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THE PONTIFICAL ACADEMY OF SCIENCES

THE PONTIFICAL ACADEMY OF SOCIAL SCIENCES

Edited by
Marcelo Suárez-Orozco
Veerabhadran Ramanathan

From Climate Crisis to Climate Resilience

A Vatican 3-day Summit for bending the curve and bouncing forward to climate resilience

Proceedings of a Joint Summit
Casina Pio IV, Vatican City, 15-17 May 2024

CLIMATE RESILIENCE SUMMITS

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Eight years have passed since I published the Encyclical Letter *Laudato Si'*, when I wanted to share with all of you, my brothers and sisters of our suffering planet, my heartfelt concerns about the care of our common home. Yet, with the passage of time, I have realized that our responses have not been adequate, while the world in which we live is collapsing and may be nearing the breaking point. In addition to this possibility, it is indubitable that the impact of climate change will increasingly prejudice the lives and families of many persons. We will feel its effects in the areas of healthcare, sources of employment, access to resources, housing, forced migrations, etc.

This is a global social issue and one intimately related to the dignity of human life. The Bishops of the United States have expressed very well this social meaning of our concern about climate change, which goes beyond a merely ecological approach, because "our care for one another and our care for the earth are intimately bound together. Climate change is one of the principal challenges facing society and the global community. The effects of climate change are borne by the most vulnerable people, whether at home or around the world". In a few words, the Bishops assembled for the Synod for Amazonia said the same thing: "Attacks on nature have consequences for people's lives". And to express bluntly that this is no longer a secondary or ideological question, but a drama that harms us all, the African Bishops stated that climate change makes manifest "a tragic and striking example of structural sin".

The Holy Father Pope Francis, *Laudate Deum*

PIVS · IIII · PONTIFEX · OPTIMVS · MAXIMVS

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Introduction

In an unprecedented gathering, Mayors and Governors from across the globe convened at the Joint Summit to share experience-near, hands-on approaches and practical experiences in protecting citizens, cities, and regions from the escalating impacts of climate change. Leaders from highly vulnerable regions joined their counterparts from various towns and states to implement exemplary best practices. They urgently discussed strategies to respond to climate shocks and develop resilient infrastructure to prevent future climate catastrophes. The Summit was a platform for exchanging valuable insights and best practices. Below are some key themes from their rich discussions, all available on the Pontifical Academies' YouTube channel.[1]

1. Leaders worldwide agreed that climate change is already impacting cities and states through extreme weather events, flooding, droughts, heatwaves, and wildfires, and emphasizing the urgency of the situation.
2. Local and state governments are on the frontlines of climate impacts and play a critical role in implementing resilience, adaptation, and mitigation strategies.
3. Many leaders highlighted the importance of aligning government spending, policies, and operations with climate goals across all departments and functions.
4. Governors have created new offices or positions, such as Massachusetts' Office of Climate Innovation and Resilience, which adopts an all-government approach to climate action.
5. Leaders emphasized the need for a comprehensive approach that integrates mitigation, adaptation, and societal transformation.
6. Many are implementing nature-based solutions, green infrastructure, and urban redesign concepts like "15-minute cities".
7. Equity and environmental justice were key themes, with leaders focusing on protecting vulnerable communities.

[1] See www.youtube.com/c/CasinaPioIV

8. Public engagement, education, and empowering citizens were crucial for most leaders.
9. Partnerships across government, academia, business, and civil society were highlighted as essential.
10. Several leaders discussed concrete examples of transitioning to clean energy, electrifying transportation, and improving building energy efficiency.
11. Water management was a significant focus for many cities dealing with floods and droughts.
12. Leaders emphasized the economic opportunities in climate action, such as green jobs.
13. Many called for more resources and authority for local governments to address climate change.
14. International cooperation between cities and states was mentioned as important for sharing best practices.
15. Several leaders highlighted youth engagement and intergenerational equity.

Address of His Holiness Pope Francis to Participants in the Summit of the Pontifical Academy of Sciences and the Pontifical Academy of Social Sciences "From Climate Crisis to Climate Resilience"

Your Eminence,
Your Excellency,
Ladies and Gentlemen,

I am pleased to welcome you, the members of the Pontifical Academies of Science and the Social Sciences. I greet the President and all the guests, mayors and governors coming from various parts of the world for this Summit on the theme, *From Climate Crisis to Climate Resilience*.

The data on climate change are growing worse with each passing year, and so it is urgent to act to protect people and nature. I commend the two Academies for their leadership in this effort and for their work in producing a universal document on resilience. The poorer peoples, who have very little to do with the pollution of the environment, need to receive much greater support and protection. They are victims.

"The destruction of the environment is an offense against God, a sin that is not only personal but also structural, one that greatly endangers all human beings, especially the most vulnerable in our midst, and threatens to unleash a conflict between generations" (*Address to COP28*, Dubai, 2 December 2023). This is the question: Are we working for a culture of life or for a culture of death? You have answered that we must heed the cry of the earth, hear the plea of the poor, and be attentive to the aspirations of the young and the dreams of children! We have a grave responsibility to ensure that their future is not denied them. You have declared your resolve to choose a sustainable human development. I very much appreciate this decision, since climate change is "a global social issue and one intimately related to the dignity of human life" (*Laudate Deum*, 3).

At present, we find ourselves faced with systemic challenges that are distinct yet interconnected: climate change, the loss of biodiversity, environ-

mental decay, global disparities, lack of food security and threats to the dignity of the peoples affected by them. Unless these issues are faced urgently and collectively, they represent existential threats for our human family, for other living beings and for all ecosystems. One thing, however, should be clear. The world's poor suffer more, even though they contribute less to these problems. The wealthier nations, around 1 billion people, produce more than half the heat trapping pollutants. On the contrary, the 3 billion poorer people contribute less than 10%, yet they suffer 75% of the resulting damage. The 46 less developed countries – mostly African – represent only 1% of global CO_2 emissions, whereas the nations of the G20 are responsible for 80% of those emissions.

Your research has indicated the tragic fact that women and children bear a disproportionate burden in this regard. Often women do not enjoy the same access to resources as men; furthermore, keeping house and caring for children can restrain them from migrating in the face of disasters. Yet women are not simply victims of climate change; they are also a powerful force for resilience and adaptation. As for children, almost 1 billion of them live in countries that face an extremely high risk of climate-related disasters. Their growth years make them all the more susceptible to the effects, both physical and psychological, of climate change.

The refusal to act quickly to protect the most vulnerable who are exposed to climate change caused by human activity is a serious offence and a grave violation of human rights, as was recently stated by the European Court of Human Rights. An orderly progress is being held back by the greedy pursuit of short-term gains by polluting industries and by the spread of disinformation, which generates confusion and obstructs collective efforts for a change in course.

Brothers and sisters, the road ahead is uphill and not without danger. The data emerging from this Summit have shown that the effects of climate change loom over every aspect of our lives, threatening water, air, food and energy systems. Likewise alarming are the threats to public health and welfare. We are witnessing the dissolution of communities and the forced dispersion of families. Atmospheric pollution takes millions of lives prematurely each year. Over 3½ billion people live in areas highly susceptible to the devastation caused by climate change, and this drives them to forced migration. In recent years, we have seen how many of our brothers and sisters have lost their lives in desperate journeys, and the forecasts for the future are troubling. Defending the dignity and rights of climate migrants

entails defending the sacredness of each human life and demanding respect for the divine command to *care for and defend our common home*.

In light of this planetary crisis, I add my voice to your heartfelt appeal.

First, there is a need to adopt a *universal approach* and a *rapid and resolute activity* capable of effecting changes and political decisions. Second, there is a need to i*nvert the global warming curve* by efforts to decrease by a half the rate of warming within the brief span of a quarter-century. Likewise, there is a need to aim for global de-carbonization and the elimination of dependence on fossil fuels. Third, the great quantities of carbon dioxide in the atmosphere must be eliminated through an environmental management programme that will span several generations. This is a lengthy yet farsighted effort, one we must all undertake together. In this effort, nature will prove to be our faithful ally, by exercising its own regenerative powers.

Let us safeguard our natural resources: the Amazon basin and that of the Congo, the peat bogs and the mangroves, the oceans, the coral reefs, the farmlands and the glacial icecaps, given the contribution they make to the reduction of global carbon emissions. This holistic approach can combat climate change, while also confronting the double crisis of the loss of biodiversity and inequality by cultivating the ecosystems that sustain life.

The climate crisis requires a synergy of cooperation and global solidarity. This effort must be symphonic, carried out harmoniously by everyone together. Thanks to emissions reduction, education in lifestyles, innovative financing and the use of proven nature-based solutions, we will reinforce resilience, and resilience to drought in particular.

Lastly, there is a need to develop a new financial architecture capable of responding to the demands of the global South and of the island states that have been seriously affected by climate catastrophes. The restructuring and reduction of debt, together with the development of a new global financial Charter by 2025, acknowledging a sort of ecological debt – we must work on this term: ecological debt – can be of great assistance in mitigating climate changes.

Dear friends, I thank you for your efforts and I encourage you to continue to work together in effecting a transition from the current climate crisis to climate resilience in equality and social justice. There is a need to act with urgency – with urgency! – compassion and determination, since the stakes could not be higher. Go forward and may God bless you. I assure you of my prayers and I ask you, please to pray for me. Thank you!

SESSION I – SETTING THE STAGE

Climate Crisis: UN IPCC Perspective

Hoesung Lee
IPCC Chair 2023

Global warming will continue, reaching 1.5°C in the first half of the 2030s and rising beyond 1.5°C, despite mitigation efforts today. The level of the temperature exceedance over 1.5°C will be in the range of 0.1°-0.2°C for several decades before the temperature declines to 1.5°C by the end of 2100, if global emissions peak in 2025 and reach net zero by 2050. This pathway would allow the world to stay within a carbon budget for limiting warming to 1.5°C by the end of this century. This pathway calls for prioritizing adaptation toward 1.5°C warming and enabling the capacity for negative emissions while pursuing rapid reductions in global emissions. Immediate reductions are necessary to reduce the temperature overshoot.

Impacts of Climate Change

The impact of current warming – the global average temperature increase of 1.1°C over the preindustrial period – is already severe and widespread. Weather and climate extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones are affecting every region. Approximately 3.3 to 3.6 billion people live in highly vulnerable areas to climate change. Between 2010 and 2020, human mortality from floods, droughts, and storms was 15 times higher in highly vulnerable regions, compared to regions with very low vulnerability. The extreme events worsened food and water insecurity in many locations in Africa, Asia, Central and South America, Small Islands and the Arctic, especially for small-scale food producers, low-income households and Indigenous Peoples. Crop yields in mid and low-latitude regions declined and agricultural productivity over the past 50 years slowed down due to climate change.

Ocean warming and ocean acidification have adversely affected food production from shellfish aquaculture and fisheries, resulting in an overall decrease in maximum catch potential. Many changes in the ocean, ice sheets and global sea level are irreversible. Sea level rise was already accelerating.[1] The average rate of sea level rise was 1.3 mm per year between 1901 and

[1] IPCC Climate Change 2023: Synthesis Report, Summary for Policymakers, A.2.1.

1971, increasing to 1.9 mm per year in the ensuing 35 years, and then almost doubling to 3.7 mm per year in the latest 12-year period ending in 2018. Ocean acidification, ocean deoxygenation and global mean sea level will continue to increase in the 21st century.

Animal and human diseases, including zoonoses, are emerging in new areas. Approximately half of the species assessed globally have shifted polewards or, on land, to higher elevations. Species' capacities for adapting to climate change through adjustments in geographic placement and shifting seasonal timing are not sufficient to cope with accelerating climate change. The impacts on some ecosystems in the mountains and Arctic of glaciers retreating and permafrost thaw are approaching irreversibility.

Global warming of 1.5°C will multiply risks to ecosystems and human systems. 3-14% of terrestrial ecosystems assessed will likely face a very high risk of extinction at a 1.5°C warming. Coral reefs are projected to decline by a further 70-90% at 1.5°C of global warming. Arctic ecosystems, dryland regions, small island development states, and Least Developed Countries face disproportionately higher risk. Many low-elevation and small glaciers around the world would lose most of their mass or disappear within decades to centuries at global warming of 1.5°C.

With 2°C warming, agricultural and ecological droughts will become more frequent and/or severe; the intensity of tropical cyclones will increase; and heat waves and drought become more frequent, occurring concurrently at multiple locations. The food security and diet quality will deteriorate particularly in sub-Saharan Africa, South Asia, and Central America. At sustained warming levels between 2°C and 3°C, the Greenland and West Antarctic ice sheets will be lost almost completely and irreversibly.

Global warming of 3°C will cause widespread systemic impacts, irreversible change, and many additional adaptation limits. The extinction risk for endemic species in biodiversity hotspots is projected to increase at least tenfold if warming rises from 1.5°C to 3°C. Flood damages are projected to be higher by 1.4-2 times at 2°C and 2.5-3.9 times at 3°C, compared to 1.5°C global warming with current level of adaptation.

Global warming of 4°C and above is projected to lead to far-reaching impacts on natural and human systems. The global burned area is projected to increase by 50-70% and the fire frequency by ~30% compared to today. About 4 billion people are projected to experience water scarcity. Every increment of global warming will increase risks from compound and cascading impacts through the food, energy, and water sectors as impacts from

weather and climate extremes propagate through supply chains, markets, and natural resource flows. Beyond 4°C of warming, projected impacts on natural systems include local extinction of ~50% of tropical marine species and biome shifts across 35% of global land area.

Risks associated with tipping points for sea level rise, continued glacier melt, permafrost carbon loss, ice sheet instability, or ecosystem loss from tropical forests become high risk between 1.5°C-2.5°C and very high risk between 2.5°C-4°C. The Atlantic Meridional Overturning Circulation is very likely to weaken over this century for all considered scenarios, however, an abrupt collapse is not expected in this century.

Effectiveness of Adaptation

The current state of adaptation is no match for the severe, widespread adverse impacts of global warming. Most observed adaptation is fragmented, small in scale, incremental, and sector specific, prioritizing immediate and near-term climate risk reduction, e.g., through hard flood protection, which neglects the need for integrated adaptation strategy capable of managing complex risks from the food-energy-water-health nexus. Ecosystem-based adaptation can generate synergies for food security, health and well-being, livelihoods and biodiversity, sustainability, and ecosystem services. But its effectiveness declines as warming continues reaching 1.5.

Urban areas urgently need integrated adaptations to counter the rapidly escalating impacts of climate change. Urban areas are now home to 50% of the world's population and account for 70% of global CO_2 emissions. Between 2015 and 2020, urban populations globally grew by more than 397 million people, with more than 90% of this growth taking place in less developed regions where adaptive capacity is limited. By 2050 an additional 2.5 billion people are projected to be living in urban areas with up to 90% of this increase concentrated in the regions of Asia and Africa. And coastal and low-lying urban areas will face additional risks of limits to adaptation to sea level rise and storm surges due to continued rapid global warming. The high density of population and infrastructure in urban areas should work as leverage for integrated adaptation strategy to address the compounding risks from the food-energy-water-health nexus.

The effectiveness of adaptation will decrease with increasing warming. This is because increased warming reduces adaptive capacity of natural and human systems. Already at current warming, natural – autonomous and evolutionary – adaptation responses by terrestrial and aquatic ecosystems

will increasingly face hard limits. At 1.5°C, humans face soft and hard limits to adaptation regarding the risks of heat stress and heat mortality. Measures such as disaster risk management, early warning systems, climate services, and risk spreading and sharing provide wide-ranging benefits to adaptation actions when combined with financial, institutional, and policy support and will lead to softening the soft limits to adaptations. Above 1.5°C, limits to adaptation spread to ecosystem-based adaptation, freshwater resources management, and measures to secure staple crops.

Currently, 60% of all adaptation measures are water-related adaptation options and their effectiveness declines with increasing warming. Most adaptation measures in agriculture – improving cultivars and agronomic practices, and changes in cropping patterns and crop systems – will become less effective from 2°C to higher levels of warming. Adaptation options for agroforestry and forestry lose their effectiveness at 3°C.

Emissions and Mitigation

The average annual GHG emissions in the last decade were higher than in any previous decade. However, the average annual GHG emissions growth between 2010 and 2019 (1.3% per year) was lower than that during the previous decade (2.1% per year) with the energy supply sector's emissions growth rate declining from 2.3% to 1.0% per year; the industry sector, from 3.4% to 1.4% per year; and the transport sector remaining roughly constant at about 2% per year. The carbon intensity of primary energy declined by 0.3% per year between 2010-2019.[2] Energy efficiency – GDP per unit of primary energy – increased by 2% per year between 2010-2019. Land was a source of net negative emissions at an annual rate of -6.6 (±4.6) $GtCO_2$ during 2010-2019.

Cumulative CO_2 emissions from 1850 to 2019 were 2400 ±240 $GtCO_2$. Of these, 42% occurred in the last 30 years between 1990 and 2019. The estimate of the total carbon budget for a 50% probability of limiting warming to 1.5 C is 2900 $GtCO_2$.[3] Four-fifths of this was already used, leaving 500 $GtCO_2$ as the remaining carbon budget from 2020.

[2] IPCC Climate Change 2022: Mitigation of Climate Change, Summary for Policymakers, B2.4.

[3] For every 1000 GtCO2 emitted by human activity, global mean temperature rises by 0.27°C-0.63°C (best estimate of 0.45°C). This relationship implies that there is a finite carbon budget that cannot be exceeded in order to limit warming to any given level.

Average per capita net anthropogenic GHG emissions in 2019 ranged from 2.6 tCO_2-eq (Southern Asia) to 19 tCO_2-eq (Europe) across ten regions with a global average of 6.9 tCO_2-eq. In seven regions, the dominant source of GHG emissions is CO_2 emissions from energy and industry. In three regions (Latin America and Caribbean, Southeast Asia and Pacific, and Africa), CO_2 emissions from land use, land use change and forestry exceed fossil fuel-generated emissions. The 10% of households with the highest per capita emissions contribute 34-45% of global consumption-based household GHG emissions, while the middle 40% contribute 40-53%, and the bottom 50% contribute 13-15%. The share of emissions from urban areas increased from 62% to 67-72% between 2015 and 2020. Over 70% of emissions are from non-OECD countries.

By 2020, 56 countries had laws on reducing GHG emissions covering 53% of global emissions. By 2020, over 20% of global GHG emissions were covered by carbon taxes or emissions trading systems, although coverage and prices have been insufficient to achieve deep reductions. Equity and distributional impacts of carbon pricing instruments are barriers to carbon pricing. Economic and regulatory instruments resulted in avoided emissions of at least 1.8 $GtCO_2$-eq per year.

At least 18 countries have sustained emission reductions – both production- and consumption-based CO_2 emissions – for longer than 10 years since 2005. Energy supply decarbonization, energy efficiency gains, and energy demand reduction contributed to emissions reductions.

From 2010 to 2019, the unit costs of renewable energy and lithium-ion batteries declined at unprecedented rates with rapid deployment. Electricity from PV and the wind is now cheaper than fossil fuel-powered electricity in many regions, electric vehicles are increasingly competitive with internal combustion engines, and large-scale battery storage on electricity grids is increasingly viable. The mix of policy instruments including public R&D, funding for demonstration and pilot projects, and deployment subsidies enabled the decarbonization of electricity and passenger cars.

However, the industrial sector's decarbonization faces technological challenges. For almost all basic materials – steel, cement, and chemicals – low- to zero-GHG intensity production processes are not yet market-ready.

More than 100 countries have pledged net zero CO_2 emissions, covering more than two-thirds of global GHG emissions, but policies are insufficient to deliver on them. The continuation of policies implemented by the end of 2020, i.e., the absence of additional policies, will lead to global warming

of 3.2°C by 2100. The best estimates of warming for 2081-2100 relative to 1850-1900 vary from 1.4°C in the very low GHG emissions scenario to 2.7°C in the intermediate GHG emissions scenario and 4.4°C in the very high GHG emissions scenario. The larger the overshoot, the more net negative CO_2 emissions needed to return to a given warming level. For every tenth of a degree of overshoot, the required net negative emissions would be 220 $GtCO_2$.[4]

Overshooting 1.5°C will result in irreversible adverse impacts on ecosystems, such as polar, mountain, and coastal ecosystems. Overshoot increases the risks that could increase GHG releases, making temperature reversal more challenging. Such impacts include increased wildfires, mass tree mortality, drying of peatlands, thawing of permafrost, and weakening natural land carbon sinks.

Carbon Dioxide Removal (CDR) can lower net CO_2 or net GHG emissions and counterbalance 'hard-to-abate' residual emissions (agriculture, aviation, shipping, industrial processes) to help reach net zero CO_2 or GHG emissions. Afforestation, reforestation, improved forest management, agroforestry, and soil carbon sequestration are CDR methods currently in use. Agroforestry has the potential to remove more than 3 Gt CO_2 per year. The IPCC assessed that costs range from lower cost (e.g., -45 to 100 USD/tCO_2 for soil carbon sequestration) to higher cost (e.g., 100-300 USD/tCO_2 for direct air carbon dioxide capture and storage). Land-based CDR methods and coastal blue carbon management can enhance biodiversity and ecosystem functions, and local livelihoods.

Average annual investment requirements for 2020 to 2030 in scenarios that limit warming to 2°C or 1.5°C are a factor of three to six greater than current levels. Accelerated financial support for developing countries where 70% of global emissions occur is a critical enabler to limit warming to 1.5°C. Developing country's high capital costs, high debt burden, and low institutional strength are barriers to overcome.

Sectoral Contributions to Mitigation

A combination of energy efficiency and conservation and a transition to low-GHG technologies and energy carriers is required to reduce GHG emissions in industry, transport, and buildings to net zero. Almost all electricity will be carbon-free in 2050. Increased electrification of energy end-

[4] IPCC Climate Change 2023: Synthesis Report, p. 87.

use will increase the share of electricity in final demand to 50% in 2050 from the current share of 20%. The final energy demand would stay constant at the current level of 410 EJ for the next 30 years due to improved energy efficiency – double the past rate of efficiency improvement by 2030 – and behavioral changes. If combined with improved infrastructure design and access, behavioral change can have the most potential in developed countries for emissions reduction.

AFOLU mitigation options – reforestation, afforestation, reduced deforestation, and bioenergy – can deliver large-scale GHG emission reductions and enhanced CO_2 removal. However, there are barriers, including the adverse impacts of climate change (release of soil carbon due to climate change), competing demands on land, conflicts with food security and livelihoods, and the complexity of land ownership and management systems. Further, land-based mitigation options – afforestation, production of biomass crops for bioenergy with carbon dioxide capture and storage, or biochar – can have adverse impacts on biodiversity, food and water security, local livelihoods and the rights of Indigenous Peoples, especially if implemented at large scales and where land tenure is insecure.

Concluding Thoughts

The aggregate effects of climate change mitigation on global GDP (excluding damages from climate change and adaptation costs) are small compared to global projected GDP growth. Even without accounting for non-economic benefits or the co-benefits of mitigation, the global benefits of limiting warming to 2°C exceed the cost of mitigation as assessed by the IPCC. Limiting global warming to 1.5°C instead of 2°C would increase the costs of mitigation, but also increase the benefits in terms of reduced impacts and related risks and reduced adaptation needs. The cumulative scientific evidence is unequivocal: climate change is a threat to human well-being and planetary health. Any further delay in global action on adaptation and mitigation will endanger a sustainable future for all.

Actions that prioritize equity, climate justice, social justice, and inclusion lead to more sustainable outcomes and co-benefits, and advance climate-resilient development. Equity, inclusion, and just transitions are key to progress on adaptation and accelerated mitigation. Eradicating poverty and providing opportunities for decent living in low-income countries in the context of achieving sustainable development objectives are possible without significant global emissions growth.

Climate Resilience. A New Way to Navigate Through the Climate Crisis

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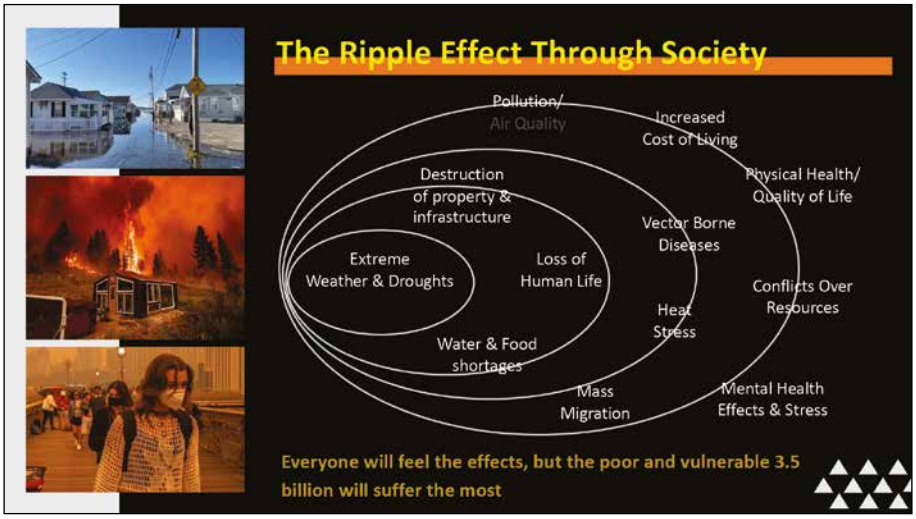
The first twenty years of the 21st century were the hottest in the global instrumental record (1). This instrumental record began around the late nineteenth century. The hottest year in the record is 2023, which may have exceeded even the paleotemperature records going back to 125,000 years ago (1).

