacts resulting in losses of coastal ecosystems and ecosystem services, groundwater salinisation, flooding and damages to coastal infrastructure that cascade into risks to livelihoods, settlements, health, well-being, food and water security, and cultural values in the near to long-term *(high confidence)*." [WGII SPM B.5.2 at SPM-19] Ecosystem degradation puts rights at risk: "The transformation of terrestrial and ocean/coastal ecosystems and loss of biodiversity, exacerbated by pollution, habitat fragmentation and land-use changes, will **threaten livelihoods and food security** *(high confidence).*" [WGII TS.C.1 at TS-23]

Current impacts of climate change are already eroding resilience and adaptation capacity, causing irreversible harm. "The rise in weather and climate extremes has led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt." [WGII SPM.B.1] The capacity for adaptation is already constrained for many places on Earth, with adaptation limits reached and at times even exceeded. [WG II TS.A.3 at TS-6; WGII SPM.C.3, C.3.3 at SPM-26-27] Overshooting 1.5°C only decreases adaptive capacity further. "Beginning at 1.5C, autonomous and evolutionary adaptation responses by terrestrial and aquatic species and ecosystems face hard limits, resulting in biodiversity decline, species extinction and loss of related livelihoods *(high confidence)*." [WGII Ch. 16, at 16-49] Human systems likewise face adaptation limits if warming exceeds 1.5°C. For example, "[a]bove 1.5C global warming level, limited freshwater resources pose potential hard limits for Small Islands and for regions dependent on glacier and snow-melt *(medium confidence)*." [WGII SPM.3.4 at SPM-27]

Loss and damage is occurring now and will occur, affecting vulnerable human and natural systems most, and often with irreversible consequences. "Widespread and severe loss and damage to human and natural systems are being driven by human-induced climate changes increasing the frequency and/or intensity and/or duration of extreme weather events… Vulnerable people and human systems, and climate sensitive species and ecosystems, are most at risk *(very high confidence)*." [WGII TS.B.2 at TS-13] Adaptation is not always possible, "does not prevent all losses and damages," [WGII SPM.C.3.5 at SPM-27] and "cannot prevent all risks to biodiversity and ecosystem services *(high confidence).*" [WGII TS.E.4.5 at TS-85] Given limits on adaptation capacity, "[t]he maintenance and recovery of natural and human systems will require the achievement of mitigation targets." [WGII TS.A.3 at TS-6]

Avoiding or mitigating irreversible impacts associated with overshoot requires urgent and substantial emissions cuts. "Deep cuts in emissions will be necessary to minimise irreversible

loss and damage *(high confidence)*." [WGII TS.E.4.5 at TS-85] "Without urgent and ambitious emissions reductions, more terrestrial, marine and freshwater species and ecosystems face conditions that approach or exceed the limits of their historical experience *(very high confidence)*." [WGII TS.C.1 at TS-23] As illustrated in past IPCC reports, such rapid reductions require accelerating the transition away from fossil fuels, through rapid and virtually complete phase out of the use of oil, gas, and coal. At present rates of emissions, warming is likely to surpass 1.5°C around 2035. [WGII TS Box TS.2 at TS-8] Now is the time to act to avoid the irreversible harm that would ensue from such a temperature rise.

II. Strategies that assume overshoot and presume the ability to return to 1.5°C or below through the use of risky and unproven technologies, like Solar Radiation Modification (SRM) and Carbon Dioxide Removal (CDR), court disaster.

If irreversible losses are to be avoided, relying on the future deployment of unproven and potentially dangerous approaches like CDR, SRM, or other geoengineering technologies is not an option. The report of IPCC Working Group I released in August 2021 recognized that "[a]ffordable and environmentally and socially acceptable CDR options at scale well before 2050 are an important element of 1.5°C-consistent pathways especially in overshoot scenarios," but simultaneously acknowledged that "two extensive reviews (Lawrence et al., 2018; Nemet et al., 2018) conclude that it is implausible that any CDR technique can be implemented at scale that is needed by 2050." [WGI Ch. 4, 4.6.3.2 at 4-80] The Working Group I and Working Group II reports recognize that responses to climate change, such as CDR and SRM, not only may fail to meet their climate objectives, but also may introduce significant risks and unintended consequences for human and natural systems, exacerbating the impacts of warming and undermining adaptation. [WGII SPM B.5.4, B.5.5 at SPM-19-20; WGII TS.C.11.10 at TS-40] These findings reinforce earlier warnings from the IPCC about the risk entailed in pathways premised on technological removal measures or so-called "negative emissions." [SR1.5, Ch. 2, ES, at 95]