The emission of the major heat-trapping pollutants is also breaking records, reaching nearly 40.9 billion tons of CO_2 in 2023 (2). CO_2 is a long-lived gas, which, once released into the air, stays there for centuries to millennia. The CO_2 blanket covering the planet now weighs about 1,200 billion tons.

The ripple effect of climate change is felt in all aspects of human existence (illustration below):



Why are the emission and temperature curves not bending despite three decades of negotiations among leaders of nations? This is for historians to ponder, but here, we will dive into the consequences of inactions to bend the curve.

Even if we take decisive actions to bend the curve now, the warming will continue to get worse for at least the next 25 years, simply because of the inertia in the natural systems (oceans and glaciers) and the social systems (scaling of technologies globally is but one example) (3). The global temperature is expected to cross the much-dreaded threshold of 1.5°C around 2030 (4). A warming planet has no climate norms, since each year will be hotter than the prior years, with more weather extremes than those experienced during prior years.

While the human-made decadal-scale warming of the planet inflicts chronic pain on people and ecosystems, the year-to-year natural variations like El Niño, over the longer-term warming, inflict acute pain through storms, floods, fires, and droughts.

The cost of doing nothing is excessive and cumulatively can reach $178 trillion from 2020 to 2070 (5), forcing a billion people to migrate. By then we will cross several tipping points in the natural and social systems.

MAST: *A New Way to Navigate Through the Climate Crisis*

We need a new way to navigate the climate crisis and protect people and ecosystems. We cannot rely just on mitigation of emissions. We need to complement mitigation with adaptation to cope with the additional heating of the planet in the coming decades to survive. We need to complement mitigation and adaptation with societal transformation to survive as well as thrive, and evolve to a sustainable way of living. An evolution to a sustainable way of living is essential to build and protect a habitable planet for our progenies and future generations.

We must broaden the current approach of a dominant focus on Mitigation to climate resilience. Resilience consists of the following actions: i) Anticipate threats and risks; ii) Prepare for threats and risks; iii) Respond to threats and risks; and iv) Recover and Rebound from threats and risks. Mitigation, Adaptation, and Societal Transformation form the three pillars for climate resilience (6). This new way of navigating through the climate crisis is referred to as the MAST approach, where MAST is the acronym for Mitigation, Adaptation and Societal Transformation (7).

Mitigation to bend the warming curve by 2050 to limit the warming to below 2°C is the first Pillar of MAST. This action will significantly reduce climate risks. We must drastically reduce four short-lived climate pollutants (methane, black carbon soot, tropospheric ozone, and HFCs) to reduce the rate of warming by half in the short term (<25 years) while transitioning away from fossil fuels to decarbonize the economy during the same time. In addition, we must remove at least 300 billion tons of CO_2 from the atmosphere during the next 40 years. The current weight of the CO_2 blanket that humans have contributed to is over 1,200 billion tons.

Adaptation: Adaptation to unavoidable climate changes is the second pillar of MAST. Adaptation has three phases: reduction in sensitivity to climate change, reduction in exposure to climate threats, and enhancement of adaptive capacity. However, there are limits to human and ecosystem adaptations, and to stay within these limits, adaptation must be tightly integrated with mitigation that slows the rate of warming in the near term.

Adaptation must receive the same priority as mitigation. Adaptation, while it has been recognized to be necessary, has not received high priority in terms of climate protocols and financial commitments.

Adaptation must start at the local level of a community, a city, a village and scale upwards to an entire nation and the planet. The following actions are examples of adaptation actions we can take: i) Protect the public against

heat stress, floods & droughts; ii) Provide physical & mental health services for those affected by fires, droughts, floods, and rising sea levels; iii) Climate proofing of infrastructure and homes; iv) Energy access, water, and food security for the poor; and v) Mass migration policies for those displaced by climate extremes.

Societal Transformation: Societal transformation to a sustainable way of living is essential for thriving after the climate crisis. Sustainability requires society to extract natural resources circularly. Currently, we are dumping about 2 billion tons of solid/liquid waste each year to landfills; about 50 billion tons of heat-trapping pollutant gases into the atmosphere, and polluting the oceans with plastics, raw sewage, and other waste products. Worldwide, we throw away about 30% to 40% of food in landfills. All this wasteful behavior contributes to climate change, biodiversity loss, and growing inequality.

Societal Transformation involves fundamental shifts in behavior and shifts in socio-economic systems and governance. Behavioral changes must include shifting from short-term benefits to individuals to longer-term shared benefits of societal actions. It must better balance technology with nature-based solutions to build climate resilience. It must make better use of indigenous knowledge and approaches to nature. In Pope Francis' words, "This transformation is akin to an ecological conversion." The climate crisis presents us with an unparalleled opportunity to build a stronger, healthier, and more just world that reflects that our thriving depends on the well-being of the natural world and other living beings.

The first step towards societal transformation is the climate/environmental literacy of the entire population from childhood to adulthood. We must develop innovative ways to provide climate and environmental literacy to educate and empower climate champions, stewards, and warriors.

Next, researchers must form transdisciplinary partnerships with civil society, including faith-based communities, to unpack climate change from all other divisive issues. We must make it crystal clear that climate change is NOT a political problem but a scientific problem backed with reliable data that threatens human survival.

In all MAST-related climate actions, nature-based solutions that are locally led and developed, targeted to reduce climate risks and to adapt to climate changes, should be given priority over all other solutions. Synergistic solutions that protect the health of nature (including biodiversity) and people's health should be given priority.

MAST: Practical Ways of Building Resilience

Overview: Adaptation and Resilience must be designed, developed and built at local levels. They must be scaled to the state and national levels to garner the required funding.

Mitigation to reduce climate risks is, in part, a top-down process beginning at the national and international levels and implemented locally. The primary reason is a scientific one: Emissions anywhere mean global heating everywhere. The long lifetimes of heat-trapping pollutants, from months to decades to centuries, imply that emissions in any corner of the planet can travel from thousands of kilometers to the entire planet from the Arctic to the Antarctic and cover it like a blanket. Like a blanket that keeps us warm during a cold winter night by trapping our body heat, the blanket of gases traps the infrared heat emitted by the surface and some atmospheric gases (water vapor mainly) and heats the planet.

Since we have been unable to bend the emissions curve, we must anticipate and prepare for hardships for at least the next few decades, when the warming curve will point upwards. The warming curve will bend in about 25 years, provided we take drastic mitigation actions now and moving forward. Implementing MAST will ensure that we survive and thrive during the next 25 years and beyond.

The issue of survival over the next 25 years will be a massive challenge for the poorest three billion people on the planet who are still relying on elemental technologies to meet basic needs such as cooking and home heating/cooling. The combined emissions of heat-trapping pollutants by these three billion is less than 10%, but they have suffered 75% of the climate-impacts-related losses during the last few decades. The societal transformation part of MAST will ensure that these three billion are treated fairly and with justice. The primary challenge for the rest of society is to ensure the security of energy, water, and food for the poorest three billion.

PAS/PASS Initiative and Leadership

A series of meetings on climate change organized by the Pontifical Academy of Sciences (PAS) since 2011 (8), as well as meetings organized jointly with the Pontifical Academy of Social Sciences (PASS) since 2014 (9), have paved the way for an influential transdisciplinary alliance between climate science, social science, policy, and religion. This alliance already has a demonstrable impact on climate change dialogue by bringing the human dimension of the climate problem to the fore. For example, in his climate

encyclical published in 2015, Pope Francis wrote: *The cry of the earth should be heard with the cry of the poor.*

The lack of enforceable emissions policies, combined with the planet's rapid warming during the first two decades of the twenty-first century, persuaded PAS and PASS that we must pursue a new way to protect people and nature. This led to a new PAS and PASS initiative called *Resilience of People and Ecosystems under Climate Stress* (10) to bring researchers, policy-makers, and faith leaders together to understand the scientific and societal challenges of climate change and develop solutions for enabling resilient people and resilient ecosystems. To take this initiative further, PAS organized a meeting of experts in July 2022 (10). At this meeting, the MAST concept for resilience was proposed (6,11). The MAST as an implementable strategy for resilience was accepted by all the experts attending the meeting in a conference declaration (12).

The 2022 resilience meeting led to the realization that resilience must be built at the local level of a city and a state. This, in turn, led to the decision that the next meeting must bring in Mayors and Governors from around the world. The call for this summit declared (13): *We no longer have the luxury of relying just on emissions mitigation. We need to build climate resilience so people can bend the emissions curve and bounce back from the climate crisis safer, healthier, and wealthier to a sustainable world*. This summit, proposed by Ramanathan (PAS) and Suárez-Orozco (PASS), was organized jointly by PAS and PASS on May 15-17, 2024.

PAS/PASS has also held several meetings on systems impacted by climate change; the most notable one was on food, titled *Science and Innovations for a Sustainable Food System* (14). The topics covered (15) included Food Systems Resilience, Climate Change and Food Systems, Water for Food Systems, and Agroecology for Low- and Middle-Income Countries.

Transdisciplinary Partnerships: The two academies brought together a diverse international group of researchers, faith leaders, policymakers, and heads of cities, towns, governorates, and provinces, assembled under the auspices of the Vatican's Pontifical Academy of Sciences and the Pontifical Academy of Social Sciences. Pope Francis presided over the summit.

The Global Summit assembled a group of mayors and governors worldwide to discuss and showcase innovative solutions for climate resilience. Participating Mayors and Governors were selected based on risks faced, population vulnerability, scalability of practices, and engagement in scaling

up solutions. The topic of the discussions was in the domains of Water, Air, Food, and Energy, with a focus on governance and human health.

Planetary Call to Action for Climate Change Resilience

The primary outcome of the summit was a Planetary Call to Action for Climate Change Resilience (Ramanathan, V; Suárez-Orozco, M; von Braun, J; Alford, H; Turkson, P; and 15 other authors – see Reference #14 below, 2024) by PAS and PASS (16), signed by all attendees including Pope Francis and all the attending Mayors and Governors. The Planetary Call to Action is fashioned somewhat along the lines of the successful Montreal Protocol, which phased out ozone-depleting chemicals from the atmosphere. The protocol elements were chosen to meet the criteria of the MAST strategy for climate change resilience. It calls for resilience as a human rights issue, addressing inequity issues for the poorest three billion people, the rapid phasing out of fossil fuels, and climate literacy for all ages from children to adulthood, among several others, that pave the way for surviving the crisis while thriving through it. Listed below are two of the protocols that relate to the implementation of the planetary call to action:

- *Researchers and policymakers working on solutions should adopt evidence-based trans-disciplinary collaborations that involve Mayors, Governors, and local NGOs to manage the resources available at various levels of government.*
- *Climate change is global, impacts locally, and requires local action. Therefore, we call upon heads of nations to facilitate more vital voices of mayors and governors in international climate policies.*

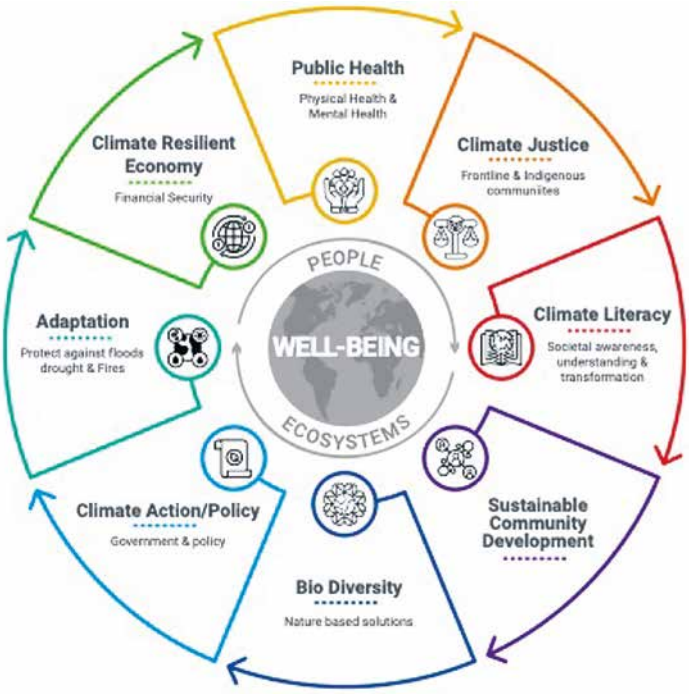
Next Steps: Sub-Regional Implementation Plans for Resilience Actions

We begin with the status of current climate action efforts dealing with climate resilience. Most of the intellectual, policy, and financial efforts of the last few decades have been directed at mitigating emissions. The topic of adaptation has largely been ignored until recently, at least concerning finance flows for adaptation.

For example, a 2023 report published by the United Nations Environment Program on adaptation, which is titled *Adaptation Gap Report 2023: Underfinanced and Underprepared* (17), concludes that inadequate investment and planning on climate adaptation leaves the world exposed. Another report published by the Global Center on Adaptation (https://gca.org) mentions that (18): Global climate finance doubled in the last two years to

USD 1.3 trillion annually in 2021-2022 compared to the USD 653 billion tracked on average in 2019-2020. Unfortunately, global adaptation finance is diminishing in importance, from 7% in 2019-2020 to 5% of total climate finance in 2021-2022.

However, the planning and policies on adaptation are in slightly better shape, as reported by IPCC in its most recent report titled *Climate Change 2023: Synthesis Report* (19): *Adaptation planning and implementation has progressed across all sectors and regions, with documented benefits and varying effectiveness. Despite progress, adaptation gaps exist and will continue to grow at current rates of implementation. Hard and soft limits to adaptation have been reached in some ecosystems and regions. Maladaptation is happening in some sectors and regions. Current global financial flows for adaptation are insufficient for, and constrain implementation of, adaptation options, especially in developing countries (high confidence).* Adaptation, as well as societal transformation, must be given the same priority as mitigation, since people are suffering from ongoing climate changes and the associated weather extremes. Resilience has to address the policies, the implementable actions and the financial flows to ensure the well being of people and ecosystems (illustrated below).



Towards this goal, we propose sub-regional summits in about 6 to 10 jurisdictions (including developed, developing, and least developed nations) worldwide. The Planetary Call to Action document spells out the actions we need to take. The regional summits should directly address implementing the MAST strategy (Mitigation/Adaptation/Societal Transformation). Specifically, the summits should address: (a) What will it take to implement the recommended solutions in the Planetary Call to Action Vatican document in disparate world regions? (b) How do we best foster a dialogue that will lead to local knowledge sharing and, whenever possible, local nature-based solutions to address regional climate challenges? (c) How do we best scale up solutions between and across participating regions?

The primary outcome of the regional summits should be city-by-city or county-by-county blueprints for climate change resilience. These blueprint efforts must be led by local leaders: mayors, governors, researchers, faith-based institutions, indigenous communities, and civic society. It is recommended that the regional Summits be co-sponsored by PAS and PASS during 2025/2026. The expectation is that the blueprints from the 6 to 10 jurisdictions will be published under the sponsorship of PAS and PASS and will serve as examples of how to make the whole world climate resilient.

We are aware that what is being proposed is a Herculean task. But the climate crisis demands it. We will survive and thrive with the MAST strategy and the Call for Action. The proposed plans will advance the Call to Action for a universal protocol of resilience, as Pope Francis called it in his speech on May 16, 2024, to the Resilience Summit attendees: "*I commend the two Academies for producing a universal protocol of resilience*."

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Climate and Migration: MAST Strategy[1]

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Abstract

This paper focuses on the nexus between climate change and migration, identifying climate change as a significant driver of mass migrations due to its exacerbation of extreme weather events and environmental degradation.

We introduce the MAST framework – Mitigation, Adaptation, and Social Transformation – as a strategic approach to addressing the impacts of climate change on migration. We examine climate change as a threat multiplier, intersecting with socioeconomic, political, and demographic factors influencing migration flows. The study also examines the differential impacts of climate change on various populations, noting that vulnerable groups, women, children, and indigenous communities are disproportionately affected.

We argue for the need to view migration not merely as a crisis but as a potential contributor to sustainable development. We advocate for comprehensive policies that integrate climate adaptation and migration, emphasizing the importance of international cooperation and the development of robust support systems to enhance the resilience of at-risk communities. The paper calls for a global covenant to protect populations most vulnerable to climate-induced migration, urging a shift in perspective to recognize migration as a testament to human resilience and adaptability.

★★★

Migration is an ancient human adaptation. Viewed anthropologically, migration is written in our genome[2] and encoded in our bodies – in our

[1] MAST – Mitigation, Adaptation, and Societal Transformation.

[2] Genetics provides compelling evidence of ancient human migration patterns. The pioneering work of PAS former member Cavalli-Sforza compiles genetic data illustrating the extensive migrations that shaped the genetic diversity of modern humans (Cavalli-Sforza, L.L., Menozzi, P., & Piazza, A., 1994. "The History and Geography of Human Genes."

bipedalism,[3] in our stereoscopic vision,[4] and our central nervous system. Migration has always been a defining feature of human resilience.[5] We are *homo sapiens mobilis*: modern humans are the children of migration.[6]

In this paper, we first address some broad features of current worldwide migration patterns. We then turn to some definitions and conceptual matters, especially addressing the nexus between climate change and migration. Thirdly, we draw on migration patterns in relation to climate and environmental risks and endeavor to assess the impacts of climate change on different populations and the role of MAST (Mitigation, Adaptation, Social Transformation) now and moving forward.

1. Migration Today

In the modern era, migrations are complex and multi-determined; they escape vulgar mechanistic models of causality. Migrations unfold in complex ecologies involving broad features of statecraft – sovereignty and managing borders, as well as demography, economy, and society. Furthermore, historical relationships, cultural affinities, political interests, and the environment itself continue to carve the pathways of the great human migrations in the new millennium (Suárez-Orozco, 2019).

Princeton University Press). For more recent studies, see https://phys.org/news/2023-07-ancient-dna-reveals-earliest-evidence.html; for a recent study of migration out of Africa, see https://scitechdaily.com/new-dna-research-changes-origin-of-human-species/

[3] Bipedalism offered early humans advantages in mobility and energy efficiency over long distances, which were crucial for migration and exploring new territories. See, Pontzer, H. (2012). "Energy expenditure in humans and other primates: a new synthesis." *Annual Review of Anthropology*, 41, 25-40.

[4] The development of stereoscopic vision in humans is linked to the need to navigate complex environments. Stereoscopic vision provides depth perception, which would have been advantageous in varied and new terrains encountered during migrations. See, Howard, I.P., & Rogers, B.J. (1995). "Binocular Vision and Stereopsis." Oxford University Press.

[5] We adhere to the IPCC-AR6 (2023) definition of resilience "as the capacity of social, economic, and environmental systems to cope with a hazardous event, trend, or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure while also maintaining the capacity for adaptation, learning, and transformation."

[6] Indeed, "the course of human history has been marked by complex patterns of migration, isolation, and admixture, the latter a term that refers to gene flow between individuals from different populations." (McGrath, 2023) See https://phys.org/news/2023-05-human-ancestry-alleles.html

All continents are involved in mass migrations – as areas of immigration, emigration, transit, and return – and often as all four at once. In the twenty-first Century, mass migration is the human face of globalization – the sounds, colors, and aromas of a miniaturized, interconnected, and ever-fragile world.

International migration has grown significantly since the turn of the millennium, reaching approximately 282 million in 2020 – after a previous high of 221 million in 2010 and 174 million in 2000 (McAuliffe, M. & Triandafyllidou, A. 2021). The World Migration Report (2022) suggests the largest international migration corridors are in North America, Europe, and Asia. By the 2020s, the largest number of international migrants (well over 50 million) resided in the United States of America, followed by Germany (approximately 16 million), Saudi Arabia (almost 14 million), the Russian Federation (approximately 12 million), and the United Kingdom of Great Britain and Northern Ireland (over 9 million). India is the largest country of origin of international migrants (with approximately 18 million emigrants), followed by Mexico (12 million). Today women comprise slightly less than half of all international migrants (McAuliffe, M. & Triandafyllidou, A. 2021).

Over the last century, well-worn migration corridors connected historically linked countries of origin with specific destinations in new societies.[7] That is the story of Latin American migrations to the United States; Mediterranean, African, and Middle Eastern migrations into Northern Europe; Ukrainian and Uzbek migrations to Russia; and Indian, Bangladeshi, and Filipino migrations into East Asia and the Middle East.

[7] Today's well-worn migration corridors have older origins in the age of European exploration and conquest. "The colonization of territories ignited the first wave of globalization. European sea captains began regular transoceanic travel in the 15th and 16th Centuries for the first time, systematically connecting lands and peoples that had been unconnected. The peoples subjected to the processes of colonial domination endured cultural, social, political, and economic mutations, mostly as a consequence of acts of war and terror, genocide, and demographic collapse. Forced labor, slavery, territorial displacement, and the appropriation of natural resources were commonplace. War and conquest destroyed civilizations, induced demographic collapse, and caused massive displacement of indigenous populations and their livelihood. The expanding European powers systematically linked the Atlantic, Pacific, and Indian Oceans, creating the largest trading systems ever seen in history. The trade routes became the great corridors for global migration during the last five centuries." Pontifical Academy of Social Sciences, 2023. See https://www.pass.va/en/events/2023/colonization.html

Large-scale migration is not random: "Long-term data shows that international migration is not uniform across the world but is shaped by economic, geographic, demographic and other factors resulting in distinct migration patterns, such as migration 'corridors' developed over many years." (IOM, 2022). At the proximate level, migration is a household strategy.[8] Distinct patterns of kinship, household, and social organization carve the pathways for worldwide migratory journeys. The fundamental unit of migration is the family – variously defined and structured by distinct, culturally coded legislative, economic, reproductive, and symbolic forms. At the distal level, migration is determined by labor markets, wage differentials, demographic imbalances, technological change, war and terror, the environment, and climate change.

2. The Climate Crisis

Climate change exacerbates the frequency and intensity of extreme weather events and environmental degradation. Observed climate impacts on human systems and ecosystems are multiple and disparate and are powerfully interconnected to mass migrations. The IPCC defines climate change as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer." (IPCC, 2018). Global warming will continue if immediate action is not taken to adapt to 1.5°C and reduce emissions.

According to the *Planetary Call to Action for Climate Change Resilience,* "2023 was the hottest year on record, resulting in severe global impacts due to extreme weather events. By February 2024, ocean temperatures soared to levels never seen, continuing a pattern that persisted throughout the preceding year. Climate experts now forecast that the Earth is very likely to exceed the critical global warming threshold of 1.5°C by 2030 to 2035. We have a limited time frame to proactively prepare for and respond to the crisis rather than simply reacting to it."

The climate crisis, its origins, and its impacts are not uniformly distributed. There are disparities between and within countries. *The Planetary Call*

[8] "International migration is a commonly used strategy through which household members seek to accumulate resources, mitigate financial uncertainty, and provide better opportunities for their families" (Wassink and Viera, 2021). See also Garip, F. (2016). *On the move: Changing mechanisms of Mexico-U.S. Migration*. Princeton, NJ, Princeton University Press.

to Action identifies three distinct groups: the Top One billion who are contributing more than 50% of heat-trapping pollutants; the Middle Four billion, and the Bottom Three billion who contribute less than 10% yet suffered 75% of the losses. The 46 Least Developed Countries (LDCs), most of them in Africa, with 15% of the population of the world, contribute only 1% of the world's CO_2 emissions.[9] In contrast, the G20 group of countries are responsible for 80% of the world's CO_2 emissions.

3. What is Climate Migration?

Climate change, environmental degradation, and geophysical hazards increase morbidity and mortality, disrupt production, decrease agricultural yields, decimate livestock, and forcefully displace millions worldwide (Suárez-Orozco, 2019; McLeman, 2014). Extreme weather patterns and weather-related hazards – *inter alia,* rising temperatures, rising sea levels, floods, high-intensity cyclones, monsoons, hurricanes, heat waves, droughts, forest fires, as well as slow-onset environmental degradation such as soil erosion, deforestation, and degradation of natural resources, intersect with other drivers of mass migrations forcing millions to escape seeking shelter.

At the end of 2023, there were 7.7 million people internally displaced globally as a result of disasters such as storms, floods, wildfires, and earthquakes (IDMC, 2024). Numerous global policy frameworks – including the Paris Agreement (UNFCCC, 2015), the United Nations Summit for Refugees and Migrants (United Nations, 2016), and the Global Compact for Migration (United Nations, 2018) recognize climate change as a driver of mass migration. While climate change is recognized as a driver of migration, it does not operate in isolation. The interaction between climate change and migration is nuanced. As a threat multiplier, climate change intersects with a complex web of other factors, including socioeconomic conditions, wage differentials, demographic imbalances, and environmental degradation (McMichael, 2023). War and terror, yet another driver of mass

[9] Dr. Wilber K. Ottichilo, Governor of Vihiga County, Kenya, notes that Kenya suffers some of the most from the adverse climate change impacts causing human suffering and economic consequences impacting some 3 to 5% of their GDP annually. Punishingly, those who contribute the least to climate change, also suffer from inadequate health care systems. Economic loses means there is less public spending on health, education, or social protections to respond to climate shocks.

migration, also intersects with climate change.[10] Migration is a complex dynamic system shaped by various push-pull factors.[11]

Climate change impacts are being felt globally, but certain regions and populations are particularly vulnerable to its effects, forcing them to migrate. As articulated in Planetary Protocol for Climate Change Resilience, "over 3.6 billion people live in areas highly susceptible to climate change. For them, extreme weather patterns are the new drivers of forced migrations. An average of 21.5 million people have been forcibly displaced by weather-related sudden-onset hazards each year since 2008. The World Bank's Groundswell report estimates that climate change could force an additional 216 million people across six world regions to move within their countries or across borders by 2050. Over a billion people could be displaced globally by 2050" (PAS & PASS, 2024).

The areas most affected by climate change include *seriatim,* (1) small island nations – especially vulnerable to sea-level rise, coastal erosion, and extreme weather events; (2) Sub-Saharan Africa – droughts, heatwaves, with food insecurity leading to forced displacement, (3) South Asia – *inter alia,* facing water scarcity, glacial melt, and extreme weather events, impacting agriculture and livelihoods, (4) Arctic region – now warming at a faster

[10] The war in Syria embodies the synergies among climate change, war and terror, and mass human displacement. The Syrian war has led to a massive displacement crisis, with significant portions of the population being forced from their homes. As of the current year, over 12 million Syrians have been forcibly displaced within the region, marking the Syria crisis as the largest displacement crisis in the world. This figure includes 5.2 million refugees and asylum-seekers in neighboring countries (including Turkey) and 6.8 million internally displaced persons (IDPs) within Syria itself (https://reporting.unhcr.org/operational/situations/syria-situation). Syria's drought is the most severe in nine hundred years. According to NASA data, it is "the driest on record." NASA scientists found that "estimating uncertainties using a resampling approach [they could] conclude that there is an 89 percent likelihood that this drought is drier than any comparable period of the last 900 years and a 98 percent likelihood that it is drier than the last 500 years" (Cook et al. 2016, 1). According to UN data, the drought caused "75 percent of Syria's farms to fail and 85 percent of livestock to die between 2006 and 2011. The collapse in crop yields forced as many as 1.5 million Syrians to migrate to urban centers like Homs and Damascus" (Stokes 2016, 2).

[11] People and families are forced to abandon their homes due to different interconnected factors where climate change is a threat multiplier. Climate change impacts (sea-level rise, and more frequent and intense drought, flooding and extreme weather events) intersect with other socioeconomic, political, demographic, and environmental factors, and it is expected that climate change will amplify the scale of human migration (McMichael, 2023).

rate than the global average, leading to melting ice, permafrost thaw, and disruptions to ecosystems and to Indigenous communities, (5) Low-lying coastal areas are at risk from sea-level rise, storm surges, and saltwater intrusion, impacting communities and infrastructure.[12]

Climate and environmental researchers from various scholarly and scientific disciplines are adding new voices and academic perspectives to the study of mass migration, a domain historically dominated by sociologists, labor economists, and anthropologists. Immigration as an area of scholarly inquiry is fertile ground for climate and environmental scientists to engage with a defining issue of our times, enter transdisciplinary conversations, and learn from but also contribute their unique craft to unexplored areas of scientific and humanistic importance.[13]

Environmental sciences and climate change scholars are adding new evidence linking climate change and mass migration. In the early 1990s, the Intergovernmental Panel on Climate Change (IPCC) noted that millions of people would be displaced because of climate change via shoreline erosion, coastal flooding, and agricultural disruptions (IOM, 2007). By 1993, the UNHCR identified four dynamics of forced displacement in the State of the World's Refugees political instability, economic pressure, environmental degradation, and ethnic conflict (UNHCR, 1993). The UNHCR noted that "[m]illions of people have been forced to leave their homes because the land on which they live has become uninhabitable or is no longer able

[12] According to the Global Report on Internal Displacement, by 2017, most new displacements occurred in "low and lower-middle income countries and as a result of large-scale weather events, and predominantly in South and East Asia. While China, the Philippines, and India have the highest absolute numbers, small island states suffer disproportionally once population size is taken into account. Slow-onset disasters, existing vulnerabilities and conflict also continue to converge into explosive tipping points for displacement" (Global Report on Internal Displacement 2017, 10).

[13] Examples of such scholarship include Black et al. (2011) who developed a conceptual framework to study the factors and drivers of migration in the context of climate change. Their model identifies five different drivers of migration (social, environmental, political, economic, and demographic), the personal and household characteristics (age, sex, education, wealth, marital status, ethnicity, religion, and language), and the intervening obstacles and facilitators (political/legal framework, cost of moving, social networks, diasporic links, recruitment agencies, technology) that influence the decision of a family to migrate. Kelman (2015) proposes a decision-making flowchart summarizing the decisions that most often need to be taken. The flowchart provides a conceptual framework for migration-decision making and articulates the challenges facing those who decide to migrate.

to support them." (UNHCR, 1993, p. 3). In sum, while the migration/climate change/environment nexus is not a new concern for scholars and international bodies, the rapidly accelerating climate crisis creates significant new pressures for mass migration.

The International Organization for Migration (IOM)[14] defines environmental migrants as "persons or groups of persons who, predominantly for reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad" (IOM, 2007, p. 1). The IOM definition recognizes three critical characteristics of the phenomenon. First are those displaced by sudden natural disasters and those who choose to move because of slow onset deteriorating environmental conditions. Second, it differentiates between short-term and long-term migrants. And third, it distinguishes between internal and international migrants.

Yet the scholarly record suggests a need for more consensus and clarity in the definition of climate migration. Furthermore, climate migrants do not fit into international protection regimes (Nishimura, 2015).

Research using a broad range of methodologies, from field-work and empirical case studies to surveys and conceptual work, illuminates the complex relationships between climate change and the various migration flows it engenders (Perch-Nielsen et al., 2008; Kaczan & Orgill-Meyer, 2020). Researchers have examined how climate change contributes to sudden and slow-onset events that induce migration. Slow-onset changes, *inter alia,* rising temperatures, deforestation, land degradation, erosion, desertification, and rising sea levels in coastal areas occur gradually, and the research suggests they tend to trigger movement in search of stability. In contrast, sudden-onset

[14] The IOM Glossary on Migration (2019) contributes to the consolidation of terminology and language concerning migration according to international law and standards. The glossary includes definitions of internal migration as "the movement of people within a State involving the establishment of a new temporary or permanent residence"; or international migration as "the movement of persons away from their place of usual residence and across an international border to a country of which they are not nationals". The Glossary includes new terms such as "environmental migration", "climate migration", or "disaster displacement" to describe the movement of a person or a group of persons who are obligated to leave their habitual place of residence temporarily or permanently for reasons of progressive or sudden changes in the environment. The term has been used to draw attention to this phenomenon despite the lack of international protection https://publications.iom.int/books/international-migration-law-ndeg34-glossary-migration

events such as floods, hurricanes, cyclones, heatwaves, and wildfires[15] tend to generate displacement as an immediate adaptation (Nishimura, 2015). Other research suggests that slow-onset events are more likely to result in voluntary migration. In contrast, sudden-onset events will likely lead to involuntary, short-term, and shorter-distance migrations (Cattaneo et al., 2019).

Migration due to climate factors can be analytically distinguished into several types: 1) short-term migration, 2) long-term migration, 3) voluntary migration, 4) forced migration, and 5) internal and international migration. Scholars have examined extreme weather events that increase the likelihood of sudden, internal, and short-term movement. Other scholarly work examines slow-onset changes (e.g., sea level rise, land degradation) as a threat multiplier pushing populations to make permanent moves versus deciding to stay and adapt (Barrett, 2012; Koubi et al., 2016; Cattaneo et al., 2019).

Climate migration is likely internal and from rural to urban areas (Martin, 2010; Ahmed, 2018). International migration is costly, requiring significant investments in household resources (Beine & Parsons 2017). The lack of international recognition and protections for climate migrants creates further barriers to international migration as destination countries do not have asylum or resettlement systems to manage the admission of persons who cannot return home due to climate and environmental threats (Martin, 2010).

Most case studies use temperature and precipitation data, household surveys, and census data to examine climate-induced migration patterns. A consistent finding in the literature suggests that temperature changes significantly impact migration (Thiede et al., 2016; Gray & Wise, 2016). For example, in South America, the odds of inter-province migration increased by 3.4% for every month when temperatures were more than two standard deviations above the long-term average (Thiede et al., 2016). Similarly, temperature variability is more important for internal than international migration in Kenya, Uganda, and Burkina Faso (Gray & Wise, 2016). Other case studies find that higher temperatures increase migration rates to urban areas and to close destinations (Cattaneo & Peri, 2016).

Precipitation and changes in rainfall have inconsistent effects on migration (Gray & Wise, 2016; Kaczan & Orgill-Meyer 2020). For example, excessive rain in Senegal increased the decision to migrate (Nawrotzki & Bakhtsiyarava, 2017), and precipitation-related disasters preceded migration within Mexico (Khamis & Li, 2020). However, research studies found

[15] As well as volcanic eruptions and earthquakes.

insignificant impacts of flooding on migration in rural Pakistan (Mueller et al., 2014) or on precipitation and migration in Burkina Faso (Gray & Wise, 2016). These empirical results are mixed and primarily context-specific (Cai et al., 2016). Significantly, researchers found that floods can also constrain the decision to migrate because they deplete household resources (Kaczan & Orgill-Meyer 2020).

Much empirical research on climate and migration comes from Africa, South America, and South Asia (Berlemann & Steinhardt, 2017). This scholarly corpus again suggests that the likelihood of migrating internally, to neighboring countries, or further away internationally will depend on various factors but very significantly on household income levels (Beine & Parsons 2017). Most studies find that rising temperatures in agriculture-dependent countries induce outmigration (Berlemann & Steinhardt, 2017). Although migration can take many forms, the causes of migration are also highly dependent on previous migration history, migration networks, and various economic, labor, political, demographic, and social factors at both the origin and destination points (Cattaneo et al., 2019). Migrants move where they have better chances of finding labor at better wages (Cattaneo & Peri, 2016, Koubi et al., 2016) and to places with lower climate vulnerability (Grecequet et al., 2017). A case study in Maldives concluded that when interviewees considered migration, they sought better living and labor conditions (Kelman et al., 2016). International migration unfolds when individuals and networks can afford to pay for the migration costs (Beine & Parsons, 2017).

The scholarly corpus offers disparate estimates of the number of migrants due to climate change. For example, Myers (2002) projected that 200 million people will migrate due to environmental changes by 2050. More recent research claims that an average of 21.5 million people have been forcibly displaced by weather-related sudden onset hazards each year since 2008. The World Bank's Groundswell report estimates that climate change could force an additional 216 million people across six world regions to move within their countries or across borders by 2050. Others suggest that over a billion people could be displaced globally by 2050.[16]

[16] Because migration is highly context-specific, the data suggests differing regional estimates moving forward, see the Groundswell report. Another World Bank study estimates that 140 million people in the South of the Sahara, South Asia, and Latin America will be displaced within their own countries to escape the slow-onset impacts of climate change and if urgent measures are not taken to fight against climate change (Rigaud et al., 2018).

The data suggest that climate and migration exist as complex dynamic systems. Climate-related migrations unfold in complex ways alongside other drivers of mass migration, such as socioeconomic and labor factors and political and demographic characteristics. The climate-induced effects on coastal flooding, reduced rainfall, heat waves, droughts, and water scarcity increase the incentive for people to migrate. However, household economics, political factors, governance, war, and terror also intersect in the decision to migrate (Black et al., 2011). Moreover, it is essential to move away from the discourse that migration threatens national security (Nishimura, 2015). As Adger et al. (2024) argue, migration can contribute to sustainable development when it does not exacerbate structural inequalities, creates synergies with elements of sustainable development, and enhances people's well-being.

4. Impacts of Climate Change on Different Migrant Populations

The current climate crisis is a planetary crisis; however, specific sectors of the population experience different impacts of climate change. Women, children, socially vulnerable people, indigenous populations, older adults, people with chronic medical conditions, people with disabilities, or outdoor workers are examples of groups who are most at risk and are more vulnerable to the impacts of climate change (USEPA, 2024). In fact, migrant populations also experience different climate-induced migration patterns.

4.1 Women and Children

As noted in *The Planetary Call to Action*, "Women and children are more vulnerable than men to the impacts of climate change since 70% of the people living in poverty (about 1.3 billion) are women. Women have less access than men to resources that would help them to adapt to climate change. Women dominate the world's food production (50-80 percent) but own less than 10% of the land. Home and childcare responsibilities prevent women from migrating when a disaster hits." Internationally, there are slightly more men than women migrants. Researchers in the field of climate and migration have examined distinct patterns experienced by women and children on the move. In an early study, Findley (1994) found that 62% of the women and children migrating during the severe 1983-1985 drought in the Sahel were more likely to be circular, short-distance migrants. Women and children temporarily migrated, often joining extended family members in villages. Women were also encouraged to marry earlier, and children were sent to less impacted neighboring villages to study, resulting in reduced

household size during stressful times. In contrast, adolescents and younger married men would migrate to cities for employment (Findley, 1994).

Carola Suárez-Orozco states in her chapter that children are particularly vulnerable to climate change because it can create or multiply pre-existing vulnerabilities, and there are important impacts on their future possibilities. C. Suárez-Orozco, in her research, identifies three groups of children considering the climate change effects: children directly affected by environmental devastation, children who migrate due to these climate-related disruptions, and children experiencing eco-anxiety. For those children, the impacts are diverse, such as physical health, increased exposure to violence and exploitation, educational disruptions, and mental health. C. Suárez-Orozco focuses on promoting resilience solutions, empowering children, and education initiatives to face the future of environmental challenges.

Ezra & Kiros (2001) argue that migration in Africa is often a significant demographic response to environmental stress and poverty – where seasonal migration is expected to supplement family income and respond to population pressure and famine. Soumya Swaminathan claims that the climate crisis is not "gender neutral." She argues that women and girls are at higher risk of poverty, food insecurity, and violence as they migrate to safer locations. Moreover, agriculture is the most critical sector for women in low- and lower-middle-income countries. For anything that impacts their crops, women have to work harder to secure the same income, and girls often have to leave school to help their mothers manage the increased burden.

Gender differences in migration are also found in various studies in Africa (Ezra & Kiros, 2001; Henry et al., 2004; Gray & Mueller, 2012; Gray & Wise, 2016), South America (Gray, 2009), and Asia (Mueller et al., 2014; Koubi et al., 2016) including cases-studies where women are more likely to migrate than men (Ezra & Kiros, 2001; Gray & Wise, 2016). Women migration is more likely to occur locally or internally than internationally (Gray, 2009). Their duration and distances distinguish men's migration, since men are more likely to opt for long distances (Gray & Mueller, 2012) or move permanently to another village in the region if the environmental situation is favorable (Schoumaker & Beauchemin, 2004). Community characteristics (Ezra & Kiros, 2001) and gender differences (Henry et al., 2004) have a role in the decision to migrate. For example, males generally move for economic reasons (Henry et al., 2004) and to supplement household income (Gray & Mueller, 2012). In contrast, women move for family reasons (Henry et al., 2004) and a desire for better facilities, such as healthcare and schools (Kelman et al., 2019).

4.2 Age

The research on age as a characteristic of migration highlights the impact of various age-related factors in the migration process. Studies show that young adults and families are more inclined to migrate, influenced by opportunities for better livelihoods and family reunification. This trend is particularly pronounced when permanent migration decisions involve following other family members who have previously migrated (Gray, 2009; Koubi et al., 2016).

Moreover, age influences migration differently across regions and contexts. For instance, in rural Ethiopia, migration tends to peak at ages 30-40 for men and 25-29 for women, while in South Africa, significant internal migration is most likely to occur between ages 15-30 (Gray & Mueller, 2012; Mastrorillo et al., 2016). These patterns reflect a complex interplay of socio-economic factors, local demographics, and life stages shaping the migration dynamics in various settings.

The broader field of migration studies has evolved to include a wide range of topics, with significant contributions from disciplines like sociology, economics, and geography. The field now acknowledges the multifaceted nature of migration, influenced not only by economic factors but also by social networks, family dynamics, and broader structural conditions (King and Skeldon, 2010; Portes, 1997). This enriched understanding helps to grasp the nuanced ways in which age and other demographic factors shape migration patterns, further supporting the development of targeted policies and interventions.

4.3 Education

Various studies analyze the effect of education on environmental migration decision-making. People with higher education levels are more likely to migrate and migrate internationally (Drabo & Mbaye, 2015; Koubi et al., 2016). The research notes that highly educated people can assume the cost of international migration (Drabo & Mbaye, 2015) and look for better professional opportunities in another location (Koubi et al., 2016). Folks with lower levels of education are more vulnerable to the impacts of climate-induced environmental change yet opt to migrate internally or to neighboring countries (Drabo & Mbaye, 2015). Income levels also reveal significant differences in the decision to migrate. Weather-induced migration is generally more frequent among wealthier than poorer individuals (Kaczan & Orgill-Meyer, 2020). Generally having more options, higher-income mi-

grants usually opt for international migration since they can afford the cost of migration (Mastrorillo et al., 2016). In contrast, lower-income folks who cannot afford migration as an option are less likely to move (Koubi et al., 2016). When they do, they opt for internal migration as an adaptation strategy (Mastrorillo et al., 2016).

4.4 Trapped Populations

Numerous case studies in the research literature shed light on the relationship between climate-induced environmental factors and migrating decisions. However, there are situations of voluntary immobility or choosing to stay in place due to attachment and sociocultural reasons versus trapped populations – who do not have the resources or networks that enable migration – who remain in areas of extreme climate risk (Gray & Wise, 2016; McMichael, 2020). A research study in Zambia (Nawrotzki et al. 2018) reveals that individuals in wealthy districts are more likely to migrate than poor districts, characterized by climate-related immobility. Access to networks also enables climate-related mobility.

Although trapped populations have received less attention in studies and policy, they will continue to experience the effects of climate and environmental changes, such as coastal and environmental degradation, water scarcity, and extreme weather events.[17] Many who will stay *in situ* must endeavor to adapt to environmental threats, unable to opt for the uncertainty and cost of migration (McMichael, 2023).

There are many reasons why people prefer to stay in their homes or livelihoods, including personal wealth, social connections, cultural norms, and government policy (Zickgraf, 2023). Nawrotzki et al. (2018) suggest that planners and policymakers need to recognize places that can trap populations and develop programs to support in situ adaptation because immobility may lead to cycles of poverty, vulnerability, and exposure to adverse climate impacts. Moreover, they also need to anticipate and prevent situations that can lead to humanitarian emergencies under climate change.

[17] International actors often must provide support to trapped populations – providing existential resources for people in places where they are not able to move (Silchenko & Murray, 2023). This assistance is often the only option for people located in more vulnerable countries and regions to cope with and alleviate the economic impact of natural disasters or extreme weather events (Cattaneo et.al., 2016; Silchenko & Murray, 2023).

4.5 Climate Migration in the Context of Adaptation

Migration is often seen as a strategy to adapt to the environmental challenges posed by climate change. A critical debate in the research literature centers on whether migration should be viewed as an adaptive response or a failure to adapt to climate change. According to Kelman and Næss (2019), migration can be a voluntary method to address climate change and an indication that climate change has not been adequately managed, leading to forced migration. This occurs alongside various other factors that influence migration. Whether migration is voluntary or involuntary, it serves as a survival strategy to reduce vulnerability to environmental changes, maintain livelihoods, and enhance individuals' ability to cope with the adverse effects of climate change.

Numerous studies emphasize the need to fund proven adaptation strategies to enhance resilience against climate change-induced migration (Black et al., 2011). Necessities include clean water and air, sustainable food, and energy sources. Effective adaptation strategies include adopting agricultural innovations and efficiency, nature-based solutions, investing in relevant technologies, formulating policies to boost resilience, and improving water supply systems (Martin, 2010; Cattaneo et al., 2019). These strategies are vital for mitigating environmental degradation and strengthening the resilience of vulnerable populations – such as the poor, children, women, the elderly, and Indigenous communities – to the impacts of climate change.

Advancing proven climate change adaptation policies is crucial to reducing vulnerabilities and protecting public health (McMichael, 2023). The ability to respond to climate change and manage its inevitable risks depends on various factors, including financial resources, governance, risk assessments, social resources, infrastructure, and technology (Barnett & Webber, 2010). Effective governance requires collaboration among government and non-governmental organizations to address these challenges. Additionally, forming multi-stakeholder and cross-disciplinary partnerships is necessary to develop initiatives that enhance climate resilience, support mitigation and adaptation efforts, and prevent forced migrations. When migration is preferred, then policies must focus on assisting and protecting people throughout the migration process, facilitating the planning, the journey, and the settlement process.

Here we present some policy recommendations in the context of migration and climate change to build solutions and knowledge for resilient people and resilient ecosystems:

1. Invest in climate adaptation and mitigation strategies: Governments and international donors must prioritize their policy agendas, budgets, and regulations to reduce the emissions of heat-trapping pollutants and invest in resilience planning. Moreover, governments should incorporate grants for community organizations to develop projects that support and advance the achievement of these objectives. Federal funding must be ensured for regions and municipalities for climate change mitigation and adaptation strategies, as well as sudden-onset climate-induced events.
2. Collaborative decision-making: Engagement between national, regional, and local levels of government, international organizations, NGOs, civil society, community organizations, indigenous groups, academia, the private sector, and key stakeholders is needed in the discussion of risks and identification of adaptation strategies and priorities.
3. Incorporation of local knowledge and local realities: The discussion of climate adaptation strategies in each country, region, or municipality should evaluate and incorporate the risks to vulnerable populations, infrastructure, and economy. Contextualized policy responses must incorporate local and indigenous knowledge and the needs of affected communities and migrants.
4. Evaluation of strategies: Governments need to incorporate evaluation processes, in collaboration with stakeholders, of the strategy to ensure that the policy addresses the problem and evaluates its implementation.
5. Consider climate change as a cross-cutting issue for the whole government: It is essential to recognize the interconnected dynamics of climate change. Governments and stakeholders have a crucial role in developing knowledge and programs that advance the understanding of how climate change impacts human health, equity, housing, migration, and the economic impacts of climate change.
6. Ensure in-situ adaptation programs in countries and regions most impacted by climate change and forced migration: Donor countries, international entities, and philanthropy must identify and fund adaptation projects in areas at risk to increase the resilience of the population, such as building safe water and air capacity, green energy, local and improved agriculture techniques, or improving access to education, among others. These projects must incorporate local stakeholders in the decision-making process. Although the decision to migrate will not depend exclusively on adopting said interventions, they can reduce forced

migrations in areas where the impacts of climate change disproportionately contribute to displacement.

7. Develop programs for sudden-onset events or shocks (e.g., floods, hurricanes, cyclones, heatwaves, wildfires).[18] Climate change will impact these events more frequently and intensify droughts, flooding, coastal hazards, etc. Preparedness for these events can help reduce risk, protect human lives, and support emergency response systems and teams to respond and protect affected communities immediately.
8. Identify and support the different migration phases as an adaptation strategy: Pre-journey, journey, reception, integration, and potential return. Governments, the international community, and stakeholders can support the different phases of the migration journey, identify the benefits and risks of migration as a climate adaptation strategy, and contribute to viewing migration as an adaptation and development rather than a failure or a threat.
9. When people decide to migrate, it is necessary to focus on humanitarian needs as well as the demographic imbalances between high- and low-income countries and ongoing needs for labor migration. The Expert Council on Integration and Migration Annual Report (2023) proposes a combination of three instruments that countries could implement: the climate passport, the climate card, and the climate work visa.[19] Since climate change is one of the most significant challenges faced by humanity, there is still too little consideration of the potential migration and refugee policy responses in this context, the political and legal responses to climate-induced migration, and the humanitarian needs of people.

[18] Also, earthquakes, volcanic eruptions, and another catastrophic events.

[19] The SRV Annual Report (2023), proposes a combination of three instruments as national measures to climate change and migration. The SRV makes the recommendations to Germany and acknowledges that these can also be transferable to other political levels and countries. The first instrument, the Climate Passport, is proposed when the country of origin is uninhabitable and migration is the only option. The second instrument, the Climate Card, refers to offering limited residence to people whose country of origin is affected by the consequences of climate change with massive destruction in the country of origin leading to temporary migration. This card is temporary and limits the right to remain. The third instrument, the Climate Work Visa, is for countries that are affected by climate change but in a lesser extent than the previous ones, but still face gradual environmental changes that impact the quality of life in country of origin. The residence permit is conditional upon employment contract.

10. Take an all-of-humanity approach. Climate change will continue exacerbating these existing inequities for present and future generations if we do not take a-whole-of-humanity response. Political leadership is essential for climate adaptation and not ignoring the challenge. It is crucial to invest in measures to protect children and their right to protection, education, healthcare, or good nutrition. In the case of trapped populations, it is essential to give them protection, security, and dignity since they are situated in areas of grave risk.
11. Develop research, information, and better data systems on climate migration: One of the main challenges in the policy arena and research is quantifying climate-induced environmental migration. It is essential to continue developing research knowledge with case studies to identify the root causes of climate migration, the impacts and patterns of migration, and the different governmental strategies. Moreover, it is also crucial to develop databases and surveys to study how slow-onset events and sudden-onset events affect population displacements in disparate contexts. Federal agencies should develop knowledge and awareness in the context of climate change and provide information, technical assistance, and recommendations for state and local governments.
12. Recognition of climate-induced environmental migrants: The scholarly literature identifies one significant challenge: the lack of official recognition from governments or international agencies of environmental migrants and refugees. While the IOM defines environmental migrants, it is essential to continue working to recognize them in international law and policy discussions.

We urgently call for a framework integrating Mitigation, Adaptation, and Societal Transformation (MAST) to address climate change and migration, as current protections for climate-change migrants are insufficient. The existing systems for safeguarding migrants and refugees are outdated and ill-suited for the challenges of climate change and environmental instability. The flaws in the current system are self-evident. Post-World War II policies, developed by the United States and its allies, assumed that the causes of displacement would eventually be resolved, allowing for temporary promises of non-refoulement, or the right not to be returned to danger (Suárez-Orozco and Suro, 2017). However, these frameworks are misaligned with current realities, as climate-degraded environments often offer no hope of safe return.