The climate effect of carbon dioxide removal at scale remains unknown and is not equivalent to the climate effect of avoiding the same quantity of carbon dioxide emissions. The unproven nature of the technologies undercuts reliance on CDR to respond to temperature rise. Scenarios that foresee even a "temporary overshoot"—and the permanent damages it entails—followed by a "course correction" effort to return to 1.5°C assume "large-scale deployment" of CDR measures**.** But, as the IPCC cautioned in its Special Report on Global Warming of 1.5°C, such measures "are uncertain and entail clear risks." [SR1.5, TS, at 33; SR1.5, Ch. 2 ES, at 95] The Summary for Policymakers of that Special Report clearly states that "CDR deployment of several hundreds of GtCO2 is subject to multiple feasibility and sustainability constraints *(high confidence)*." [SR1.5 SPM C.3, at 17]

"Limits to our understanding of how the carbon cycle responds to net negative emissions increase the uncertainty about the effectiveness of CDR to decline temperatures after a peak. Limitations

on the speed, scale and societal acceptability of CDR deployment also limit the conceivable extent of temperature overshoot." [SR1.5, Ch. 2, ES, at 34] As the IPCC found in its Working Group I report released last year, the asymmetry between how the atmosphere may respond on a century-scale to a CO2 emission versus a removal complicates the ability to predict whether and how CDR may operate to alter conditions after overshoot. The implication of that disconnect is that "an extra amount of CDR is required to compensate for a positive emission of a given magnitude to attain the same change in atmospheric CO2." [WGI TS 3.3.2 at TS-65; WGI Ch. 5, ES at 5-9 & 5.6.2.1.4, Figure 5.35 at 5-106] This risk of rebound after removal and the impermanence of removals undercuts the projected role of CDR in climate pathways. [WG I, Ch. 5, 5.6.2.1 at 5-102] **Noting that CDR may be ineffective in reversing temperature rise following overshoot and that it is unproven at scale, the IPCC SR 1.5 report found that it is risky to rely on such technology to limit warming to 1.5°C, rather than energy efficiency and low-demand strategies that drastically reduce GHGs in the near term.** [SR 1.5 Ch. 2, ES] The key to achieving faster reduction of net CO2 emissions is pursuing measures that result in less CO2 being produced and emitted. [SR 1.5 Ch. 2, ES]

On top of the uncertainties surrounding the effectiveness of CDR at reducing temperature rise, Working Group II highlights the risk of severe unintended consequences. Proposed methods of carbon dioxide removal such as afforestation or bioenergy with carbon capture and storage (BECCS) could compromise ecosystem health and food and water security, for example. "Risks arise from some responses that are intended to reduce the risks of climate change, including risks from maladaptation and adverse side effects of some emission reduction and carbon dioxide removal measures *(high confidence)*. Deployment of afforestation of naturally unforested land, or poorly implemented bioenergy, with or without carbon capture and storage, can compound climate-related risks to biodiversity, water and food security, and livelihoods, especially if implemented at large scales, especially in regions with insecure land tenure *(high confidence)*." [WGII SPM B.5.4 at SPM-19] The wide-ranging side effects of CDR on biogeochemical cycles and climate could weaken its carbon sequestration and cooling potential, and "deployment of CDR, particularly on land, can also affect water quality and quantity, food production and biodiversity *(high confidence)*." [WGI TS 3.3.2 at TS-65; *see also* WGI SPM D.1.4 at 29]

The Working Group II report also sounds the alarm about the risks of deploying SRM as a response to the climate emergency–both because it has no impact on the emissions causing warming, and because there is high confidence that it would endanger human and natural systems. SRM refers to approaches and associated technologies intended to mask the warming impact of GHG emissions by reducing the amount of incoming solar radiation reaching the earth's surface. As the Working Group II Summary for Policymakers notes: "Solar radiation modification approaches, if they were to be implemented, introduce a widespread range of new risks to people and ecosystems, which are not well understood *(high confidence)*. Solar radiation modification approaches have potential to offset warming and ameliorate some climate hazards, but substantial residual climate change or overcompensating change would occur at regional scales and seasonal timescales *(high confidence)*. Large uncertainties and knowledge gaps are associated with the potential of solar radiation modification approaches to reduce climate change risks. Solar radiation modification would not stop atmospheric CO2 concentrations from

increasing or reduce resulting ocean acidification under continued anthropogenic emissions *(high confidence)*." [WGII SPM B.5.5 at SPM-20] Fundamentally, SRM fails to address the underlying driver of climate change–GHGs–and therefore is no substitute for measures that prevent emissions or remove CO2 from the atmosphere. In contrast to climate mitigation activities, SRM "introduces a 'mask' to the climate change problem by altering the Earth's radiation budget, rather than attempting to address the root cause of the problem, which is the increase in GHGs in the atmosphere." [WGII Ch. 16, Cross-Working Group Box SRM: Solar Radiation Modification, at 16-83] Just as SRM does nothing to stop the accumulation of atmospheric CO2, it also has no ability to "reduce resulting ocean acidification under continued anthropogenic emissions *(high confidence)*." [WGII TS.C.13.4 at TS-43]