A new approach is necessary to address climate change-induced migrations. Without immediate action, the 3.6 billion people living in areas highly vulnerable to climate change will continue to face escalating environmental risks. The current status quo, characterized by zones of entrapment and forced migrations, endangers millions. A new global covenant is needed to protect the most vulnerable populations from a climate crisis they did not create.

Migration is a fundamental aspect of the human condition, rooted in our evolutionary history and adaptability. Modern migration patterns are closely linked to the environmental challenges of climate change, highlighting the need for comprehensive strategies. MAST exemplifies the approaches required today. By viewing migration through the lenses of our biological and social imperatives alongside the demands of climate adaptation, we can recognize its role as part of broader social transformations. Viewing climate migrants as threats to national security is akin to viewing humanity itself as a threat. Migration is a testament to human resilience and adaptability.

The relationship between human mobility and climate change presents challenges and opportunities for global policy. When climate change directly affects human security, protecting individuals and communities from disruptions and threats to their well-being becomes imperative. Whether people choose to migrate or not, the core of the debate must focus on the protection, dignity, and security of those affected by climate change. As we explore the impacts of climate change on migration, policies must evolve to support and manage migration, leveraging its potential benefits while mitigating risks. Implementing MAST strategies effectively will require cross-border and interdisciplinary collaboration, fostering resilience and empowering at-risk communities.

We must confront the reality that regions most vulnerable to climate impacts are already experiencing the beginnings of more significant waves of forced migration. Data suggests that hundreds of millions may be displaced by mid-century. To address this, we must enhance the resilience of vulnerable communities and strengthen international cooperation and commitment. Only through a coordinated approach, with robust support systems and proactive planning, can we effectively manage the challenges of climate-driven migration, ensuring safety and dignity for all affected populations.

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Governing in the Time of Climate Disruption

Maura T. Healey
Governor of Massachusetts

It is an honor to address this summit and its opening session, and I'd like to thank our chairs and the Pontifical Academy for the invitation. It's a pleasure to follow our chairs, in particular, Professor and Chancellor of the University of Massachusetts Boston Marcelo Suárez-Orozco. He is a leader not only in higher education, but so much more for Massachusetts, for our country, for our world. I am especially grateful to His Holiness, Pope Francis, for bringing us together, and for his unwavering global leadership on climate change and the collective responsibility and opportunity we share for "our common home."

As we gather this morning there are billions who are counting on us, particularly those who are the most vulnerable, the poor, the closest to the pain. Those folks do not have the wherewithal or the agency that we have. And so, we must act. At COP28, His Holiness spoke of the need for a "breakthrough that is not a partial change of course, but rather a new way of making progress together." Today, I humbly will focus on a new way of making progress in governing.

Last year in Massachusetts, many of our communities were struck by tremendous flooding at a scale and frequency no one could remember seeing before. After a series of severe rainstorms, rivers burst their banks and drainage systems were overwhelmed. Hundreds of farms were damaged, losing their entire season's crops just before harvest. I waded through fields, knee deep in muddy water with farmers whose hard work and investment were destroyed. Their communities suffered as well, because most of these farms supply food pantries that help our most vulnerable residents. We rallied the state to raise relief and keep our farms going.

We also paid attention to what these events were telling us. Weather events are more severe, more frequent, more damaging than ever before. Sea levels are rising more quickly along our 1,500 miles of shoreline in Massachusetts. Our infrastructure is aging, and much of it was not designed to withstand these conditions in the first place. Lives and livelihoods, business-

es and homes are all at risk. The same is true, of course, across the world. Climate change is hurting all of us.

As elected leaders, our response can no longer be seen as a question of ideology, or the work of a single agency focused on the environment. Rather, in my view, climate action falls squarely within the fundamental responsibilities of government – of a government who is there to protect public safety and prevent future harm; a government who is there to safeguard public resources; a government who is there to ensure stability in our economies.

In Massachusetts, getting to net zero carbon emissions by 2050 is not just the law, it is a social and economic imperative. But, like our aging infrastructure, our government systems were not designed to meet the scale or the urgency of this moment. We need to change the way we work to be more nimble, more innovative, and more collaborative, so we can work across every function of government in every sector of the economy. We need to align all our efforts around our climate goals. That means alignment of administrative infrastructure, alignment of science and policy, alignment of state spending, investment, and financing. It means alignment around a committed and internalized understanding that while we mitigate and build resilience, we must also prepare our communities physically, culturally, and psychologically, for the adaptation and transformation that is going to occur. And of course, we need to do this at a pace we've never seen before. In short, we need a new way of governing. And in Massachusetts, we've been working on a blueprint.

On my first day in office just over a year ago, I issued an executive order creating the Office of Climate Innovation and Resilience and the position of Climate Chief. We're the first state in the United States to do so and Chief [Melissa] Hoffer, whom I appointed, is here with us today. Now, the Climate Chief's principal responsibility, of course, is to advise me as governor on all matters related to climate. But more importantly, her charge is to be responsible for driving a climate agenda across every aspect of government.

Here's what that whole-of-government approach looks like. Every agency – education, transportation, health and human services, budget, so on and so forth – every agency has an appointed Climate Officer. They meet regularly with the Climate Chief, and they have goals to manage and to implement. In housing, for example, we're prioritizing the decarbonization of the building sector, which in urban areas drives up to 70 percent of

emissions. In transportation we're investing in public transit to get cars off the road, and we're building electric vehicle infrastructure. In education, we are funding energy efficient school buildings and teaching our young people climate careers through pathways in our high schools. In health care, we're looking to identify and mitigate the harms of extreme heat stress and air pollution. In emergency management, we're focused on readiness and resiliency. And across all these areas, we're prioritizing environmental justice to put first those who have been harmed most.

As Governor, I regularly engage with businesses, labor unions, philanthropists, community groups, and young people in this work. We've got to get everyone thinking about resilience and adaptation and then working together, and I know the Mayor of Boston shares this vision as well. It is a vision of an economy that works for everyone, and that recognizes the tremendous value nature provides in the form of clean water, healthy soil, forests, marshland that can help sequester carbon to protect those resources. It's an economy that also uses technology wisely to develop clean fuels, regenerative agricultural practices, and nature-based resilience solutions.

In Massachusetts, this approach is getting results. For example, last year we created the Massachusetts Community Climate Bank. It is the first green bank in the United States that is dedicated to decarbonizing affordable housing. We also developed a planning tool to ensure that our state capital budget is investing in plans that are consistent with achieving net zero by 2050 – because a big part of what government needs to do is align our spending with our climate goals, and see that we don't have to choose between a healthy economy and climate protection. We know that climate change threatens our insurance and our real estate markets and financial systems. Climate protection is an essential element to a healthy economy.

President Biden has led the way with what is the largest clean energy investment in America's history. In Massachusetts, we are using that opportunity to deploy our unique talent for innovation to help solve the climate crisis. Our economic development legislation calls for a $1.3 billion investment in technologies that will accelerate the energy transition, decarbonize the economy, and increase resilience. In Massachusetts we are home to one of the world's leading climate tech ecosystems, with research universities, startups, venture capital, all connected. We have companies commercializing technology developed in our universities that right now are working to decarbonize steel, cement, working on battery production, hydrogen fuel and so much more.

I'm proud that in Time Magazine's list of top climate technology companies, 28 of them are based in Massachusetts. These are companies that are spun from our ecosystem of colleges and universities, which we invest heavily in, which will green the global economy and return our investments many times over. We've done this before in Massachusetts, we've invested in medical science and became the world's global hub for Life Sciences, a producer of life saving cures and vaccines. I want us also to be the global innovation lab for the clean energy revolution.

Now to do that, we're going to need a number of well-trained and well-paid workers. Because the heroes of this revolution will be the electricians, train operators, heat pump installers, wind turbine technicians, and much more. We need people who are skilled and ready to do these jobs, and we need to bring these opportunities to those who need them most. This means adapting our education and training systems along with our economy. So, we've been working with our schools, with our colleges, with our unions, and with employers to create new pathways into climate careers.

Today, I am proud to announce the Massachusetts Climate Careers Fund. This is a first-of-its-kind social impact fund to grow and support a workforce that is training in climate technologies. This fund will leverage philanthropic, public, and private-sector resources to accelerate the work. It will provide no-cost loans to support high quality training, including supportive needs such as childcare and transportation – because if you're going to educate, you need to treat the whole person. This will enable, importantly, more women, more people of color, more low-income residents to participate in this clean energy economy and revolution in our state. It's a recycling fund, where workers and employers pay back the loans into the fund as they accumulate income, which will help train more people and fill more jobs.

The Massachusetts Climate Careers Fund is led by Social Finance, the innovator of social impact investment. Its co-founder and CEO Tracy Palandjian is here this week, and we're so grateful for her partnership. In Massachusetts, we cherish a history of mission-driven innovation. We're America's state of firsts – the first public school, public library, park, and subway system all built in Massachusetts. We pioneered cancer treatment, computers, and COVID vaccines. As we speak, America's only utility-scale offshore wind farm is operating off our coasts, powering thousands of homes and businesses. America's first green bank for affordable housing is making environmental justice a reality for communities. The first social impact fund for climate careers is set to launch. These are the innovations unlocked so far by our

blueprint for a new approach to government in this era of climate change. We're eager to see them built on across America and the world.

We know there is so much we can and must do. I want to acknowledge that this is a challenging time, a hard time for leaders in government and outside elected positions as well. We are being tested; we will be tested. We will continue to need to support our communities and our people as they face, as we face, unfathomable loss and tragedy. But this should not discourage us. It should only motivate us to align government and governing with this new reality. It requires a fundamental change in both what and how we do it. That's what we're doing now – leaders in this room, navigating an unprecedented challenge by creating new paths bringing government together with our corporate, academic, and advocacy partners.

Governing in this time of climate disruption requires us to be serious about transforming how we work. It takes a willingness to listen, to adapt, to change, and to grow. It takes a commitment to break through barriers that divide our work and to truly collaborate across government, academia, industry, philanthropy. It's something I will encourage all of my fellow governors to do. I'm grateful for the opportunity to be here to learn and to foster collaboration. It is our obligation to those we serve and represent to seize upon collective action for our common home, a home more just, more equitable, more healing for our planet and our communities. We gather in this room on holy ground, where others have gathered in times of challenge, where others have gathered seeking answers, understanding, and resolve. This is our time, and this is our work. Thank you.

YOUTUBE PRESENTATIONS

Mohamed Hassan

https://youtu.be/07xY8l7J2s8?si=-jhKGIYMxQiisTsa

H.E. Dr. Wilber K. Ottichilo E.G.H.

Governor of Vihiga County, Kenya

https://youtu.be/jnwtuxEkyx4?si=b0OJGUVyulW9Ik8s

Hon. Roberto Gualtieri

Mayor of Rome

https://youtu.be/a4b-sxUjCkc?si=J7MEGRbPoEmsabA3

Hon. Ricardo Nunes

Mayor of São Paulo

https://youtu.be/5Ik4iLxg1C4?si=SgJ2Uj6Lh5fciLFh

SESSION II – WATER

Sponge Planet: A Holistic Unified Water-Based Solution to the Climate Emergency

Kongjian Yu
Peking University and Turenscape

Abstract

This paper critically assesses the shortcomings of current climate crisis mitigation adaptation strategies, particularly the reliance on carbon reduction and gray infrastructure and proposes the Sponge Planet Model (SPM) that focuses on practical, scalable, water-based (thus community-based) solutions that aim to address the "tragedy of the commons" in carbon-focused climate mitigation strategies and singular-goal minded unsustainable gray infrastructure-centered adaptation strategies.

1. Introduction

The climate crisis presents an unprecedented challenge, characterized by rising global temperatures, increasing sea levels, extreme weather events, and a significant loss in biodiversity. Despite global efforts to reduce carbon emissions, the impacts of climate change continue to escalate, pointing to the necessity for more innovative solutions. The following four major challenges are critical areas requiring attention and action:

(1) The Inadequacy of Carbon-Centered Mitigation Strategies and the Need for a Holistic Approach: Current carbon-focused mitigation strategies fail to comprehensively tackle climate change, often missing out on nature-based solutions and the necessity to address socio-economic inequalities (von Braun et al., 2022). Furthermore, the reliance on carbon offsets has been criticized as mere "greenwashing," enabling ongoing excessive consumption without substantial emission reductions, a concern highlighted by Pope Francis in his 2015 encyclical, *Laudato si'* (Pope Francis, 2015). A combined approach of mitigation and adaptation is essential for sustainable results.

(2) Unsustainable and Short-Sighted Gray Infrastructure-Centered Adaptation: Traditional adaptation strategies often focus on gray infrastructure, such as concrete dams, seawalls, levees, and aqueducts, which

typically provide short-term, singular solutions. While widely used, these gray infrastructure approaches have demonstrated limitations in delivering long-term resilience and sustainability. This raises the need for more integrated solutions, combining gray infrastructure with Nature-Based Solutions (NBS) to enhance effectiveness and sustainability (Seddon, 2020).

(3) Unfocused Nature-Based Solutions: Although Nature-Based Solutions (NBS) offer a sustainable approach to climate change adaptation, there is often a lack of focus on where investment in these solutions should be directed. This challenge calls for a more targeted approach to NBS, and how to create Nature-based Infrastructure, ensuring that the most effective strategies are prioritized for investment and implementation.

(4) Politics of No One's Responsibility: The "tragedy of the commons" is a well-known concept that describes the dilemma of collective resource management. Climate change presents a similar challenge, where responsibility for addressing it is often unclear or dispersed among various stakeholders. This challenge involves finding ways to navigate the political landscape to ensure that collective action is taken, and that accountability is established among governments, corporations, and individuals.

As the global community confronts these escalating challenges, the necessity for a paradigm shift towards more holistic and inclusive approaches becomes evident. Strategies that prioritize ecosystem-based adaptation, sustainable agriculture, and comprehensive water management are essential to navigate the complexities of the climate crisis and secure a resilient future (Colls, Ash, and Ikkala,2009, Miller & Belton, 2014).

2. Towards a Unified Water-Driven Strategy for Nature-Based Solutions

In response to the challenges outlined, the author introduces a comprehensive and inclusive green-gray infrastructure solution called the Sponge Planet Model (SPM). This model shifts the focus from carbon to water as the key to building resilience against climate challenges. An evolution of the Sponge City concept, the SPM has been tested at scale in China and internationally (Yu et al., 2015; Yu, 2017; Gies, 2022; Peng et al., 2022). By positioning water at the heart of climate adaptation, the SPM integrates water management, ecological resilience, and urban infrastructure to address both climate change and its impacts. Drawing inspiration from natural systems and centuries of wisdom in managing irregular rainfall and monsoon climates, the SPM is based on three core principles: capturing

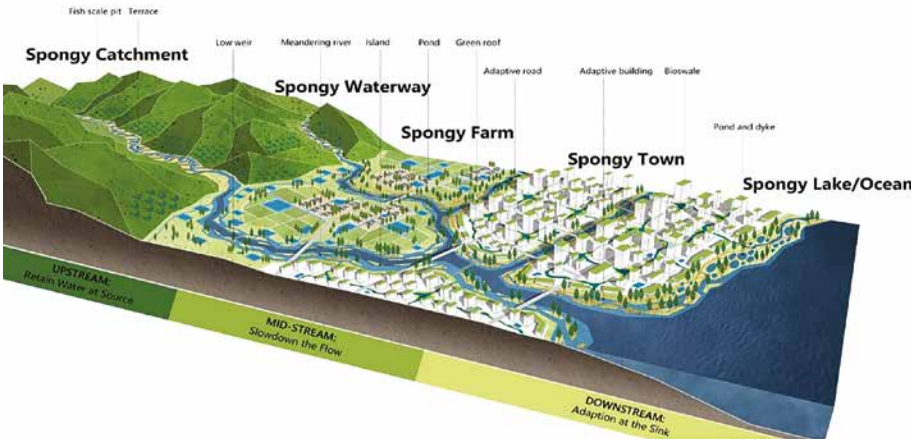

Figure 1. Sponge planet: a watershed model.

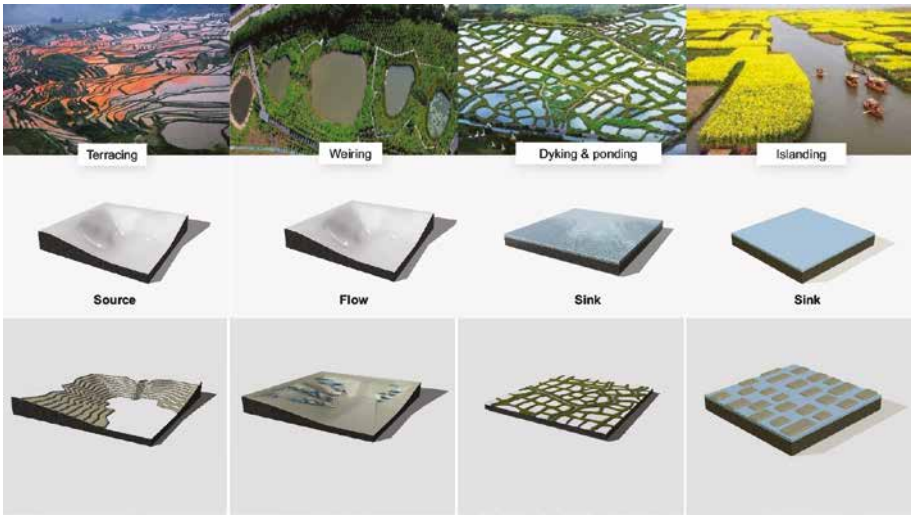

Figure 2. Sponge planet: Modular practicing techniques inspired by ancient farming wisdom adapting to changing climate (Yu, 2019; 2021).

rain where it falls, slowing water as it moves, and adjusting human activities and infrastructure to fluctuating water levels by creating more space for water on land. These principles are in stark contrast to conventional gray infrastructure solutions. Beyond mitigating the adverse effects of climate change, the SPM aims to restore biodiversity and natural habitats, offering a holistic solution to the environmental, social, and economic challenges posed by climate change.

2.1 Retaining Water at Its Source

The core of this principle lies in the strategic retention of water where it falls, advocating for a decentralized approach to water management. Unlike conventional methods that focus on concentrating water in dams and reservoirs – often leading to environmental degradation and a heightened risk of failure, as tragically demonstrated in recent events in South Brazil, Kenya, Pakistan, and even in the arid Libyan desert – SPM emphasizes the importance of porous landscapes and permeable land surface. These features allow rainwater to be absorbed and stored underground, replenishing aquifers and maintaining soil moisture. This approach champions a sustainable alternative, reducing the risks associated with large-scale water infrastructure while supporting local ecosystems.

(1) Conventional Solutions of Centralized System: Centralized water management systems have been the cornerstone of urban planning and agricultural practices for centuries. These systems, characterized by the concentration of water through dams, long-distance aqueducts, and the drainage of water via channels and impermeable surfaces, have supported the growth of cities and agricultural productivity. However, they also embody significant environmental and social costs, including habitat destruction, water over-extraction, and the displacement of communities (Kusena, 2022).

(2) Retaining Water at Its Source: Transitioning to a decentralized, nature-based system marks a critical paradigm shift in water resource management. This approach, inspired by the inherent properties of the SPM, emphasizes water retention at the source through porous landscapes, terraces, localized small pond systems, and distributed water management. Unlike conventional systems that expedite water runoff, these nature-based solutions slow down water flow, allowing for natural filtration and recharge of groundwater, thus enhancing the resilience of ecosystems to climate variability (Goodwin et al., 2023).

(3) Benefits of Retaining Water On-Site: The benefits of onsite rain retention extend far beyond water management. By mitigating the impacts of floods, drought, and fires, these practices contribute significantly to climate crisis adaptation. Ecologically, they support biodiversity and habitat restoration (O'Leary et al., 2023). Socially and economically, decentralized water management reduces infrastructure costs, lowers the risk of waterborne diseases, and promotes community engagement in sustainable practices (Pan et al., 2023). Moreover, the replenishment of

aquifers and the enhancement of soil moisture through these methods secure food production and water supply in an era of unpredictable climate patterns (Razzaghi et al., 2020).

2.2 Slow Down Flow

Unlike traditional drainage systems that quickly divert water away from urban areas, often exacerbating downstream flooding and depleting valuable water resources, the SPM proposes the creation of meandering green-blue integrated waterways. These systems, designed to emulate natural river dynamics, not only enhance infiltration and reduce flooding risks but also foster biodiverse, multifunctional spaces beneficial to communities.

(1) Conventional Drainage Solutions in Addressing Floods: Traditional drainage systems, often referred to as 'gray infrastructure,' have long been the foundation of urban water management. These systems, which rely on concrete, pipes, and pumps, are engineered to rapidly divert water from built environments, reducing waterlogging and mitigating potential flood damage in urban areas. Components such as sewers, concrete channels, and storm drains are designed for efficient water conveyance, directing runoff swiftly to nearby water bodies. However, this approach presents notable limitations. It accelerates water flow, increasing the risk of downstream flooding, while also reducing groundwater recharge and disrupting natural hydrological cycles that eventually contribute significantly to sea level rise (Schultz, 2011; Wood and Hyndman, 2017, 2018). The environmental consequences are significant, contributing to ecosystem degradation, loss of biodiversity, and the urban heat island effect due to the prevalence of impermeable surfaces. In response, more sustainable alternatives, including nature-based solutions (NBS), are being developed globally (Fletcher et al., 2015; Well & Ludwig, 2021), with Sponge City emerging as a comprehensive approach (Yu et al., 2015).

(2) Slow Down Flow: A Paradigm Shift in Drainage Systems: The "Slow Down Flow" principle marks a significant departure from traditional drainage systems, which focus on rapidly channeling water away. This new approach prioritizes moderating water flow, encouraging infiltration, and replicating natural hydrological patterns. Features like meandering green-blue waterways and low weirs, as opposed to high dams, are key to this method, fostering interaction between vegetation and water to slow movement.

(3) The Importance of Slowing Down Flow: Slowing water flow is essential for flood risk reduction, as it decreases the destructive force of water and promotes more even distribution across landscapes, providing a sustainable alternative to traditional flood management methods (Qi et al., 2020; Peng et al., 2022). This strategy also promotes biodiversity by replicating natural river patterns, increasing habitat complexity, and supporting diverse species (Graziano et al., 2022; Yu, 2013). Furthermore, green-blue "sponge" systems improve water quality by filtering pollutants through natural filtration and bioremediation processes (Kumwimba et al., 2023).

Beyond the ecological and functional advantages, these spaces enhance residents' well-being by increasing waterfront safety, offering recreational opportunities, improving urban aesthetics, and providing educational value to communities.

2.3 Embracing Water Surplus – Giving Water More Space

As climate-related water crises become more severe and frequent, it's important to rethink traditional flood defense strategies. In the past, these methods focused on building strong barriers and complex systems to prevent flooding. However, these approaches have limitations and often harm the environment. This shows the need for a shift toward more sustainable solutions, like the "Embracing Water Surplus" principle, which offers a more adaptive and water-friendly way to manage floods.

(1) Conventional Defensive Solutions: Traditional flood defense strategies focus on physical barriers, such as flood walls and sea walls, coupled with extensive networks of pipes and pumps to manage urban and regional flooding. This 'resistance' approach seeks to hold back or quickly divert water away from vulnerable areas. While these methods can offer immediate protection, they often result in ecological damage and heightened vulnerability to climate change. In response, SPM (Sponge City Planning) advocates for a paradigm shift towards giving water more space and harnessing natural processes for water management. This includes adaptive designs in urban and building forms that minimize the need for defensive actions, promoting resilience through sustainable, ecological solutions.

(2) Embracing Water Surplus: SPM introduces a transformative approach to water management with its "Embrace Water Surplus" principle. This concept reimagines excess water as an opportunity rather than a problem, advocating for landscapes and infrastructures that leverage surplus water

for ecological and urban benefits. Instead of relying solely on traditional barriers, SPM promotes strategies such as wetland restoration, flood parks, and utilizing available spaces to absorb and manage excess water. The approach emphasizes adaptive designs in buildings and infrastructure, incorporating features like elevated siting, raised thresholds for homes, and integrating skywalks in urban environments (Yu, Zhang, & Li, 2008; Yu,2021). These solutions aim to harmonize urban development with natural hydrological cycles, fostering resilience against flooding while enhancing urban livability.

(3) The Benefits of Embracing Water Surplus: Adopting nature-based solutions to embrace water surplus effectively mitigates flood risks and reduces the impact of extreme weather events. Additionally, it provides essential ecosystem services, including water purification, habitat creation, and carbon sequestration, all of which are vital for enhancing urban resilience and promoting public health (Oral et al., 2020; Lallemant et al., 2021; Penning et al., 2023).

Beyond ecological advantages, the development of flood parks and green spaces yields significant socioeconomic benefits. These include increased recreational opportunities, improved mental health, and higher property values, which together contribute to the creation of healthier and more vibrant communities (Kolimenakis et al., 2021). These multifunctional spaces not only strengthen environmental sustainability but also foster social well-being and economic growth.

3. Demonstrating Sponge Planet

For the past 30 years, the author and his team have tested the Sponge Planet Model (SPM) in over 250 Chinese cities, implementing more than 1,000 projects across various scales, from entire watersheds spanning hundreds of square kilometers to urban sponge parks covering hectares. These initiatives have been proven successful, with significant performance results (Saunders, 2012; Yu et al., 2015, Yu, 2019; see: www.turenscape.com). The following three examples demonstrate this success, each illustrating one of the core SPM principles.

(1) Retention: Retaining Water at Its Source: Bangkok Benjakitti Forest Park morphs from industrial to ecological marvel, showcasing "Principle 1: Retention" at its core. The park's cut-and-fill strategy forms porous landscape made of wetlands and islets, holding 200,000 cubic meters of stormwater, buffering the city against monsoon impacts. This transforma-

tion not only curtails flooding but fosters biodiversity, proving urban spaces can harmoniously coexist with nature-based water solutions, enhancing urban resilience and community spaces (Yu and Wang, 2023).