Data gaps remain regarding purported climate impacts of SRM and insufficient attention has been paid to the severe human and ecological risks posed by the technology. Even if it were effective in alleviating warming, SRM "would not maintain the climate in a present-day state nor return the climate to a pre-industrial state…" [WGII Ch. 16 at 16-85] The IPCC notes that "large uncertainties still exist for climate processes associated with SRM options," and that "compared with climate hazards, many fewer studies have examined SRM risks" including on human health and wellbeing. [WG II Ch 16 at 16-85-86]

Beyond concerns about the inefficacy of SRM, the IPCC's latest findings reinforce its prior observations about the collateral damage that SRM could cause. Not only does SRM merely mask some of the symptoms of climate change rather than treating the disease, it also could trigger devastating side effects. Likely effects, including ozone depletion and altered regional rainfall pattern, pose further risks to human health and ecosystems [WGI Ch. 4; WGII Ch. 16, Cross-Working Group Box SRM: Solar Radiation Modification, at 16-86]. SRM "could generate substantial impacts on large-scale biogeochemical cycles" and its "risks and potential for risk reduction for marine and terrestrial ecosystems and biodiversity remain largely unknown." [WGII Ch. 16, Cross-Working Group Box SRM: Solar Radiation Modification, at 16-87-88]. Further, "SRM may also introduce novel risks for international collaboration and peace." [WGII Ch. 16, Cross-Working Group Box SRM: Solar Radiation Modification, at 16-87; *see also* WGII Ch. 16 at 16-6]

Perhaps most concerningly, once deployed, SRM cannot be stopped without triggering even more rapid warming and negative impacts, a risk referred to as "termination shock." The IPCC clearly warns of this danger in its latest report: "**Large negative impacts are projected** from rapid warming **for a sudden and sustained termination of SRM** in a high-CO2 scenario." [TS.C.13.4 at TS-43] Such shock would involve abrupt climate and water cycle changes. [WG I, Ch. 4, 4.6.3.3 at 4-85]

The studies presented by Working Group II further erode scientific and political defensibility of planning for overshoot and purported technological return. In reiterating and amplifying its previous findings about the foreseeable risks posed by reliance on CDR and SRM, the IPCC elucidates the recklessness of such strategies. More than any previous report, Working Group II makes clear that effective, reliable, and equitable responses to the climate emergency must reject risky and unproven technologies and instead build community and ecological resilience with a grounding in justice and respect for Indigenous knowledge and human rights.

III. Climate responses, including adaptation, must integrate social justice and equity, and center Indigenous and local knowledge

For the first time, the IPCC's Working Group II report includes a pronounced focus on the importance of addressing social inequities in climate vulnerabilities and responses. The IPCC affirms that centering climate justice, and incorporating Indigenous rights and knowledge, in climate responses is both imperative and effective. [WGII SPM Introduction, at SPM-5; WGII TS.A, at TS-3, TS-5] The Summary for Policymakers acknowledges that climate justice "links development and human rights to achieve a rights-based approach to addressing climate change." [WGII SPM n.14 at SPM-5] "Gender-sensitive, equity and justice-based adaptation approaches, integration of Indigenous knowledge systems within legal frameworks, and promotion of Indigenous land tenure rights," the report finds, "reduce vulnerability and increase resilience *(high confidence)*." [WGII TS.E.2.4 at TS-81]

Climate breakdown magnifies existing social inequities. The IPCC recognizes that vulnerability to climate change is driven by "patterns of intersecting socio-economic development, unsustainable ocean and land use, inequity, marginalization, historical and ongoing patterns of inequity such as colonialism, and governance *(high confidence)*." [WGII SPM B.2 at SPM-11] Those with the fewest resources (impoverished peoples) and historically marginalized and oppressed groups are especially vulnerable to climate damages [WGII SPM.B.2.4 at SPM-12], including the irreversible harm caused by overshoot. This vicious circle exacerbates climate injustice–the concept that the people who contributed least to the problem suffer its worst consequences.

Adaptation is especially limited for the most vulnerable groups, who are disproportionately exposed to climate impacts. The IPCC recognizes that to avoid exacerbating existing inequalities and vulnerabilities (maladaptation), climate responses must center justice**.** [WGII TS.D.3.4 at TS-59; WGII SPM.C.5.6 at SPM-30, D.2 at SPM-32] Climate response technologies and approaches that place disproportionate risks on vulnerable or marginalized populations—who are least able to cope with heightened risks due to limited resources, mobility, and support structures—are deeply incompatible with such a justice-centered approach.