Figure 3a.

Figure 3b.

Figure 3a,b. Retention: Bangkok Benjakitti Forest Park, before vs after.

(2) Slow Down: Managing Urban Water Flows. Liupanshui Minhu Wetland exemplifies "Principle 2: Slow Down Flow," transforming a polluted and channelized drain into a thriving, clean waterway. By reintroducing wetlands and low weirs, it combats flooding and pollution, weaving the community back into the urban fabric with green spaces and recovered native habitats. Its approach demonstrates the synergy between civil engineering and ecological design, serving as a benchmark for urban waterway revival (Yu, 2019).

Figure 4a.

Figure 4b.

Figure 4a,b. Slowing Water Flow in Liupanshui Minhu Wetland: The creation of low weirs and wetlands along the watercourse helps to slow down water flow and restore the degraded river. The comparison illustrates the changes before and after the intervention.

(3) Embracing Flood and Mitigating Drought in the Urban Center: Sanya, on southern China's Hainan Island, has long been impacted by severe flooding and urban inundation due to the monsoon climate and global climate change. These challenges, along with pollution and habitat loss, made the city an ideal testing ground for SPM. Dong'an Wetland has since become one of the most significant multifunctional demonstration projects of China's nationwide sponge city initiative. Inspired by ancient farming wisdom, the project was completed swiftly, cost-effectively, and designed for large-scale replication. The green sponge system consists of hundreds of pond-dykes, forested islands, and a flood-adaptive network of skywalks above the canopy and boardwalks below it. This water-driven holistic solution addresses numerous climate challenges, including flooding, drought, biodiversity loss, and urban heat. Additionally, it has spurred economic development, increasing surrounding property values by 400% and reducing temperatures by 8°C under the canopy (Yu, 2021).

Figure 5a.

Figure 5b.

Figure 5a,b. Embracing Water at Sanya Dong'an Wetland, Hainan Island, China: A sponge city was created by giving water more space in the heart of the city, addressing issues of monsoon flooding and drought, while also restoring a native habitat and providing much-needed public space.

3 Conclusion: Towards a Holistic and Unified, Water-Driven Paradigm in Nature-Based Climate Solutions

The Sponge Planet Model (SPM) offers a holistic, nature-based approach that is vital for addressing the climate crisis through integrated water management strategies. It challenges carbon-centric mitigation and conventional gray infrastructure adaptation solutions by prioritizing water-centric methods that address both mitigation and adaptation. SPM enhances biodiversity while providing socio-economic benefits. It promotes a shift from unsustainable gray infrastructure to more sustainable green-gray systems, focusing on water retention, slow flow, and the use of surplus water, making nature-based solutions more precise and impactful. By fostering interdisciplinary collaboration and advocating for a global transition from gray to green infrastructure, SPM builds strong connections with communities, offering a resilient and sustainable future. This approach reimagines our relationship with the environment, advocating for innovative, territory-based solutions that address climate challenges through practical water resource management.

Implementing SPM principles presents challenges like policy integration, interdisciplinary collaboration, long-term planning, community engagement, funding, and, most importantly, shifting from a carbon-dominant to a pragmatic down to earth, water-driven NbS approach – while sustaining carbon reduction efforts. Key priorities include interdisciplinary research, supportive NbS policies, and increased community participation in decision-making. These steps will promote water-driven climate strategies that integrate ecological restoration and biodiversity enhancement at global, national, regional, and local scales. The ultimate goal is to restore a "Sponge Planet" through holistic, water-centric design to tackle global water mismanagement.

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Synthesis for Session II Water: Transformative Action Needed Now

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> "Fresh drinking water is an issue of primary importance, since it is indispensable for human life and for supporting terrestrial and aquatic ecosystems. Sources of fresh water are necessary for health care, agriculture and industry. Water supplies used to be relatively constant, but now in many places demand exceeds the sustainable supply, with dramatic consequences in the short and long term. Large cities dependent on significant supplies of water have experienced periods of shortage, and at critical moments these have not always been administered with sufficient oversight and impartiality. Water poverty especially affects Africa where large sectors of the population have no access to safe drinking water or experience droughts which impede agricultural production. Some countries have areas rich in water while others endure drastic scarcity … the deterioration of the environment and of society affects the most vulnerable people on the planet."
>
> Pope Francis, *On Care for Our Common Home*

> "Water is the lifeblood of humanity. It is vital for survival itself and supports the health, resilience, development and prosperity of people and planet alike. But humanity is blindly traveling a dangerous path. Vampiric overconsumption and overdevelopment, unsustainable water use, pollution and unchecked global warming are draining humanity's lifeblood, drop by drop. The effects are all around us – from climate change-driven heatwaves, droughts, floods and violent storms, to the world's supply of fresh water being contaminated by pollutants, chemicals and torrents of salt water from rising seas."
>
> António Guterres, Secretary General of the United Nations,
> 2023 UN World Water Development Report

1. Introduction

"Water is life" declared Dr. Narain in her Water Session talk, as water is essential for humans and ecosystems to thrive. To meet human needs, presently irrigation accounts for approximately 70% of total global water withdrawals, followed by industrial use at 18% and municipal use at 12% (United Nations, 2023). The report also notes that there exist important regional differences in water use; e.g. in South Asia, the amounts are 91% for irrigation, 2% for industrial, and 7% for municipal. Instream uses support hydropower production, recreation, thermal and nuclear power plant cooling, and provide flows for shipping and ecosystems. Caretta et al. (2022) reports that probably

approximately 50% of the global population now experience severe water scarcity at least part of the year and, at the opposite end of the spectrum, 44% of all disasters since 1970 are flood related. More ecosystem degradation and water-related disease outbreaks are now also occurring (Caretta et al., 2022). Populations that are vulnerable due to gender, income, age, being indigenous are and will continue to be the most impacted (Caretta et al., 2022).

Figure 1 shows the Global Water Security Index, which combines indicators of freshwater availability, water services, water management, water quality, and flood risk (Caretta et al., 2022). As can be seen, with the excep-

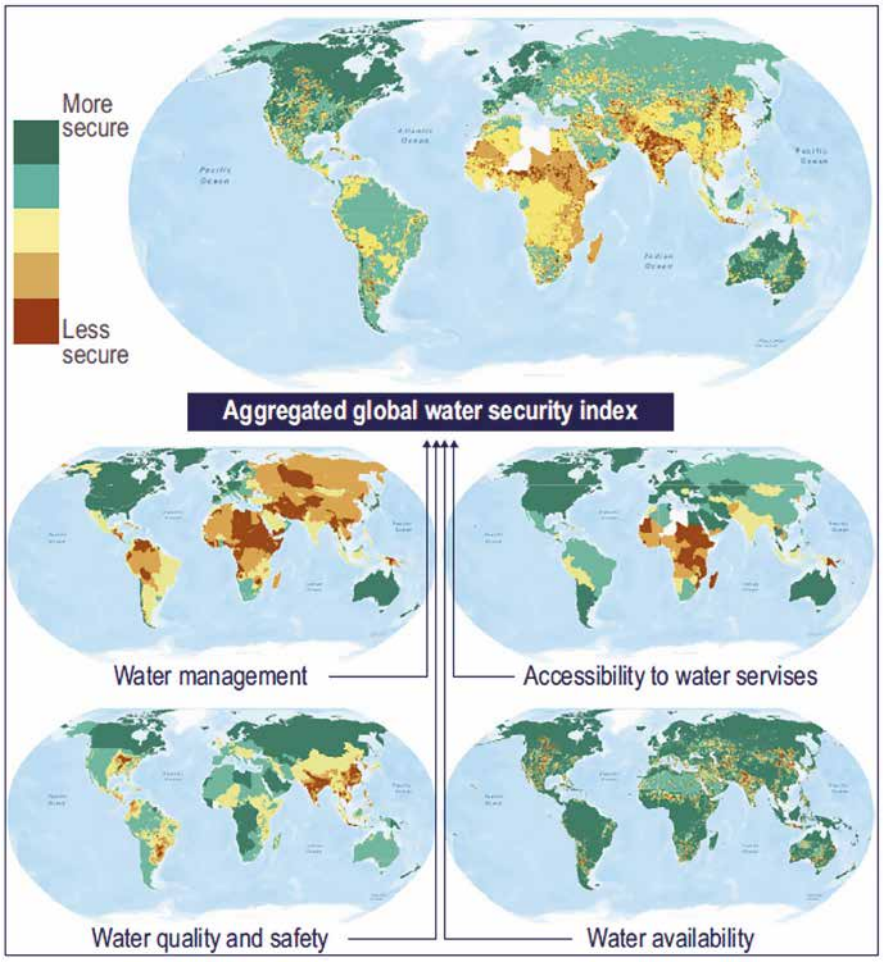

Figure 1. Present Values of Global Water Security Index (from Caretta et al., 2022).

tion of parts of South America, there is considerably less water security in the Global South than elsewhere. With global water demand projected to increase by 20-30% by 2050 (Caretta et al., 2022) and with climate change increasing the frequencies of floods and droughts, water security will decrease unless management actions are taken.

The papers from the Water Session provided detailed evidence of these water challenges in the Global South and elsewhere. For examples, Dr. Narain reported that extreme precipitation has increased significantly in parts of India and this and other climate changes in some cases are causing migration; Dr. Kimutai noted that due to local increases in precipitation, lake levels have permanently risen in the Rift Valley Lakes in Kenya destroying some livelihoods; Dr. Strzepek pointed out the challenges smallholder farmers in Southern Africa, who regionally produce the most food, face because of increasing droughts and subsequent decreases in yields; Dr. Yu described the increased global failures of urban drainage networks that rely upon traditional gray infrastructure; and Dr. Muhinda discussed how climate change has contributed to ecological degradation of agricultural land through hillside soil erosion, landslides and recurrent floods.

Thus, there is an urgency to increase the resilience of our water resources to not only current challenges, but also to the new, uncertain threats from climate change. This synthesis paper reviews some of the common themes of the session's papers and other sources on water-related challenges and management strategies relevant to the Global South. Before this is presented, however, at least two of the threats not covered in this session must be summarized.

Much of the world's population, economic activities and critical infrastructure are concentrated in the coastal zone, with 41% of the global population living within 100 km of the shoreline (Martinez et al., 2007). Additionally, coastal ports provide critical pathways to transport materials into the interior of a region. These areas are particularly vulnerable: they are affected by compound disasters from both the land and the sea. In addition, sea level rise impacts freshwater resources by salt water intrusion into groundwater, increasing salinity in estuaries, and impeding urban drainage into oceans.

Another additional threat is the reduction in the extent of inland glaciers in the Andes and Central Asia as mentioned by Dr. Narain. These will result in significant declines in streamflows that could affect agriculture, industrial production, and municipal supply. By mid-21 century, these impacts may be felt by 1.5 billion people (Caretta et al., 2022)

2. Cross-Cutting Stresses

The first cross-cutting theme from the Water Session is that while reducing greenhouse gases is top priority, it is too late to reverse the impacts of climate change and transformative adaptation is thus urgently needed.

All the session's papers noted that the causes of present and future water stresses are due to both hydrologic conditions as well as socio-economic conditions. For examples, Dr. Kimutai and Dr. Muhinda describe how land use and settlement patterns result in flood losses, not just extreme flows. Dr. Strzepek notes that drought impacts occur due to both demand and supply conditions.

Another common thread addressed by all the speakers is that the Global South is suffering the most under climate change while generally contributing the least to global emissions – an instance of environmental injustice; "the ultimate immorality" as stated by Dr. Narain. Additionally, the Global South encompasses pockets of impoverished and marginalized people with low adaptive capacity and weak institutions, high population growth rates, and sometimes civil unrest. Therefore, these regions face both excess burdens from climate change and limited capacity to adapt to their effects. For example, as Dr. Strzepek notes, globally smallholder farmers (84% of farms globally) will suffer the most from drought as they have high sensitivity to rainfall and low adaptive capacity. These overlapping challenges illustrate how improving adaptive capacity in the Global South must be a priority.

Another theme is that many regions of the world suffer from multiple water threats, not just a single threat. For example, large parts of West Africa, South Asia and other regions suffer from both floods and droughts, have large coastal zones, are heavily populated by cities with limited water infrastructure, and are highly dependent upon rain-fed agriculture. Dr. Kimutai pointed out that flood impacts in Kenya's Rift Valley Lakes were exacerbated by recurring droughts. Beside economic losses, the counties of the Global South face cultural and biodiversity losses and public health impacts from all types of disasters. Therefore, the management of one water challenge cannot be looked at in isolation from the others, or from the social, cultural, and political systems in which they are embedded. Out-migration and displacement from water-scarce or flooded regions are occurring to escape these climate threats. In addition, many of the river basins facing risks from climate change are transboundary – requiring extensive negotiation and governance regimes for sustainable management.

In fact, related to the above, many nations not only face threats to water resources, but also to air quality, food, energy, and others and these

threats are all inter-related and need to operate in unison, e.g. the Food-Energy-Water Nexus (e.g., see D'Odorico et al., 2018). Therefore, these challenges must also be cross-sectionally managed, the growing field of Multi-Sector Dynamics (https://multisectordynamics.org/). As an example, Dr. Muhinda related agricultural challenges to not only water management, but also to land use.

Another common thread is that many nations of the Global South are challenged to meet the targets of Sustainable Development Goal (SDG) 6 – "Ensure Availability and Sustainable Management of Water and Sanitation for All." Presently, two billion people are without safe drinking water and 3.6 billion are without safe sanitation (United Nations, 2023). Other SDG 6 targets include reducing water pollution, increasing water reuse, increasing water-use efficiency, implementing integrated water resources management (IWRM) and transboundary cooperation, restoring and protecting ecosystems, supporting the Global South in expanding capacity building, and strengthening participation of local communities in water management. The Global Water Partnership (2009) defines IWRM as a "process that promotes the coordinated development and management of water, land, and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." IWRM is carried out in the social, cultural, and political systems in which a water system is embedded. SDG 6 is closely related to all the other Goals, for examples, poverty reduction, hunger, health, education, justice, energy, livelihoods, and cities. Climate change threatens the ability to achieve any of the SDGs.

Given the increase in climate risk and the highly interconnected nature of water systems, there is the need for rapid adaptation of water resources to climate change. A review of a few water-related adaptation concepts suggested at the Summit and elsewhere follow. The end result must be affordable water for all (Dr. Narain).

3. Cross-cutting Solutions

An initial action is to implement holistic water security planning throughout the Global South. Water security is "the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water related risks to people, environments and economies" (Gray and Sadoff, 2007). World Bank (2018) reports that UN-Water expanded this to "the capacity of a popu-

lation to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against waterborne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability." For SDG 6, UN-Water (2020) emphasizes this could be achieved by accelerating 1) Financing; 2) Data and information; 3) Capacity development; 4) Innovation; and 5) Governance. The importance of good governance cannot be overlooked. Dr. Muhinda noted that the success of the ecosystem restoration program in Rwanda was partly due to strong governance. In general, "the objective should be to simultaneously balance economics, societal well-being, and sustainability – acknowledging that no one of them can be achieved if one is dropped" (personal communication, Jonathan Lamontagne).

Nature-Based Solutions (NBS) present an alternative to traditional grey approaches and can possibly manage many of the compound climate threats to water systems. NBS are engineered systems that mimic some aspects of natural systems and they are supported by a growing field of research and practice. In addition, they have important social and environmental co-benefits. For example, Sponge Cities mentioned by Dr. Yu in this session not only help manage urban flooding but also provide groundwater recharge for water supply, create habitat, provide recreation, counter urban heat island effect, and store carbon. Several of the speakers recognized that such effective approaches are based upon valuable indigenous knowledge.

Associated with NBS are other low technology, decentralized, democratic approaches to water management that need to be expanded – many based upon indigenous knowledge. For example, these strategies include the small reservoir storage systems in the Sahel-Sudan and Sri Lanka, regenerative agriculture, water conservation and floodplain management, and preservation of wetlands and marshes. Widely cited low-tech approaches for improving agricultural productivity also include access to markets and services, safety nets, increased agricultural research, information and credit availability, and the adoption of farming practices that improve climatic resilience.

At the other end of the spectrum are options for advanced technology in water management, with specific attention to multi-sectoral design avoiding the past approaches of viewing water in isolation. Much of this can be implemented while rebuilding from natural and human related disasters or in areas with existing minimal services with the goal of leapfrogging over, as Dr. Narain pointed out, some of the past single sector, silo-based

approaches. In a fully connected system, water management is considered a circular system with no water seen as waste and the outputs from one sector are re-cycled or re-used in another. In an urban area this is referred to as Integrated Urban Water Management (IUWM), which is the holistic management of urban water supply, sanitation, stormwater, and wastewater to achieve sustainable economic, social and environmental objectives. All parts of the urban water cycle are managed together instead of separately. There are already a few global examples of direct potable re-use which not only solves the water supply problem but also the wastewater problem. Safely capturing the water, heat and nutrients in urban wastewater for use in other sectors is also possible as Dr. Narain and others also emphasized. The overall goal is "reduce, remove, reuse, recycle" (Carretta et al. 2023). Using sensors, monitoring technology, weather forecasting and advanced management algorithms can to lead "intelligent" water management with significant cost savings and efficiency in all water sectors, particularly in cities and agriculture (e.g. see Kerkez et al., 2016). Machine learning to unravel complex data sets and/or replace or augment traditional process based hydrologic and hydraulic models is also feasible (Ghobadi and Kang, 2023). For example, Tulbure et al. (2022) used machine learning algorithms combined with remote sensing, another available advanced tool, to generate historic surface water flooding.

Dr. Kimutai and others stated transformative funding is also urgently needed. For example, the World Bank estimates that funding to meet water supply and sanitation goals in the Global South need to increase by 200-300% annually (https://www.worldbank.org/en/topic/water/publication/funding-a-water-secure-future).

In regards to the adaptation planning process, advanced algorithms for decision making under the deep uncertainty of climate change are being integrated with participatory planning methods within the frameworks of IWRM and Multi-Sector Dynamics to develop innovative and equitable adaptation strategies to climate changes using adaptive management (e.g., see Marchu et al., 2019).

4. Summary

Climate change presents threats to water systems that unequally impacts the Global South, indicating the pressing need for effective and thoughtful adaptation. Water systems are highly connected to each other and to other sectors such as health, and we must design our adaptations to reflect that and

the societal, cultural, and political contexts in which they exist. Approaches for adaptation should be guided by holistic, participatory planning and designed to simultaneously bolster resiliency in multiple systems against many threats using a variety of appropriate approaches. More research is needed on all aspects of water management to hasten the transformative changes needed.

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YOUTUBE PRESENTATIONS

Building New Water Practices for Resilience in the Age of Climate Change

Sunita Narain

Director General of the Centre for Science and the Environment, India

https://youtu.be/7OIemZ84LfQ?si=3CCH-GlraxR5DOP7

Floods: Is Horn of Africa Prepared?

Dr. Joyce Kimutai

Research Associate in the Analysis and Interpretation of Climate Data for Extreme Weather, African Climate & Development Initiative, University of Cape Town

https://youtu.be/huc3aTFOybM?si=CetPZAzPP0E3yINE

Climate Change and Drought: The Impact on the Invisible 60% of Africa's Population

Kenneth Strzepek

MIT Jameel Water and Food Systems Lab, International Food Policy Research Institute, Industrial Economic, Inc.

Rev. Len Abrams

Church of England, Development Consultant

Timothy S. Thomas

Senior Research Fellow, International Food Policy Research Institute (IFPRI), Washington DC

https://youtu.be/Jd_205SHlMY?si=SzdrWKgCqUHdRbBX

Africa's Vulnerability to Climate Change

Jean Jacques Muhinda

AGRA, East Africa

https://youtu.be/A4TTTcvoJ0Q?si=bJgHERIFekvC4p5d

SESSION III – AIR

Fossil Fuel-Attributable Air Pollution Deaths

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Abstract

The World Health Organization highlights the severe impact of air pollution on human health, leading to millions of excess deaths a year globally. Previous studies have suggested that switching from fossil fuels to renewable energy sources could save lives and limit climate change. However, estimates of mortality from air pollution vary widely. This study uses new risk functions, an updated global atmospheric model and exposure data to assess the health consequences of phasing out fossil fuels. The results suggest that a worldwide phase-out of fossil fuels could avoid approximately five million excess deaths a year from air pollution, particularly in the densely populated South and East Asia, where air quality is strongly compromised. The study emphasizes the urgent need to transition from fossil to clean energy sources to achieve significant health benefits.

1. Introduction

The World Health Organization (WHO) emphasizes the profound impact of air pollution on human health, likening its effects to tobacco smoking. The recently updated WHO air quality guidelines reflect this concern [1]. However, these guidelines are violated in most countries worldwide, which causes millions of excess deaths annually, as reported in the 2019 Global Burden of Disease (GBD) study [2]. Transitioning from fossil fuels to renewable energy sources could prevent many of these deaths and help limit the global temperature rise to below 2°C, aligning with the Paris Climate Agreement. However, estimating the mortality burden from degraded air quality is challenging, with varying estimates and limited studies assessing outcomes due to all pollution-related causes of death, while a larger number of analyses have addressed specific disease categories.

The present report is based on a recent study, reported in *The BMJ*, which evaluated the impacts of phasing out fossil fuels on disease-specific and all-cause mortality attributable to air pollution [3]. It contributed to

the United Nations Climate Change Conference, i.e., the Conference of the Parties of the UNFCCC, or COP28, held in Dubai, United Arab Emirates, in 2023. The research utilized a new risk model and updated exposure estimates to fine particulate matter with a diameter of less than 2.5 μm ($PM_{2.5}$) and ozone [4]. An Earth system model was employed to calculate atmospheric composition and global air quality to apportion pollution exposure and the health impacts to the source categories, notably the energy, mobility and industrial sectors that depend on fossil fuel combustion. The study assessed the health benefits from partial and full phaseouts of fossil fuels, assuming the transition into clean, renewable technologies.

2. Methods

The study employed a novel global atmospheric modelling method to compute gaseous and particulate air pollutants and attribute them to various source categories. Focusing on 2019 to align with recent disease burden assessments, the study utilized observational satellite and air quality station data to calculate long-term exposure to $PM_{2.5}$ at a global horizontal resolution of 10 km (ref. 5). Based on the model results, we estimated fractional changes in $PM_{2.5}$ related to emission sectors by simulating scenarios assuming that non-polluting alternatives, especially renewable energy sources, substitute different pollution categories. Emission sectors include fossil fuel combustion, e.g., energy production, industry, land transport, shipping and aviation. Other anthropogenic sources involve, e.g., residential energy from solid biofuels, waste incineration, agriculture, solvent production and use. Note that the residential combustion of solid biofuels in households significantly contributes to both indoor and ambient air pollution, with pervasive health impacts in South and East Asia and Africa.

The Earth system model employed (EMAC) [6] integrates global atmospheric, land and ocean submodels, exchange processes, and detailed air chemistry and aerosol routines. Meteorological data from 2019 are assimilated in the model using Newtonian nudging towards meteorological reanalysis data. Emission data for gaseous and particulate pollutants are derived from the Community Emission Data System [7]. Four scenarios were considered, of which three are presented here, ranging from phasing out all fossil fuel-related emission sources to removing all anthropogenic sources, also considering natural sources such as aeolian dust and wildfires. Evaluation against observational data and ground-based measurements indicated close agreement with the model's $PM_{2.5}$ and ozone (O_3) results [8].

The study also calculated exposure to ozone in 2019, in addition to $PM_{2.5}$, based on atmospheric model results only, even though the relatively coarse model resolution limits its ability to capture local ozone variability; however, longer-term averages are generally well captured. Note that ozone-attributable deaths account for less than 5% of those attributed to PM2.5, minimizing the impact of ozone-related uncertainties on the mortality assessment. Of the three scenarios, the first includes all emissions described above, the second simulates a complete phaseout of fossil fuels, and the third "halfway" scenario assumes that 50% of the phaseout has been achieved. Note that ref. 3 also presents a "quarterway" scenario in which 25% of the phaseout is achieved. These scenarios were applied to study potential non-linearities along the pathway toward a complete phaseout and determine the health benefits of intermediate goals.

The study employs the FUSION relative risk model to estimate all-cause and cause-specific mortality associated with long-term exposure to $PM_{2.5}$ (ref. 4). Relative risk functions derived from epidemiological cohort studies have provided the basis to estimate the global number of deaths attributable to air pollution, accounting for six disease categories: ischemic heart disease (IHD), stroke (ST), diabetes mellitus type-2 (DM), lung cancer (LC), chronic obstructive pulmonary disease (COPD) and lower respiratory infections (LRI). The counterfactual concentration range for $PM_{2.5}$, below which health impacts are not statistically significant, is 2.4-5.9 $\mu g/m^3$. Consistency with the GBD methodology is maintained for mortality attributable to ozone, focusing on COPD-related deaths.

Comparison with the GBD methodology shows that the FUSION relative risk model yields larger health benefits from reductions in air pollution, especially at the high and low ends of the $PM_{2.5}$ concentration range. It was found that FUSION is particularly suited for global applications across various income levels and exposures [3,4].

3. Results

3.1 Global Mortality Burden

The results highlight the significant number of deaths worldwide attributable to long-term exposure to $PM_{2.5}$ and O_3, with a particularly large number of cases in South and East Asia, Eastern Europe, the Middle East, and West Africa. The global total all-cause excess mortality was estimated at 8.34 million per year, with a 95% confidence interval (CI) of 5.63-11.19 per year (Fig. 1). Cardiometabolic conditions, such as IHD, ST and DM con-

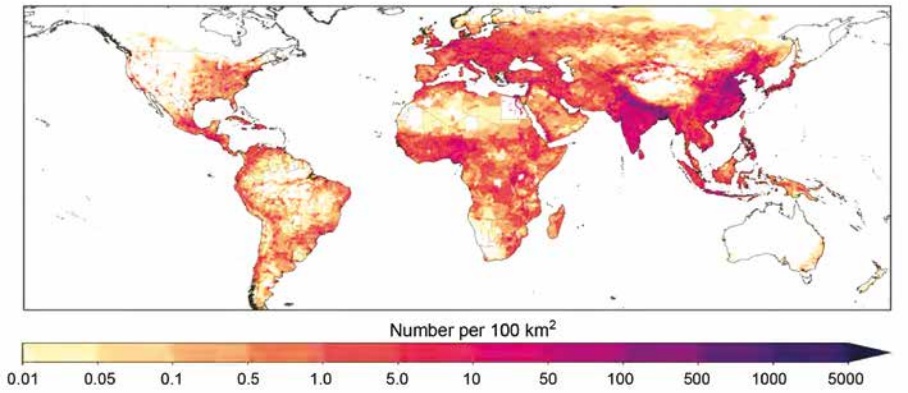

Figure 1. Annual all-cause excess mortality attributable to fine particulate matter ($PM_{2.5}$) and ozone (O_3) (from ref. 3, with permission). Units are numbers per area of 10km x 10km.

tribute significantly to the mortality burden, with IHD alone contributing about 30% to the total.

While specific causes of death are identifiable, there is "another" category representing additional health outcomes from exposure to air pollution, adding up to about 20% of the total excess deaths. This indicates the need for further research, e.g., on pollution impacts through hypertension and neurological diseases [9.10]. South and East Asia, the Middle East, and Eastern Europe were shown to exhibit particularly high per-capita mortality rates. China and India stand out with the highest total attributable mortality, reflecting both the size of the population and the severity of air pollution in these regions.

3.2 Fossil Fuel-Related Mortality

Fossil fuel-related emissions, predominantly from industry, transportation, and power generation, contribute significantly to global mortality related to air pollution. Coal combustion is the leading contributor to fossil fuel-related mortality. Phasing out fossil fuels could potentially lead to significant relative reductions in attributable mortality in high-income countries that strongly rely on this energy source. In absolute numbers, fossil fuel phaseouts are highly effective in reducing attributable deaths in many low- and middle-income countries.

The global total contribution from exposure to fossil fuel-related air pollution is 61%, i.e., 5.13 (95%CI 3.63-6.32) excess deaths annually. This

amounts to 82% of all anthropogenic and, hence, potentially avoidable deaths from air pollution. Smaller reductions in fossil fuel-related emissions rather than a radical phaseout still yield significant positive health outcomes. It was found that the health benefits respond relatively linearly to the lowering of exposure (Fig. 2). In high-income countries, the halfway scenario is comparatively most effective because, in some countries, the counterfactual $PM_{2.5}$ level (below 5 $\mu g/m^3$) can be reached under this scenario. Nevertheless, the 50% phaseout greatly improves air quality in all regions.

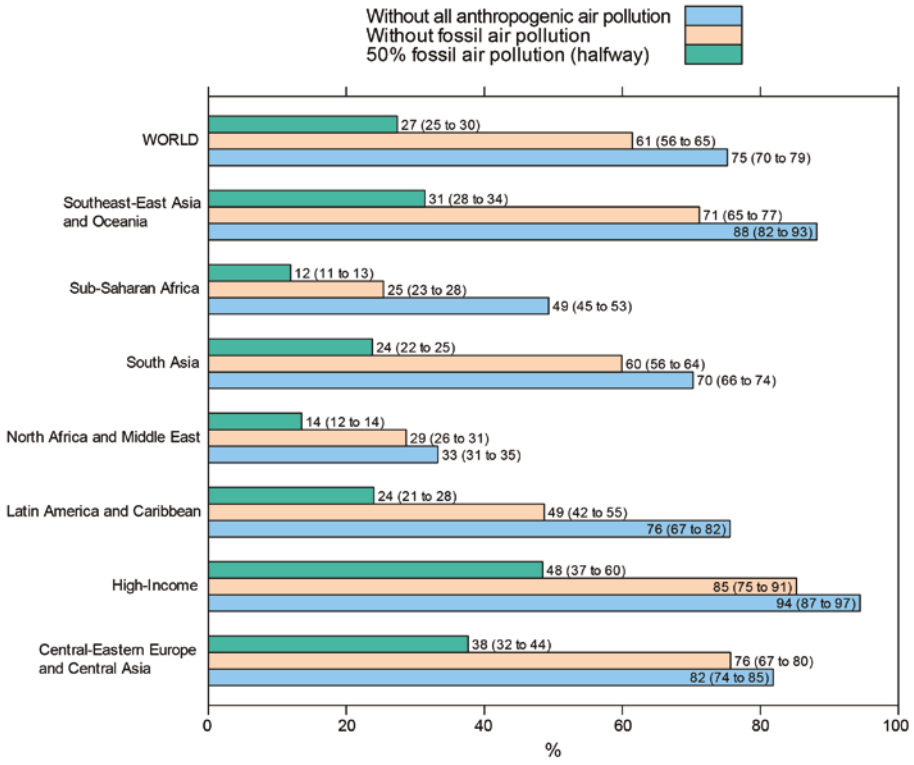

Figure 2. Percentage reductions in annual deaths attributable to air pollution from removing fossil fuel-related and all anthropogenic emissions of $PM_{2.5}$ and O_3 for seven macro-regions and the world (yellow and blue, respectively). The green bars depict the "halfway" scenario by assuming that 50% of the fossil fuel phaseout is achieved. The numbers in parentheses indicate the 95% confidence intervals.

4 Discussion

Applying the new FUSION risk model, coupled with updated data on exposure to ambient fine particulate matter ($PM_{2.5}$) and ozone (O_3), we estimate global all-cause attributable mortality at about 8.3 million per year, higher than previously reported by the GBD Study for 2019 (ref. 2). The all-cause mortality related to $PM_{2.5}$ exposure alone (i.e., without O_3) is estimated at nearly eight million per year, slightly lower than previous estimates [3,11].

Differences with the GBD results are primarily due to the FUSION model's optimization of the exposure-response relationship across ambient $PM_{2.5}$ levels. The relatively low number estimated by the GBD is attributed to its use of integrated exposure-response functions, based on $PM_{2.5}$ dosage and toxicity assumptions of second-hand smoking and indoor air pollution, used as proxies for high levels of air pollution. In contrast, FUSION only considers studies involving ambient air pollution, including those representing heavily polluted air.

The study finds high attributable mortality rates in South and East Asia, as well as in Eastern Europe and parts of the Middle East. South, East, and Southeast Asia account for 55% of the world's population but 70% of air pollution-related mortality. Cardiometabolic diseases, including ischemic heart disease, stroke, and diabetes, contribute about 65% to the global disease-specific mortality burden from ambient air pollution.

A global phaseout of fossil fuels is projected to yield substantial health benefits, particularly in reducing mortality from cardiometabolic outcomes but also chronic obstructive pulmonary disease (COPD) and lung cancer. However, lower respiratory infections (LRIs), most frequent in low-income countries, may see fewer reductions related to the less prevalent role of fossil fuels in air pollution. The study attributes a worldwide major fraction of mortality to fossil fuel-related air pollution owing to its leading influence on exposure to $PM_{2.5}$, especially in the low – to moderately high concentration ranges. By phasing out fossil fuel use in industry, energy generation and transportation, most countries will accomplish the WHO air quality guideline concentration of 5 $\mu g/m^3$, i.e., at the level of the counterfactual concentration.

The FUSION relative risk model draws on various epidemiological cohort studies worldwide. However, some continents, like Africa, are underrepresented, and there is a need to develop such studies there. An analysis by Pope et al.[12] has addressed general questions about mortality risk

calculations. They showed that disease burden analyses, based on growing epidemiological data and supported by numerous clinical and toxicological studies in the past 25 years, have become robust and that initial concerns raised several decades ago have been largely overcome. Nevertheless, challenges persist in fully accounting for confounding factors. While cohort studies adjust for numerous covariates, residual confounding remains a possibility.

Since most epidemiological cohort studies have been performed in high- and middle-income countries, additional focus on low-income countries is needed to understand better the health impacts of air pollution on a global scale. Despite becoming part of regular disease burden updates, assessing long-term health impacts still faces methodological heterogeneity, particularly concerning exposure data and relative risk functions.

Finally, toxicological analyses indicate variations in the oxidative potential of $PM_{2.5}$ from different sources, challenging the assumption of equal toxicity of all particulate components in relative risk models. Oxidative stress has been implicated as a driver of health impacts, e.g., leading to epithelial dysfunction and inflammatory responses [13,14]. Relatively high toxicity has been attributed to combustion sources of $PM_{2.5}$, both from fossil fuel and residential energy use [15,16]. In the future, it may be helpful to additionally account for the oxidative potential of particulate pollution in disease burden analyses, provided that such data can be derived from air quality measurement networks.

5. Conclusions

Air pollution remains a leading public health hazard, leading to more than eight million excess deaths annually. A substantial portion of these deaths are preventable, stemming from human activities, particularly the use of fossil fuels, globally accounting for more than five million excess deaths per year. This represents about 82% of the exposure to anthropogenic emissions. While a complete fossil-fuel phaseout is not a realistic objective in the near term, our results emphasize the tremendous health benefits of a world that would have adopted a sustainable pathway of generating energy for industry, air conditioning (heating, cooling) and transportation. Aligning with the objectives of the Paris Climate Agreement to achieve climate neutrality by 2050, transitioning to clean, renewable energy sources presents a remarkable opportunity for improving public health and mitigating climate change.

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Bending the Temperature Curve Down

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Summary

The record-breaking heat of 2023 ushered in the first recorded 12-month period of temperatures exceeding 1.5°C over pre-industrial levels. The extreme heat we are facing today and the more punishing 2-3°C expected by the end of the century mean that the climate crisis is made up of not one but two climate emergencies – today's still manageable emergency and tomorrow's catastrophic and far less manageable emergency. Addressing both climate emergencies requires understanding that there are two distinct categories of climate pollutants that are warming the planet: long-lived carbon dioxide (CO_2), responsible for half of historic warming, and non-CO_2 super climate pollutants responsible for the other half, including the short-lived climate pollutants: methane, hydrofluorocarbons, tropospheric ozone, and black carbon. Reigning in the temperature in the near-term of the next 10 to 20 years – which is critical for slowing self-amplifying feedbacks and avoiding or slowing irreversible tipping points – is only possible if we cut the super pollutants in addition to CO_2. Reigning in warming in the longer term later this century requires phasing out fossil fuels to get to zero CO_2 emissions by mid-century. But the most aggressive cuts to CO_2 cannot alone address the near-term climate emergency, in large part because shifting to clean energy reduces cooling sulfates that are emitted along with CO_2 and the net effect only bends the warming curve by a modest amount through 2050. To address both climate emergencies, leaders and institutions must take actions to make deep cuts to both CO_2 and these other super climate pollutants. These actions are complementary and not interchangeable. They are also essential to protecting human rights and the natural systems we depend on.

We are facing two climate emergencies

Most attention has been focused on the level of global warming at the end of the century. There has been some progress in this regard. Projections based on current policies and commitments suggest that human-caused

emissions of carbon dioxide from burning fossil fuels and cutting down forests put us on the path for a warming of around 2.7°C by the end of the century, compared with around 4°C prior to the Paris Agreement.[1] This is progress. But even warming of 2.7°C would place nearly a third of humanity outside the corridor of life that human civilization has existed in for the past 6000 years,[2] while pushing the planet past a series of expected tipping points where impacts will be abrupt in some cases, non-linear, irreversible, and catastrophic.[3]

It is this end-of-century climate emergency that demands we stop adding carbon dioxide (CO_2) to the atmosphere. Every ton of CO_2 we emit is a legacy of committed warming for our children and future generations. This is the marathon that we are running now to free our economies from fossil fuel addiction.

But there is another climate emergency. This is the climate emergency we are facing today. We are already experiencing the extreme heatwaves, storms, floods, and droughts of a changed climate. Billion-dollar disasters are becoming more frequent,[4] and these financial costs only hint at the human costs and suffering as extreme weather, failed crops, and sea level rise drive tens of millions from their homes and fuel a global climate migration crisis.[5]

As an example of how climate change is affecting our lives, consider the state of California where I grew up. When I was a child, fire season lasted a few months. Now there are years where every month is fire season, and smoke turns the sky orange.[6] The impacts of climate trauma go beyond phys-

[1] UNFCCC (2023) Technical dialogue of the first global stocktake. Synthesis report by the co-facilitators on the technical dialogue, 13. See https://unfccc.int/documents/631600

[2] Lenton T.M., Xu C., Abrams J.F., Ghadiali A., Loriani S., Sakschewski B., Zimm C., Ebi K.L., Dunn R.R., Svenning J.-C., & Scheffer M. (2023) Quantifying the human cost of global warming, *Nat Sustain* 1-11, 7.

[3] Lenton T.M., *et al*. (2023) *The Global Tipping Points Report 2023*, University of Exeter, Exeter, UK. See https://global-tipping-points.org/

[4] *See* National Oceanic and Atmospheric Administration (*last accessed* 1 October 2023) Billion-Dollar Weather and Climate Disasters. See https://www.ncei.noaa.gov/access/billions/

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[6] BBC News (10 September 2020) California wildfires: Smoke turns skies orange. https://www.bbc.com/news/world-us-canada-54096319 *See also* Frontline Wildfire De-

ical and financial to mental health and cognitive function.[7] And these impacts will grow as fossil-fueled fires burn more of western North America.[8]

Human-caused climate change is already reshaping our world. Indeed, experts in climate attribution science tell us that the "current climate has changed so significantly that the pre-industrial world [has become] a poor basis of comparison."[9]

And this is with current warming of about 1.2°C above pre-industrial levels. Under current rates of warming, we are expected to lock in 1.5°C by 2030 when we exhaust the carbon budget.[10] Every tenth of a degree of warming increases the severity and frequency of extreme climate and weather disasters, as laid out starkly by the 2018 Special Report on 1.5°C by the Intergovernmental Panel on Climate Change and the more recent Sixth Assessment Report by the IPCC. We also know that beyond 1.5°C the risks of crossing irreversible tipping points in the climate system increase (Table 1).[11]

If cutting carbon dioxide is the marathon we are running today to limit the climate emergency at the end of the century, then cutting methane and the other super climate pollutants is the sprint we also need to run this decade to slow warming and limit today's climate emergency.

fense (*last accessed* 14 July 2024) Statistics and historical data ("Many experts agree that a year-round fire season is a new norm."). https://www.frontlinewildfire.com/california-wildfire-map/

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[9] Harrington L.J., Ebi K.L., Frame D.J., & Otto F.E.L. (2022) Integrating attribution with adaptation for unprecedented future heatwaves, *Clim. Change* 172(2): 1-7, 3. See https://link.springer.com/article/10.1007/s10584-022-03357-4

[10] Forster P. M., *et al.* (2024) Indicators of Global Climate Change 2023: annual update of key indicators of the state of the climate system and human influence, *Earth System Science Data* 16(6): 2625-58. See https://essd.copernicus.org/articles/16/2625/2024/

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	Earth system component	Tipping: Possible above	Tipping: Likely above	Impacts
Tipping points	Warm water coral collapse	1°C	1.5°C	Mass bleaching events; biodiversity loss; loss of fisheries & coastal protection
	Greenland ice sheet collapse	1.2°C	2°C	Up to 7 meters of sea level rise; potential to disrupt or weaken ocean circulation
	West Antarctic ice sheet collapse	1.2°C	2°C	Up to 3 meters of sea level rise; potential to disrupt or weaken ocean circulation
	Abrupt permafrost thaw	1.2°C	localized/regional tipping points	Potential to release 40% more greenhouse gases (CO_2, CH_4, N_2O) on top of gradual thaw emissions (see *Feedbacks*, below)
	N. Atlantic subpolar gyre collapse	1.2°C	1.8°C	N. Atlantic cooling of 2–3°C; weather extremes in Europe; could trigger other tipping points in N. Atlantic
	Boreal forest dieback	1.5°C	≥3°C	Contains a large portion of of terrestrial carbon sink, which could be released in dieback; loss of biodiversity
	Mangrove collapse	1.5°C	?	Can release greenhouse gases (CO_2, CH_4, N_2O) when degraded, although climate feedback uncertain; loss of fisheries
	Seagrass meadow collapse	1.5°C	?	Loss of fisheries; impacts on food webs & ecosystems
	East Antarctic marine basin collapse	2°C	≥3°C	Subglacial basins could contribute up to 19 meters of sea level rise; potential to disrupt or weaken ocean circulation
	Amazon rainforest dieback	2°C	≥3°C or 20–40% deforestation	Additional 0.1–0.3°C of warming in event of collapse; widespread impacts on agriculture & water security in Amazon basin
	Atlantic meridional overturning circulation (AMOC) collapse	1.5°C	≥4°C may depend on rate of salinity change	Up to 3.5°C of cooling in parts of Europe; faster sea level rise in eastern United States; warming & drying of Amazon; shift in S. Hemisphere monsoon
Feedbacks	Permafrost thaw (global, gradual)	—		Gradual release of greenhouse gases could add 0.05–0.7 °C to warming by 2100; damage to infrastructure
	Loss of Arctic September sea ice	—		Complete loss expected around 2050; loss of albedo to add 25 years' worth of CO_2 emissions to warming

Table 1. Summary of key climate tipping points and feedbacks. Adapted from The Global Tipping Points Report https://global-tipping-points.org/ (2023) and sources summarized in Zaelke, Picolotti, and Dreyfus (2024) The Need for Fast Near-Term Climate Mitigation to Slow Feedbacks and Avoid Tipping Points https://www.igsd.org/wp-content/uploads/2024/01/IGSD-Background-Note.pdf

The other half of warming

Nearly half of today's warming from greenhouse gases is caused by super climate pollutants other than carbon dioxide (Figure 1). Super climate pollutants include methane, ground-level ozone smog, fluorinated gases, and nitrous oxide. There's also black carbon soot, which isn't a greenhouse gas but a particle that both contributes to warming and is a major air pollutant. These pollutants are tens to thousands of times more potent than CO_2 at trapping heat in our atmosphere. And most of them are short-lived, meaning they only last for days to 15 years in the atmosphere.

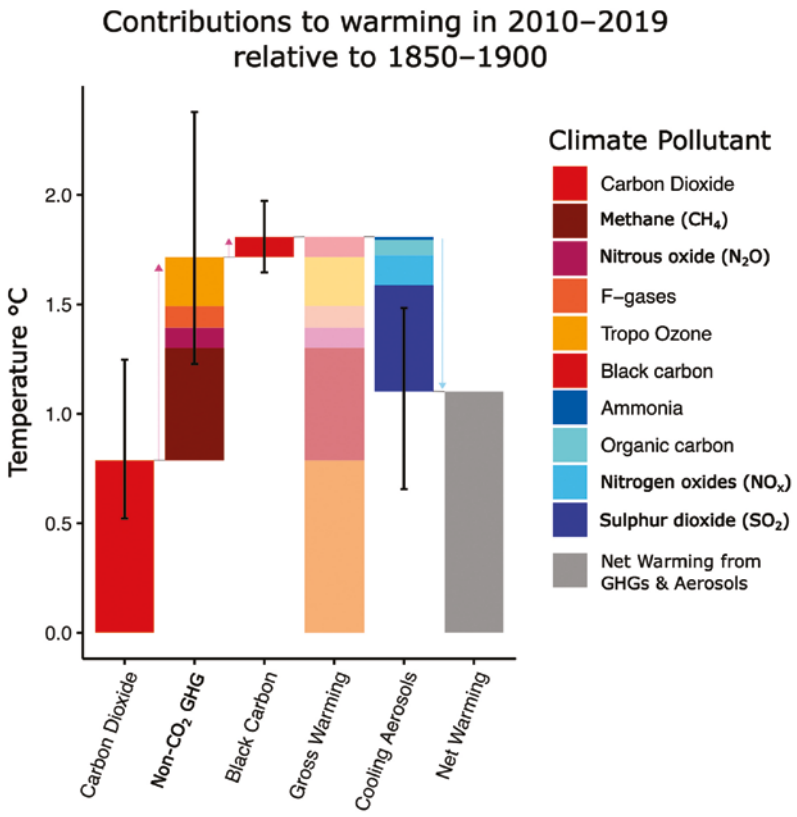

Figure 1. Contributions to warming by climate pollutant. Data from Szopa, S.; Smith, C.; Blichner, S.; Berntsen, T.; Collins, B.; Gillett, N.; Thorne, P.; Trewin, B. (2021): Summary for Policymakers of the Working Group I Contribution to the IPCC Sixth Assessment Report – data for Figure SPM.2 (v20210809). NERC EDS Centre for Environmental Data Analysis, 09 August 2021. doi:10.5285/c1eb6dad1598427f8f9f3eae346ece2f.

If carbon dioxide is the slow burner, methane and the other super climate pollutants are the blow torch, together bringing our climate to a boil.[12]

According to the IPCC, carbon dioxide emissions are contributing about 0.8°C of present warming, while these other super climate pollutants are contributing a similar level of warming (Figure 1).

[12] Harvey F. (29 November 2023) 'Enough of endless delays': Will COP28 force a course change for the world?, *The Guardian*. See https://www.theguardian.com/environment/ng-interactive/2023/nov/29/cop28-what-could-climate-conference-achieve

But that alone adds up to over 1.5°C, you might be thinking, and you're right.

In addition to greenhouse gases, human activity also creates particle pollution or aerosols. Some of these contribute to warming, like black carbon, but others like sulfate aerosols are reflective and have a cooling effect. The cooling effect from these reflective aerosols is masking some of the warming from greenhouse gases. The main source of the cooling aerosols is burning fossil fuels. This means that as we run the marathon to cut carbon dioxide by transitioning our economies, there will be less of these cooling aerosols and more of the warming will be unmasked.[13] As highlighted by Jos Lelieveld and Örjan Gustafsson in their presentations, in addition to net warming, the pollution from burning fossil fuels is responsible for millions of premature deaths annually, so this unmasking effect is no reason to slow the fossil fuel phaseout. Instead, it is a reason to slash short-lived climate pollutants like methane alongside the energy transition.

Running two (or three) races simultaneously

To tackle both climate emergencies, we need our leaders and institutions to take actions to make deep cuts to both carbon dioxide and these other super climate pollutants. We can and we must bend down the temperature curve as soon and as quickly as possible to stay within the limits of the capacities of human and natural systems to adapt.

The sprint to cut methane and the other super climate pollutants is the best way we know to slow warming in the near term. While the marathon to phase out fossil fuels is the only way to limit warming in the longer term. Both these strategies are essential. They are complementary and they are not interchangeable. Cutting CO_2 faster won't slow warming in the near term because of the sulfate unmasking. At the same time, only cutting methane and the super climate pollutants without stopping CO_2 emissions locks in long-term warming.

This is why we are in a dual race – two races at the same time – a sprint and a marathon. The good news is that there are many mitigation options available that are low-cost (Table 2). In addition to renewable energy from solar and wind, protecting forests and other existing carbon sinks, plugging

[13] Dreyfus G.B., Xu Y., Shindell D.T., Zaelke D., & Ramanathan V. (2022) Mitigating climate disruption in time: A self-consistent approach for avoiding both near-term and long-term global warming, *Proc. Natl. Acad. Sci.* 119(22): e2123536119. See https://www.pnas.org/doi/10.1073/pnas.2123536119

Pollutant	Reduction Target	Sources	Lifetime	GWP-20	Mitigation Strategies
Methane (CH_4)	40–45% by 2030[1]		12 years	81–83	Improved livestock feeding; coal mine methane recovery; prevent methane gas leaks in energy sector; stop non-emergency flaring; capture & use landfill methane; divert organic waste from landfills; upgrade wastewater treatment
Tropospheric ozone (O_3)	Reduce precursor emissions (incl. methane)		Days to weeks	—	Mitigate black carbon and methane; strengthen vehicle emission standards to address ozone smog
Black carbon	35% by 2050[2]		4–12 days	460–1,500	Expand access to clean cooking & heating technologies; cut tailpipe emissions & implement global soot-free vehicle emission standard; eliminate open burning in waste & agriculture sectors
Hydrofluorocarbons (HFCs)	85% by 2050[3]		15 years	17–12,400	Phasedown production & consumption; replace with lower GWP refrigerants; end dumping of high-GWP, inefficient cooling equipment
Nitrous oxide (N_2O)	20% by 2050[4]		109 years	273	Precision farming using variable rate technology; use of nitrogen inhibitors to suppress microbial in agriculture; abatement at nitric and adipic acid plants

[1] Relative to 2030 levels; see *Global Methane Assessment: 2030 Baseline Report* (2022).
[2] Relative to 2010 levels; see IPCC's *Special Report on Global Warming of 1.5°C* (2018).
[3] Relative to 2019 levels.
[4] Relative to 2019 levels; see IPCC's *Sixth Assessment Report of Working Group III* (2022).