The IPCC emphasizes the need to center justice from the start in climate action and ensure participatory planning and decision-making involving vulnerable communities throughout design and implementation. Such inclusive approaches, the report notes, can make for more effective and sustainable adaptation that helps alleviate social inequities, and ensure climate-resilient development. [WGII SPM C.5.6 at SPM-30, D.2, D.2.2 at SPM-32] "Embedding effective and equitable adaptation and mitigation in development planning can reduce vulnerability, conserve and restore ecosystems, and enable climate resilient development.... Integrated and inclusive system-oriented solutions based on equity and social and climate justice reduce risks and enable climate resilient development *(high confidence)*." [WGII SPM.D.1.3 at SPM-31] The report expressly finds that informed consent together with other "[r]ights-based approaches to

adaptation, participatory methodologies and inclusion of local and Indigenous knowledge," can help avoid pitfalls in adaptation action. [WGII TS.D.3.2 at TS-59] This finding assumes particular importance in light of the disproportionate risks of SRM and CDR technologies for Indigenous Peoples and communities in the Global South.

Rights-based approaches advance both the legitimacy and efficacy of adaptation measures. The WGII Summary for Policymakers recognizes that "[s]tructural vulnerabilities to climate change can be reduced" through interventions "that address inequities based on gender, ethnicity, disability, age, location and income (very high confidence)," including "rights-based approaches that focus on capacity building, meaningful participation of the most vulnerable groups and their access to key resources, including financing, to reduce risk and adapt (high confidence)." [WGII, SPM D.2.1 at SPM-32] Principles of justice and equity in decision-making are essential for adaptation, and can reduce the risk of maladaptation: "Adaptation actions consistent with climate justice address near and long-term risks through decision-making processes that attend to moral and legal principles of fairness, equity and responsibility including to historically marginalized communities and that distribute benefits, burdens and risks equitably (high confidence). Concepts of justice, consent and rights-based decision making, together with societal measures of well-being, are increasingly used to legitimate adaptation actions and evaluate the impacts on individuals and ecosystems, diverse communities and across generations (medium confidence)." [WGII TS.D.9 at TS-72]

Indigenous knowledge must be recognized and can strengthen adaptation and resilience. The Summary for Policymakers acknowledges that involving local and Indigenous knowledge increases the prospects for climate-resilient development [WGII SPM D.5.2 at SPM-35], citing evidence that shows such involvement makes climate-resilient development processes "more effective and sustainable because they are locally appropriate and lead to more legitimate, relevant and effective actions *(high confidence)*." [WGII SPM D.2.1 at SPM-32] Specifically, Working Group II observes that "Indigenous Peoples have been faced with adaptation challenges for centuries and have developed strategies for resilience in changing environments that can enrich and strengthen other adaptation efforts *(high confidence).*" [WGII TS.E.3.4 at TS-83] Accordingly, IPCC concludes that *"***Supporting indigenous self-determination, recognizing Indigenous Peoples' rights,** and **supporting Indigenous knowledge-based adaptation can accelerate effective robust climate resilient development pathways** *(very high confidence).*" [Id.] IPCC further recognizes that "Indigenous knowledge underpins successful understanding of, responses to and governance of climate change risks *(high confidence).* For example, Indigenous knowledge contains resource-use practices and ecosystem stewardship strategies that conserve and enhance both wild and domestic biodiversity, resulting in terrestrial and aquatic ecosystems and species that are often less degraded in Indigenous managed lands [than] in other lands *(medium confidence).*" [WGII TS.E.3.4 at TS-83] Thus, the report concludes that: "**Valuing Indigenous knowledge systems is a key component of climate justice** *(high confidence)*." [Id.]

IV. Conclusion

The WGII report's message is clear: Climate impacts are already harming people and ecosystems, with the most vulnerable communities disproportionately exposed to the most severe effects; both mitigation efforts and adaptive responses must center social justice, build ecological resilience, and respect Indigenous rights and knowledge. Adaptation, however, has its limits and becomes much more difficult, if not impossible, when temperature rise exceeds 1.5°C. Overshooting the 1.5 mark, even temporarily, results in irreversible damage to many ecosystems and severely threatens human lives and human rights. Pathways that assume overshoot and the ability to return, relying on large-scale, unproven carbon removal technologies or high-risk geoengineering gambles like SRM, could unleash irreparable harm. Avoiding and minimizing such permanent impacts requires immediate, deep emissions cuts, including through rapid phaseout of fossil fuel production and combustion. Near-term action is crucial. As the IPCC warns, "[a]ny 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 *(very high confidence)*." [WGII SPM D.5.3 at SPM-35]