Oil, gas, and coal extraction
Fossil fuel energy use
Livestock
Agriculture (rice)
Waste & agricultural burning
Vehicle & transport emissions
Waste
Household heating & cooking
Refrigerants
Fire extinguishers
Other industry & manufacturing

Table 2. Overview of super climate pollutants and their mitigation potential, sources, atmospheric lifetimes, 20-year global warming potential, and mitigation strategies. Adapted from sources summarized in Zaelke, Picolotti, and Dreyfus (2024) The Need for Fast Near-Term Climate Mitigation to Slow Feedbacks and Avoid Tipping Points https://www.igsd.org/wp-content/uploads/2024/01/IGSD-Background-Note.pdf

methane leaks and using the Montreal Protocol to speed a transition to energy efficient and climate-friendly cooling are readily available strategies. And we are also starting a third race: the ultramarathon to develop approaches to remove carbon dioxide and possibly methane from the atmosphere.

The barriers to winning these races are generally not a question of science or knowledge, but the laws and policies that govern who gets to pollute and who pays for the impacts of that pollution. The science and scientists have done their job to make clear the risks we face. Now it is time for policy makers and the private sector to do their job and implement the known technologies at speed and scale so we can win both the sprint and the marathon.

Acknowledgements

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Pathways to a Healthy, Net-Zero Future

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Summary

Building climate resilience in the face of unprecedented threats will require ambitious policies and actions that prioritize health and equity. Effective strategies to reduce greenhouse gas emissions will reduce the health impacts of climate change and bring many near-term health (co-) benefits. This chapter draws on key findings from the report of the Lancet Pathfinder Commission on pathways to a healthy net-zero future,[1] and highlights the potential for transformative changes in sectors such as energy, transport, food systems, and housing to address both climate and health challenges.

Introduction

The climate crisis is a health crisis, driven by an unsustainable status quo that threatens to undermine and reverse progress on health and development. Climate change is already impacting health in a variety of direct and indirect ways, including through extreme weather events, increased risk of infectious disease spread, reduced yield and nutritional quality of crops, effects on mental health, and reduced labour productivity.[2,3] Impoverished communities, the elderly and pregnant women are disproportionately impacted by climate breakdown, but no country or population is unaffected.

Both mitigation – reducing greenhouse gas (GHG) emissions, and adaptation – addressing changes that cannot be prevented, are vital to pro-

[1] Whitmee, S., Green, R., Belesova, K., et al. (2024). Pathways to a healthy net-zero future: Report of The Lancet Pathfinder Commission. *Lancet*, *403*(10421), 67–110. doi:10.1016/s0140-6736(23)02466-2

[2] Cissé, G., R. McLeman, H. Adams, P., et al. (2022): Health, Wellbeing, and the Changing Structure of Communities. In H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. et al. (Eds.), *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1041–1170). Cambridge University Press. doi:10.1017/9781009325844.009.

[3] World Health Organization. (2023). Climate Change. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

tect health and build climate resilience. This paper focuses primarily on the health benefits of climate mitigation actions, highlighting evidence and recommendations from the Lancet Pathfinder Commission report on pathways to a healthy net-zero future.[1]

The 2023 UN Emissions Gap report suggests that current action is insufficient and that GHG emissions must fall by 42% by 2030 to limit global temperature rise to the Paris Agreement goal of 1.5°C above pre-industrial levels and 28% to limit warming to below 2°C.[4] Climate mitigation actions can bring major near-term benefits to human health, in addition to reducing the health impacts of climate change. These health co-benefits are delivered through three main pathways: reduced air pollution from phasing out fossil fuels and replacing them with clean, renewable sources of energy; the consumption of healthier, more sustainable diets; and increased physical activity from promoting active travel (walking and cycling) and public transport.[1] Figure 1 illustrates these and other pathways.

To capitalize on the health benefits that can be achieved and tackle the interlinked crises of climate change, biodiversity loss and global inequity, a whole-of-society, systemic approach that integrates mitigation and adaptation actions is required to trigger transformative changes in all sectors. Decision makers must use the best available evidence to implement solutions at scale, as well as monitoring and evaluating the impact of actions on GHG emissions, health and equity to ensure accountability and inform further action. Strengthened collaboration between policymakers, researchers, funders, civil society organizations, and practitioners, as well as co-design of solutions with local communities, will be key to accelerating the transition to healthier, more equitable, climate resilient societies.

The health co-benefits of climate action

Current GHG-intensive food, energy and transport systems are harming public health.[5] Over 5 million deaths per year are attributable to air pollution from fossil fuel burning (Figure 2);[6] over 5 million deaths annually

[4] United Nations Environment Programme. (2023). *Emissions Gap Report 2023: Broken Record – Temperatures hit new highs, yet world fails to cut emissions (again)*. https://wedocs.unep.org/20.500.11822/43922

[5] Pathfinder Initiative. (2023). *Summary of the Lancet Pathfinder Commission report: Pathways to a healthy net-zero future*. https://climatehealthevidence.org/sites/default/files/uploads/files/lancet_pathfinder_commission_report_summary.pdf

[6] Lelieveld, J., Haines, A., Burnett, R., et al. (2023). Air pollution deaths attributable

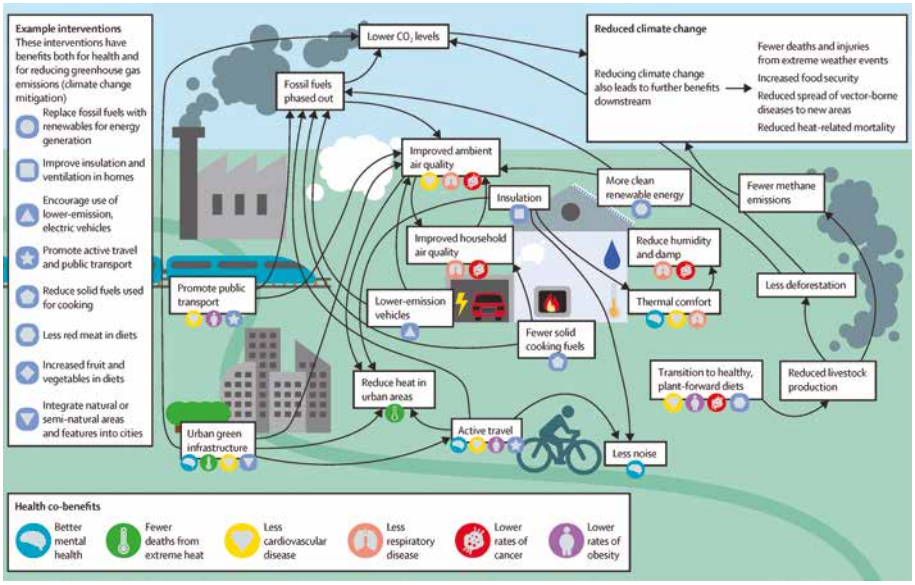

Figure 1. Key pathways and connections between climate mitigation actions and health. (Source: Whitmee, S., Green, R., Belesova, K., et al. (2024). Pathways to a healthy net-zero future: Report of The Lancet Pathfinder Commission. *Lancet*, 403(1042[1]), 67–110. doi:10.1016/s0140-6736(23)02466-2[1]).

are attributable to physical inactivity;[7] and over 10 million deaths annually could be prevented from transitioning to healthier, more sustainable diets that include more whole grains, nuts, vegetables and fruits by 2050.[8]

GHG emission reductions in line with the Nationally Determined Contributions (NDCs) to achieve the Paris Agreement goals in just nine countries could prevent each year by 2040: 1·2 million air pollution-related deaths, 5·9 million diet-related deaths, and 1·15 million deaths due to phys-

to fossil fuels: Observational and Modelling Study. *BMJ*, *383*, e077784. doi:10.1136/bmj-2023-077784

[7] Lee I.M., Shiroma E.J., Lobelo F., et al. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*, *380*(9838), 219–29. doi:10.1016/S0140-6736(12)61031-9

[8] Willett, W., Rockström, J., Loken, B., et al. (2019). Food in the anthropocene: The EAT–Lancet Commission on healthy diets from sustainable food systems. *Lancet*, *393*(10170), 447–492. doi:10.1016/s0140-6736(18)31788-4

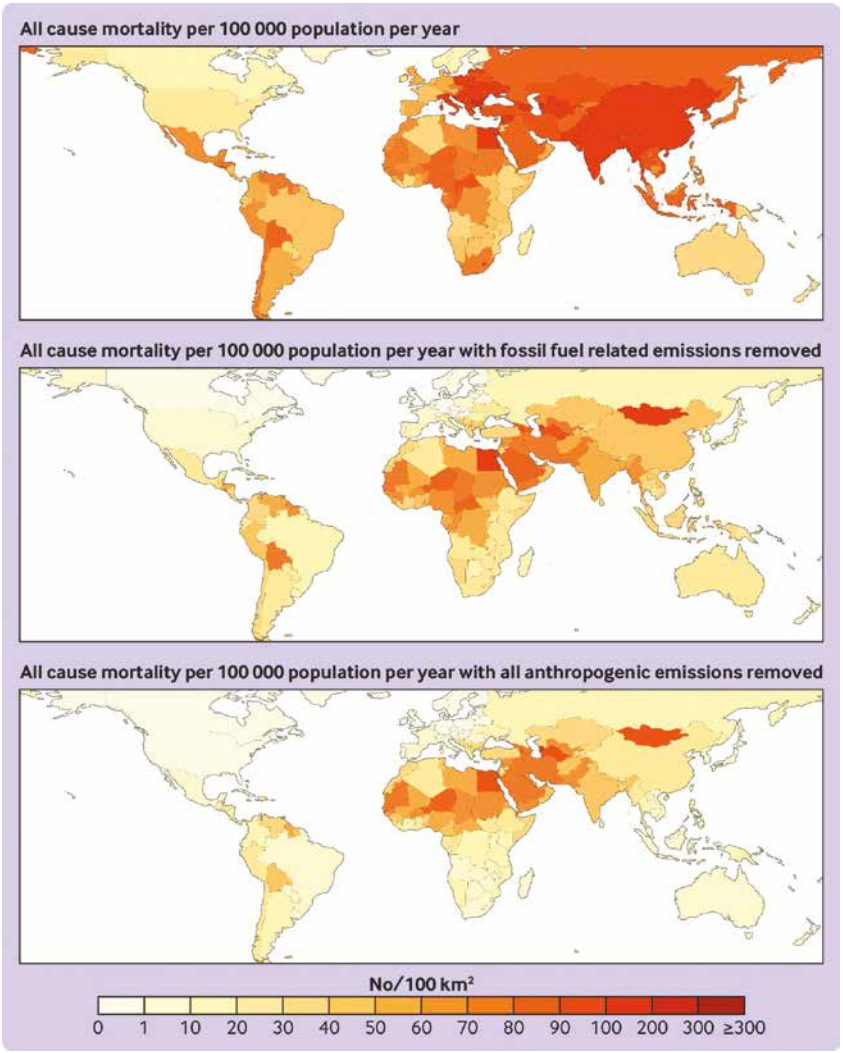

Figure 2. Country average, all cause deaths per 100 000 population per year attributable to fine particulate matter (PM2.5) and ozone (O3), and with fossil fuel related and all anthropogenic emissions removed. (Source: Lelieveld, J., Haines, A., Burnett, R., et al. (2023). Air pollution deaths attributable to fossil fuels: Observational and Modelling Study. BMJ, 383, e077784. doi:10.1136/bmj-2023-077784[6]).

ical inactivity, when compared with the current emissions scenario (with some overlap between the prevented deaths).[9]

While decarbonising the healthcare sector, which accounts for over 4% of global GHG emissions,[10] is an important contribution to achieving net zero, cutting emissions across all sectors is vital to protect and promote health.

Energy transition

A clean and equitable energy transition through fossil fuel phase out is critical to achieving net zero and will bring major health benefits by reducing air pollution.[1] Co-benefits of improved air quality result largely from lower PM2.5 levels and include reduced risk of non-communicable diseases (NCDs) such as ischaemic heart disease, stroke, diabetes, chronic obstructive pulmonary disease (COPD) and lung cancer, as well as acute respiratory infections.[1] Almost the entire global population (99%) breathes polluted air that exceeds WHO air quality limits.[11]

The health benefits of reducing air pollution would be greatest in Asia where fossil fuel related air pollution levels are high,[1] and in high-income countries that have economies powered by fossil energy.[6] Air pollution levels are rising in countries across Africa, but there are opportunities to adopt low carbon development pathways.[1]

Phasing out coal will bring the largest climate and health benefits, with coal combustion being responsible for over 50% of fossil fuel-related air pollution globally.[1] Gas is less polluting than coal, but still a significant source of GHG emissions from gas leaks that release methane (CH4) and from CO_2 when burnt.[1]

Though investments in renewables increased globally in 2022, investments in fossil fuels have continued and increased in some countries.[4] Higher ambition is needed to achieve net zero by 2050 at the latest, and countries with greater capacity and responsibility will need to make the deepest, most rapid emissions cuts.

[9] Hamilton, I., Kennard, H., McGushin, A., et al. (2021). The Public Health Implications of the Paris Agreement: A modelling study. *The Lancet Planetary Health*, *5*(2), e74–e83. doi:10.1016/s2542-5196(20)30249-7

[10] Health Care Without Harm. (2019). *How the Health Sector Contributes to the Global Climate Crisis and Opportunities for Action*. https://noharm-global.org/documents/health-care-climate-footprint-report

[11] World Health Organization (2022). Billions of people still breathe unhealthy air: new WHO data. https://www.who.int/news/item/04-04-2022-billions-of-people-still-breathe-unhealthy-air-new-who-data

The climate and health benefits of renewable energy are illustrated by studies of the US power sector between 2005 and 2016, which show that in 2015 alone, 147 megatonnes of CO_2 were avoided from replacing some of the US' coal and natural gas energy generation with solar and wind power.[12,13,14,15] Between 2007 and 2015, improved air quality prevented between 3,000 to 13,000 premature deaths, with health benefits valued between 30 and over 100 billion US dollars.[15]

Clean cookstoves

In low and middle-income countries, replacing solid fuels with clean energy sources can also bring health benefits from reduced household and ambient air pollution. The Pathfinder Initiative review of evidence highlighted that clean cookstove provisions in India could save an estimated 1,279 years of life per 100,000 population per year.[1,16,17] Although the climate benefits of clean cookstoves are modest, providing universal access to clean energy is imperative for a just transition.[1]

A recent review also showed, however, that improved solid fuel combustion stoves do not reduce air pollution sufficiently to achieve the WHO interim target PM2·5 level, and the adoption of cleaner fuels such as ethanol, liquefied petroleum gas, and increasingly electricity from clean renewable sources for cooking, should be prioritised.[18]

[12] From coal and natural gas to renewables in the US. *Pathfinder Initiative Climate & Health Evidence Bank*. https://climatehealthevidence.org/case-studies/coal-and-natural-gas-renewables-us

[13] Barbose, G., Wiser, R., Heeter, J., et al. (2016). A retrospective analysis of benefits and impacts of U.S. renewable portfolio standards. *Energy Policy*, *96*, 645–660. doi:10.1016/j.enpol.2016.06.035

[14] Burney, J. A. (2020). The downstream air pollution impacts of the transition from coal to natural gas in the United States. *Nature Sustainability*, *3*(2), 152–160. doi:10.1038/s41893-019-0453-5

[15] Millstein, D., Wiser, R., Bolinger, M., et al. (2017). The climate and air-quality benefits of wind and solar power in the United States. *Nature Energy*, 2(9). doi:10.1038/nenergy.2017.134

[16] Venkataraman, C., Sagar, A.D., Habib, G., et al. (2010). The Indian National Initiative for Advanced Biomass Cookstoves: The benefits of Clean Combustion. *Energy for Sustainable Development*, *14*(2), 63–72. doi:10.1016/j.esd.2010.04.005

[17] Wilkinson, P., Smith, K.R., Davies, et al. (2009). Public health benefits of strategies to reduce greenhouse-gas emissions: Household energy. *Lancet*, *374*(9705), 1917–1929. doi:10.1016/s0140-6736(09)61713-x

[18] Pope, D., Johnson, M., Fleeman, N., et al. (2021). Are cleaner cooking solu-

Sustainable and active transport

Global emissions from the transport sector must fall by around a quarter by 2030 to align with the International Energy Agency's Net Zero Scenario.[19] System-wide changes that combine promotion of active travel and increased use of public transport with reduced private car use are needed to achieve climate and health benefits.[1]

Single interventions have limited effects, for example, switching to electric vehicles will reduce GHG emissions and air pollution, but will not bring health benefits from increased physical activity.[1] In addition, effects on PM2.5 from brakes and tires depend on vehicle weight, driving style, and the use of regenerative breaking.[20]

Many cities are taking action to promote active travel. For example, Buenos Aires introduced the "Más Bicis, Menos Emisiones" programme, a network of cycle lanes and a bicycle sharing scheme, that resulted in a 131% increase in cycle trips since 2013, a reduction of over 12,000 tons of CO_2 emissions, and safer roads for cyclists.[21,22]

Healthy, sustainable food systems

The agriculture, forestry and other land use (AFOLU) sector contributes to around a quarter of global GHG emissions,[23] largely from methane (CH4) produced by livestock, CO_2 from deforestation, and nitrous oxide (N_2O).[1]

Sustainable diets that are predominantly plant-based and low in animal-sourced foods, particularly red and processed meats (in high-consum-

tions clean enough? A systematic review and meta-analysis of particulate and carbon monoxide concentrations and Exposures. *Environmental Research Letters*, *16*(8), 083002. doi:10.1088/1748-9326/ac13ec

[19] International Energy Agency. Transport. https://www.iea.org/energy-system/transport

[20] Beddows, D.C.S., & Harrison, R.M. (2021). PM10 and PM2.5 emission factors for non-exhaust particles from road vehicles: Dependence upon vehicle mass and implications for Battery Electric Vehicles. *Atmospheric Environment*, *244*, 117886. doi:10.1016/j.atmosenv.2020.117886

[21] More Bikes, Less Emissions. *Pathfinder Initiative Climate & Health Evidence Bank*. https://climatehealthevidence.org/case-studies/more-bikes-less-emissions

[22] City of Buenos Aires. (2020). Climate Action Plan 2050. https://buenosaires.gob.ar/sites/default/files/2023-02/pac_2050_buenos_aires_eng_0.pdf

[23] IPCC. (2022). Summary for Policymakers. In: P.R. Shukla, J. Skea, R. Slade, et al., (Eds.), Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. (pp. 3–48). Cambridge University Press. doi:10.1017/9781009157926.001.

ing countries),[24] can bring health benefits such increased life expectancy and reduced risk of a range of NCDs.[25]

A study in the UK found that intermediate to high adherence to the 'Eatwell Guide' to a healthy balanced diet (Figure 3) led to an estimated 7% reduction in mortality and 30% reduction in emissions compared with low adherence (an average reduction of 0.58 tonnes GHGe/person/year).[26]

Ensuring equitable access to and affordability of healthy, sustainable food choices should be a priority to encourage the necessary shifts in dietary patterns.[27] Sustainable diets also need to be properly implemented to avoid micronutrient deficiencies.[28,29]

[24] Jarmul, S., Dangour, A.D., Green, R., et al. (2020). Climate change mitigation through dietary change: A systematic review of empirical and modelling studies on the environmental footprints and health effects of 'sustainable diets.' *Environ Res Lett*, *15*(12), 123014. doi:10.1088/1748-9326/abc2f7

[25] Milner, J., Green, R., Dangour, A.D., et al. (2015). Health effects of adopting low greenhouse gas emission diets in the UK. *BMJ Open*, *5*(4). doi:10.1136/bmjopen-2014-007364

[26] Scheelbeek, P., Green, R., Papier, K., et al. (2020). Health impacts and environmental footprints of diets that meet the Eatwell guide recommendations: Analyses of multiple UK studies. *BMJ Open*, *10*(8), e037554. doi:10.1136/bmjopen-2020-037554

[27] Springmann, M., Clark, M.A., Rayner, M., et al. (2021). The global and regional costs of healthy and sustainable dietary patterns: A modelling study. *The Lancet Planetary Health*, *5*(11), e797-e807. doi:10.1016/s2542-5196(21)00251-5

[28] Chen, C., Chaudhary, A., & Mathys, A. (2019). Dietary change scenarios and implications for environmental, nutrition, human health and economic dimensions of food sustainability. *Nutrients*, *11*(4), 856. doi:10.3390/nu11040856

[29] Eshel, G., Shepon, A., Noor, E., et al. (2016). Environmentally optimal, nutritionally aware beef replacement plant-based diets. *Environ Sci Technol*, *50*(15), 8164–8168. doi:10.1021/acs.est.6b01006

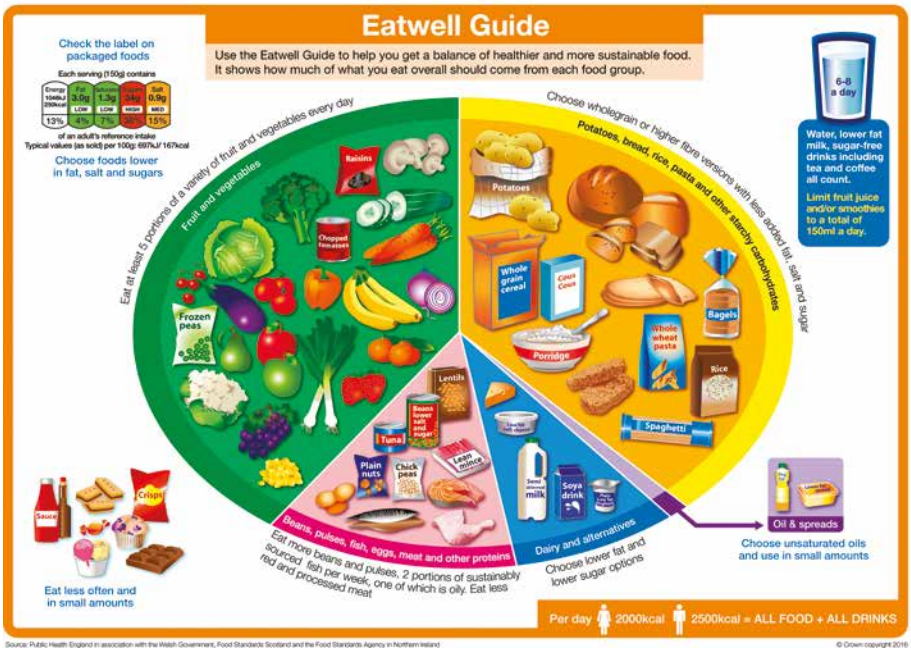

Figure 3. Eatwell Guide. (Source: OHID in association with the Welsh government, Food Standards Scotland and the Food Standards Agency in Northern Ireland.[30] Crown Copyright 2016).

Energy efficient housing

Reducing GHG emissions in the housing sector will require decarbonising the energy system and retrofitting homes.[1] Improving home insulation can increase energy efficiency and reduce cold exposure in temperate climates, leading to health benefits if ventilation requirements are met.[31]

A randomised controlled trial evaluating the impact of home energy efficiency and thermal comfort upgrades in Victoria, Australia, found that in intervention homes reduced gas and electricity use resulted in lower CO_2eq

[30] The Office for Health Improvement and Disparities (previously Public Health England). (2016). The Eatwell Guide. https://www.gov.uk/government/publications/the-eatwell-guide

[31] Milner, J., Turner, G., Ibbetson, A., et al. (2023). Impact on mortality of pathways to net zero greenhouse gas emissions in England and Wales: A multisectoral modelling study. *The Lancet Planetary Health*, 7(2), e128-e136. doi:10.1016/s2542-5196(22)00310-2

emissions and energy cost savings.[32],[33] Intervention households were warmer and had lower healthcare costs than those in the control group, and householders reported better mental health and reduced breathlessness.

Nature-based solutions

Nature-based solutions (NbS) work to protect, sustainably manage and restore natural or modified ecosystems, protecting biodiversity while addressing societal challenges (Figure 4).[34] NbS enable integration of adaptation and mitigation actions, and can bring physical and mental health benefits.

There are significant opportunities to integrate nature into cities, for example through urban trees, which can improve air quality and provide climate mitigation benefits.[1] However, benefits depend on the type of trees planted as some produce allergenic pollen or volatile organic compounds that are precursors of tropospheric ozone.

NbS such as forest protection, agroforestry and land restoration, can also provide mitigation benefits by sequestering and storing carbon, but quantitative estimates of health effects are limited.[1]

[32] Victorian Healthy Homes Program. *Pathfinder Initiative Climate & Health Evidence Bank*. https://climatehealthevidence.org/case-studies/victorian-healthy-homes-program

[33] Sustainability Victoria. (2022). *The Victorian Healthy Homes Program: research findings*. https://www.sustainability.vic.gov.au/research-data-and-insights/research/research-reports/the-victorian-healthy-homes-program-research-findings

[34] Cohen-Shacham, E., Walters, G., Janzen, C., et al. (2016). *Nature-Based Solutions to Address Global Societal Challenges*. doi:10.2305/iucn.ch.2016.13.en

	Forests	Rivers and watersheds	Farmland	Cities	Coasts and oceans
Example of solutions	Protect, restore, or sustainably manage forests through REDD+ initiatives	Restoration and protection of wetlands and peatlands	Agroforestry: integrated land management (eg, growing trees and crops or grazing animals on the same land)	Green infrastructure: harnessing and integrating nature and natural systems in urban infrastructure (eg, parks, green walls or roofs)	Protect and restore wetland and marine habitats, such as mangroves, coral reefs, seagrass, and kelp forests
Mitigation action	Increased uptake and storage of carbon from the atmosphere Prevention of further emissions from decomposition and wildfires	Enhanced carbon sinks through sequestration and storage Avoidance of methane emissions from intact wetlands	Enhanced carbon sinks through sequestration and storage Improved productivity means less land use and disturbance, and reduced fertiliser use	Enhanced carbon and surface ozone sequestration Reduction of urban heat island effect leading to reduced energy demand through passive cooling	Enhanced storage of both blue and green carbon through sequestration Avoidance of methane emissions from intact wetlands
Health co-benefits	Livelihood benefits and poverty reduction (eg, from sale of non-timber products) Gender participation and equality Enhanced forest ecosystem services (eg, flood protection and regulation of zoonotic diseases and air quality)	Natural water quality improvement reducing occurrence of algal blooms Enhanced wetland ecosystem services (eg, flood control) Reduced poverty from income generation through recreation and tourism	Increased crop yields and food security Livelihood benefits and income diversification from sale of timber Enhanced local microclimates generating a cooling effect Improved hydrological cycles and water catchment, and increased flood protection	Reduced heat-related deaths and morbidity Reduced storm water run-off buffers against extreme rainfall events Removal of harmful air pollutants Recreational spaces increase physical activity, reducing incidence of cardiovascular disease and improving mental health	Livelihood benefits and income diversification from fishing and sustainable building material Increased food security and key sources of protein Natural barrier to limit the impact of floods, storms, and sea-level rise Marine ecosystems are a novel source of pharmaceutical compounds

Figure 4. Pathways to health and equity from nature-based solutions (REDD+=Reducing Emissions from Deforestation and Degradation). (Source: Whitmee, S., Green, R., Belesova, K., et al. (2024). Pathways to a healthy net-zero future: Report of The Lancet Pathfinder Commission. *Lancet*, 403(10421), 67–110. doi:10.1016/s0140-6736(23)02466-2;[1] Pathways adapted from the Global Commission on Adaptation).[35]

Climate resilient low carbon development

The large gap in per capita emissions between the highest and lowest emitting nations,[36] emphasizes the need for policies to prioritize emissions reductions in the highest emitters, while ensuring the needs of all are met. Provision of adequate financing for low-emission, resilient development in low and middle-income countries is crucial to meeting the Paris Agreement targets and Sustainable Development Goals.

Actions should aim to ensure that co-benefits of climate mitigation benefit all and that vulnerable groups, including Indigenous communities, displaced people, people with disabilities, and low-income communities, are protected from unintended consequences and trade-offs.[37] This will require

[35] The Global Commission on Adaptation. (2019). *Adapt now: a global call for leadership on climate resilience*. https://gca.org/reports/adapt-now-a-global-call-for-leadership-on-climate-resilience/

[36] Chancel, L. (2022). Global carbon inequality over 1990–2019. *Nat Sustain*, *5*(11), 931–938. doi:10.1038/s41893-022-00955-z

[37] Pathfinder Initiative. (2023). *Pathfinder Policy Brief COP28: Healthy and Just Transi-*

careful planning of policies and interventions in partnership with local communities, and monitoring the impact of actions on health and livelihoods.

Transformative change

Moving towards a healthy, sustainable future requires cross-sectoral transformative changes that challenge the dominant social and economic systems that have caused the climate crisis. Incremental changes and undue reliance on unproven solutions such as carbon capture will be insufficient and potentially harmful to progress towards net zero, leading to missed opportunities to improve the health and well-being of populations.

Policies and actions should harness new technologies, but must go beyond seeking efficiency improvements while leaving in place unsustainable systems.[1] Actions need to target systems change including by reducing demand for energy and materials in high consuming countries, and promoting and enabling widespread behaviour change. Circular economy approaches that reduce waste and encourage practices like refurbishing, repurposing and redistributing, have the potential to reduce environmental impact,[38] but more evidence is needed to understand health effects.[1]

Conclusion

This paper has focused on the major health benefits that can be achieved through well-designed climate mitigation actions. The climate crisis poses unprecedented threats to human health, but also presents an opportunity to create fairer societies and more resilient ecosystems that support the health of people and the planet.

Though data gaps on climate and health remain, there is more than enough evidence to inform and spur action across all sectors at multiple scales. Commitments such as the recent COP28 climate and health resolution, endorsed by more than 150 countries,[39] and increasing mention of health co-benefits in NDCs,[40] highlight growing political recognition of the need to integrate health and health co-benefits into climate policies.

tions. https://climatehealthevidence.org/sites/default/files/uploads/files/pathfinder_policy_brief_cop28_healthy_and_just_transitions.pdf

[38] European Environment Agency. (2024). Circular Economy. https://www.eea.europa.eu/en/topics/in-depth/circular-economy

[39] COP28 Presidency. (2023). COP28 UAE Declaration on climate and health. https://www.cop28.com/en/cop28-uae-declaration-on-climate-and-health

[40] World Health Organization. (2023). *2023 WHO review of health in Nationally Deter-*

Governments and decision makers, in collaboration with funders, researchers, civil society, practitioners and local communities, now need to scale up ambition and implement evidence-based solutions that are driven by the imperative to protect human health and the natural systems on which it depends. Concerted efforts to evaluate the impact of actions are also needed to ensure they achieve the intended effects on climate and health, and provide equitable distribution of benefits.

Acknowledgement

With thanks to the authors of the Lancet Pathfinder Commission report, including the Co-Chairs, Commissioners and the Pathfinder Initiative research team at the London School of Hygiene & Tropical Medicine.

mined Contributions and long-term strategies: health at the heart of the Paris Agreement. https://cdn.who.int/media/docs/default-source/climate-change/9789240074729-v2.pdf?sfvrsn=f4c8b157_4

People-Centred Approaches to Deliver Nature-Based Solutions for Climate Adaptation

Virgílio Viana

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1. The problem

Extreme weather events have increased dramatically over the last few years. This scenario was predicted by IPCC as the earth is passing the 1.5-degree temperature increase above pre-industrial levels. I will bring a perspective from the Amazon, where I live and have been working for the past several decades. Regions like the Amazon are crossing the tipping point. Forests are becoming drier and more vulnerable to forest fires, which is a driver of ecosystem degradation. Degradation results in reduction of evapotranspiration of forests, affecting rainfall patterns and resulting in longer dry seasons. This, in turn, increases the flammability of forests. Increase in regional temperature further contributes to an observed frequency of forest fires. For example, in the first seven months of 2024 the Brazilian Amazon had a 77% increase in forest fires compared to 2023, even in the context of a 50% reduction of deforestation.

There are several signs that the Amazon has already passed the tipping point. The river system of the Amazon is a result of a balance of tributaries coming from the north (Venezuela and Colombia), the south (states of Mato Grosso, Rondônia and Tocantins in Brazil) and from the west (Bolivia, Peru, Ecuador, Colombia). Changes in rainfall regimes throughout the region have altered the balance of this river system. The observed consequences are the recent events: an all-time (since 1903) record flood in 2021 and again in 2022, followed by record droughts in 2023 and 2024. In southern Brazil, an all-time record flood in 2024. In 2024 São Paulo, the largest city of Latin America, also had a record storm. The list is long and is all over the world.

Increased frequency and magnitude of extreme events have played an important role in the debate on climate change. These events have served the purpose of rising climate change to the forefront of national debate. Climate sceptics have lost ground in Brazil, as the majority of the population

associates these extreme events to climate change. The record flood in Rio Grande do Sul in Brazil was perceived by 94% of Brazilians to be associated with climate change.[1] Extreme events have had dramatic consequences for people, especially the poor, who are the most vulnerable to climate change.

The case for climate justice has gained a new momentum. There is a need to give greater emphasis to climate adaptation and climate justice. We have entered the Era of Adaptation. This can be defined as a new epoch in human history where all societies will have to adapt to different climate conditions. This does not mean that mitigation of climate change should be abandoned. On the contrary, there is a need to increase action to avoid breaking another landmark: the 2-degree limit.

The problem is that adaptation has received very little attention. More worrisome, an analysis of international public adaptation finance flows to developing countries estimates these at US$21 billion in 2021 – a 15% decrease compared to 2020. As of 2024, the global Adaptation Fund has allocated just over US$ 1.1 billion.[2] This is less than 1% of the estimated costs of adaptation, which range between US$215 and 387 billion/year for developing countries this decade, according to UNEP's Adaptation Gap Report. An analysis of international public adaptation finance flows to developing countries estimates these at US$21 billion in 2021 – a 15% decrease compared to 2020. Considering all funding to adaptation, the finance gap has grown significantly since previous assessments.[3] The estimated costs/needs of adaptation are now approximately 10-18 times as much as international public adaptation finance flows. These costs are projected to rise over future decades, further aggravating climate injustice.[4]

The United Nations (UN) has a core principle around climate negotiations since the historic Rio 92 Conference, when the Climate Convention was signed. This is the principle of common but differentiated responsibilities. This means that all parties share the responsibility to tackle climate

[1] G1 2024. https://g1.globo.com/politica/noticia/2024/05/09/quaest-64percent-acreditam-que-tragedia-no-rs-tem-ligacao-com-as-mudancas-climaticas.ghtml

[2] https://www.adaptation-fund.org/ accessed 10/20/2024.

[3] State and Trends in Climate Adaptation Finance 2023. Dharshan Wignarajah, Morgan Richmond, Sean Stout, Guillermo Martinez, Ken Schell-Smith and Rajashree Padmanabhi. December 14, 2023.

[4] https://weadapt.org/knowledge-base/vulnerability/unep-adaptation-gap-report-2023/#:~:text=Adaptation%20finance%20gap,from%20the%20previous%20AGR%20estimate. Accessed 10/20/2024.

change, but in different ways, based on historic emissions and development status. As of 2015, the USA was responsible for 40% of global CO_2 emissions. The European Union (EU-28) was responsible for 29%. Countries classified by the UN Framework Convention on Climate Change as Annex I nations (ie, most industrialised countries) were responsible for 90% of excess emissions. The Global North was responsible for 92% of historic emissions.[5] There is a moral and ethical obligation of the Global North to increase funding to the Global South for climate adaptation.

In addition to the funding challenge, there is a problem of the adaptation implementation strategy. There is a historic bias towards investing in artificial technological solutions compared to nature-based ones. Furthermore, there is a bias towards investing in capital-intensive solutions compared to pro-poor alternatives. This paper addresses the problem of how to deploy adaptation finance on the ground. I argue that a people-centered approach to deliver nature-based solutions for climate adaptation is the most cost-effective and most capable of reducing poverty and inequality, thus addressing the climate justice goal.

2. A dual solution

A dual solution to tackle climate adaptation is to focus on nature and people. This can be referred to as: *people-centered approaches to deliver nature-based solutions for climate adaptation*. This means that there are two components of this dual solution, each with a different rationale.

By people-centered approach I mean a focus on the poor, which are the most vulnerable to climate change and also those with the smallest historic and present carbon footprint. According to the World Economic Forum, the lowest-income countries produce one-tenth of emissions, but are the most heavily impacted by climate change. Vulnerable populations in these countries suffer damaging outcomes in terms of health, food and water, education and more.[6]

According to the World Bank, the 74 lowest income countries will be more affected by the effects of climate change compared to the 1980s. They have already experienced approximately eight times as many natural disas-

[5] Hickel, J. 2020. Quantifying national responsibility for climate breakdown: an equality-based attribution approach for carbon dioxide emissions in excess of the planetary boundary https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(20)30196-0/fulltext

[6] https://www.weforum.org/agenda/2023/01/climate-crisis-poor-davos2023/ Accessed 10/20/2024.

ters in the past 10 years. By 2050, unchecked climate change might force more than 200 million people to migrate within their own countries, pushing up to 130 million people into poverty and unravelling decades of hard-won development achievements. The challenge to end extreme poverty even in the face of climate change, in order to succeed, will need to integrate climate considerations into development work. And we will need to act fast, because as climate impacts increase, so will the difficulty and cost of eradicating poverty.[7]

In relation to nature-based approaches for climate adaptation, I argue that these solutions are the most cost effective and with greater potential of reducing poverty and inequality. The European Commission defines nature-based solutions as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions". Nature-based solutions support the delivery of a range of ecosystem services.

Nature-based solutions are recognised as multi-purpose solutions that are often having larger co-benefits than traditional technical measures. The EU Adaptation Strategy, updated in 2021, puts a strong emphasis on ecosystem-based approaches, and particularly on nature-based solutions. Ecosystem-based adaptation focuses on ecosystem restoration and enhancement of ecosystem services to protect society against negative impacts of climate change. As climate change impacts become more obvious, e.g., droughts, flooding or extreme temperatures, the urgency of adaptation measures increases.[8] Nature-based solutions (NbS) encompass a range of ecosystem-based approaches that aim to increase resilience to climate change. NbS are typically stakeholder-driven and tailored to regional conditions.[9]

[7] https://www.worldbank.org/en/news/feature/2015/11/08/rapid-climate-informed-development-needed-to-keep-climate-change-from-pushing-more-than-100-million-people-into-poverty-by-2030

[8] European Union – Climate Adapt 2024. https://climate-adapt.eea.europa.eu/en/eu-adaptation-policy/key-eu-actions/NbS

[9] 6th IPCC Report – Climate Change 2022: Impacts, Adaptation and Vulnerability. https://www.ipcc.ch/report/ar6/wg2/

3. Conclusions

People-centered approaches to deliver nature-based solutions can play a major role for climate adaptation in developing countries. They can bring multiple benefits to people and nature, including potential co-benefits to mitigation of climate change. For example, resilience of food production systems can be enhanced by programs to control soil erosion and promote watershed management. Tree planting in urban areas can alleviate heat and its consequences for human health and well-being.

Nature-based solutions can be labour-intensive and thus contribute to reduction of inequalities. Pro-poor nature restoration can have positive outcomes for both adaptation and mitigation. Labour-intensive agroforestry systems can sequester carbon (50-100 tons CO_2eq/hectare) and at the same time provide tree-based resilient food production systems.

People-centred approaches to deliver nature-based solutions need to developed through participatory, bottom-up approaches to design adaptation plans. This is essential to draw on traditional and local knowledge systems of indigenous peoples to design and implement adaptation strategies and thereby increase their efficiency and efficacy.

These approaches have to be incorporated in education programs. There is a moral and ethical issue that needs to be addressed. Poor people have to know what science predicts for their region so as to develop their own adaptation strategies. These programs should focus on developing youth leadership for adaptation to climate change.

A systemic approach for climate adaptation is needed. Sectoral policies or narrow programs with a single focus lack long-term efficacy. There is a need to understand the complexity of impacts of climate change on individuals, families, communities, regions and countries. These impacts include mental health, food security, political stability and conflicts – among others.

Implementation of Sustainable Development Goals (SDGs) should prioritize people-centered approaches to deliver nature-based solutions to deliver multiple goals. This requires multidisciplinary thinking and knowledge, including education programs for sustainable use of biodiversity.

Adaptation finance is insufficient. Nature-based and labour-intensive pro-poor solutions require substantial increase in funding. There is a moral and ethical obligation of developed countries to mitigate climate injustice. Adaptation finance flows declined as a proportion of total climate finance. While mitigation finance has accelerated dramatically in the last years to USD 1.2 trillion annually, adaptation finance saw a more modest increase.

It is important to note that adaptation finance needs are rising. The global adaptation funding gap continues to widen concerningly, driven by accelerating climate impacts and lack of international cooperation.

The private sector, including business and philanthropy, has been almost entirely focused on mitigation. Greater attention should be given to nature-based and labour-intensive pro-poor solutions that can have potential benefits to both adaptation and mitigation.

Debt remains the primary financial instrument for adaptation. Multilateral financing institutions should reassess foreign debt of poorest countries and develop debt-for-climate adaptation to allow investment in nature-based and labour-intensive pro-poor solutions.

Adaptation is intertwined with peace-making, humanitarian aid and conflict resolutions. Coordinated action on these actions can increase their efficiency and effectiveness. Proactive adaptation action can avoid or minimize spending on humanitarian aid later. Nature-based and labour-intensive pro-poor solutions should be an integral part of the peace process in conflict zones around the world.

Defending Humankind. The Human Right to Resilience as a Framework for Policy and Investment Guidance

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IGSD-USA & Argentina

Abstract

In response to escalating climate threats, the recognition of the human right to resilience emerges as a critical imperative. Pope Francis, through his Planetary Call to Action for Climate Change Resilience, underscores this necessity.[1] This article advocates for framing resilience as a human right, urging its integration into policy frameworks and investment strategies to address climate change.

The evolving interpretation of human rights treaties must now encompass the existential threat posed by the climate emergency, recognizing the human right to resilience as a derivative of the right to life.

By recognizing resilience as a human right, this article contends that we can transcend the current paradigm of voluntary approaches to address the climate emergency. It calls for clear legal obligations guided by scientific evidence to mitigate, adapt, and restore – the core obligations of the right to resilience. These obligations are pivotal to ensure human rights for present and future generations. This approach challenges the discretion of States, international financial institutions, and the private sector to determine whether or not to pursue effective actions to address the climate emergency.

The human right to resilience, grounded in science and ethics, emerges as a North Star to keep our mitigation, adaptation, and restoration efforts on track to deliver effective climate action.

1. The Era of Resilience

Humanity has entered an era of unprecedented climate instability. The familiar climate conditions that have nurtured human civilization are rap-

[1] Pontifical Academy of Sciences, Planetary Call to Action for Climate Change Resilience (May 16, 2024).

idly changing. Scientific evidence indicates that we are already in a state of planetary emergency.[2]

At today's 1.2°C of warming,[3] we are already experiencing significant human and economic impacts. The risk of triggering non-linear, abrupt, and potentially irreversible tipping points increases dramatically as we approach 1.5°C to 2°C of warming.[4] Earth system models project six abrupt shifts between 1°C and 1.5°C warming and another eleven shifts between 1.5°C and 2°C,[5] consistent with two IPCC Special Reports.[6] This science is pivotal to understand the realities we face and the actions we must take.

We now find ourselves in the Era of Resilience, facing an unparalleled challenge: the imperative to stabilize our climate system to ensure the collective survival of humankind, without leaving anyone behind. This era demands a mandatory and immediate effective response to build and maintain resilience for present and future generations.

The climate emergency is not an ordinary crisis: it is an existential threat to humankind. As unnatural extreme weather events become more frequent and intense, people are questioning the ability of States and democratic governments to protect them from what seems to be an apocalyptic future.

[2] *E.g.*, Veerabhadran Ramanathan, Climate Resilience: Why, When and How? in *Resilience of People and Ecosystems under Climate Stress* 172 (Veerabhadran Ramanathan & Joachim von Braun eds., Scripta Varia 152, LEV, Vatican City, 2023).

[3] World Meteorological Organization, *State of the Global Climate 2023,* at 3 (Mar. 19, 2024).

[4] D.I. Armstrong McKay et al., Exceeding 1.5°C global warming could trigger multiple climate tipping points, 377 *Science* 6611, 7-8 (2022) (hereinafter "Armstrong McKay, Exceeding 1.5°C"); *and* D.I. Armstrong McKay & S. Loriani (eds.), Section 1: Earth systems tipping points, in *Global Tipping Points Report 2023* 12 (T.M Lenton et al. eds., 2023) (hereinafter "Earth systems tipping points").

[5] S. Drijfhout et al., *Catalogue of Abrupt Shifts in Intergovernmental Panel on Climate Change Climate Models*, 112 Proc. Nat'l Acad. Sci. E5777 (2015).

[6] Intergovernmental Panel on Climate Change, 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* [V. Masson-Delmotte et al. (eds.)], at 262 (2018) (hereinafter "IPCC, 2018: Global Warming of 1.5°C"); *and* N. Abram, et al., Chapter 1: Framing and Context of the Report, in *The Ocean and Cryosphere in a Changing Climate*, *Special Report of the Intergovernmental Panel on Climate Change* (H.-O. Pörtner et al. eds., 2019).

The challenge is to protect present generations from ongoing climate impacts, prevent irreversible harm to future generations, and shift from today's largely voluntary climate actions to stronger, mandatory measures.

In essence, we need to ensure that our policies and financial decisions build climate change resilience and protect everyone's human rights.

2. Defining Resilience

The Pontifical Academy of Sciences follows the IPCC definition of resilience as the capacity of social, economic systems and ecosystems to cope with a hazardous event, trend, or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure while also maintaining the capacity for adaptation, learning, and transformation.[7]

The IPCC states that "climate resilient development" is the process of implementing greenhouse gas mitigation and adaptation measures to support sustainable development for all.[8] The Paris Agreement states that "to limit the temperature increase to 1.5°C above pre-industrial levels" would "significantly reduce the risks and impacts of climate change."[9] In addition, the Parties agreed to increase "the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development" and to make "finance flows consistent with a pathway" towards such development.[10]

With the planet already too hot at 1.2°C, we have very little time to deploy necessary measures to ensure the resilience of present and future generations is not compromised. Building resilience requires strategic and focused measures to ensure that current efforts to address climate change are not rendered futile by the planet crossing critical climate tipping points. To avoid this fate our actions must simultaneously address the near-term rate of warming as well as stabilize the climate system in the long term.

[7] Intergovernmental Panel on Climate Change, Climate Change 2022: Impacts, Adaptation and Vulnerability, *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* 7 (H.-O. Pörtner et al. eds., 2022) at fn 12 (hereinafter "IPCC 2022, AR6 WGII").

[8] *Id*. at 7 fn 20.

[9] Paris Agreement art. 2(1)(a), Dec. 12, 2015, T.I.A.S. No. 16-1104.

[10] *Id*. arts. 2(1)(b), (c).

3. The Human Right to Resilience as a North Star to Inform Policies and Investments

Throughout history, human rights law has served as both a beacon of hope and a North Star, guiding humanity from the darkest atrocities towards a world where peace and solidarity are attainable.

Human rights treaties are living instruments that evolve to respond to changing times and conditions. The existential threat that the climate emergency poses to humankind warrants an evolutive interpretation of human rights law to recognize the human right to resilience as a derivative of the human right to life.

The human right to resilience in the context of climate refers to the right of every individual and group to access, develop, and maintain the capacity to withstand, adapt to, and recover from the adverse impacts of climate change.

This right ensures that both present and future generations can sustain their essential functions, identity, and structure in the face of climate-related stresses and shocks. It requires that policies, investments, and actions by states, international institutions, and private entities prioritize climate adaptation, mitigation, and restoration efforts that bolster the resilience of individuals and communities against the escalating threats of climate change.

The human right to resilience has significant implications for State and private sector responsibility, delineated by three core obligations grounded in climate science, due diligence, and the duty of care:

1. The obligation of effective mitigation.
2. The obligation of effective adaptation.
3. The obligation of effective restoration.

3.1 The Obligation of Effective Mitigation

Limiting the increase in global temperature is essential to build and maintain resilience. At the current rate of warming, we are compromising the resilience of present and future generations. We need more time to ensure that we can adapt to and manage climate risks effectively.

The only way to give us this time is to reduce the rate and amount of warming in the near term. This is because extreme climate impacts depend both on the rate of warming as well as the total amount of warming, and the sustained rate of increases in CO_2 and emissions of other climate pollut-

ants is especially dangerous.[11] Critically, slowing the rate of warming will also make it possible to postpone exceeding critical climate tipping points.[12]

As the IPCC has emphasized, it is crucial to understand that adaptation has its limits;[13] certain warming scenarios with limited mitigation will render some adaptation impossible. This means that we cannot only invest in adaptation, we must also urgently mitigate. Some climate impacts, once manifested, will leave behind an altered world that cannot be reversed by just bringing the temperature down.[14]

Grounded in the best available science, the obligation of effective mitigation requires implementing measures to reduce the rate of warming in the near term and limit global temperature increases to 1.5°C with limited overshoot.

Science indicates that only actions aimed at mitigating non-CO_2 pollutants – the short-lived climate pollutants – especially methane, can reduce temperature in the short term,[15] but these measures must be deployed at scale within the next few years. Specifically, the scientific evidence identifies the following targets for non-CO_2 climate pollutants to keep 1.5°C within reach:

– reducing global methane emissions by 40-45% by 2030 relative to 2030 projected levels;[16]

[11] See E.M. Fischer, S. Sippel, & R. Knutti, *Increasing probability of record-shattering climate extremes*, 11 Nat. Clim. Change 689, Supp. Info. (2021).

[12] Armstrong McKay, Exceeding 1.5°C, *supra* note 4, at 7.

[13] IPCC, *AR6 Synthesis Report: Climate Change 2023, Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (P. Arias et al. eds., 2023), 8, 19, 24-26 (hereinafter "IPCC, AR6 Synthesis Report").

[14] A. Reisinger & O. Geden, *Temporary Overshoot: Origins, Prospects, and a Long Path Ahead*, 6 *One Earth* 1631, 1634 (2023).

[15] G.B. Dreyfus, Y. Xu, D. Shindell, D. Zaelke, & V. Ramanathan, *Mitigating Climate Disruption in Time: A Self-Consistent Approach for Avoiding Both Near-Term and Long-Term. Global Warming*, 119 Proc. Nat'l Acad. Sci. 1, 1-8 (2022).

[16] UNEP & CCAC, Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions, at 11 (2021); UNEP & CCAC, *Global Methane Assessment: 2030 Baseline Report* 6 (2022); IPCC (2022) Summary for Policymakers, in *Climate Change 2022: Mitigation of Climate Change*, *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* 17 (P.R. Shukla et al. eds., 2022) (hereinafter "IPCC, 2022: AR6 WGIII"). The methane reduction percentage is broadly equivalent to the target in UNEP's Global Methane Assessment.

- reducing emissions of fluorinated gases, including hydrofluorocarbons (HFCs) by 85% by 2050 relative to 2019 levels;[17]
- reducing nitrous oxide (N_2O) emissions 20% by 2050 relative to 2019 levels;[18] and
- reducing black carbon emissions by 35% by 2050 relative to 2010 levels.[19]

While many cost-effective technologies already exist to reduce these emissions – and while their deployment would create jobs, local health benefits, and increase food security – mandatory obligations under international law to achieve these reductions are largely lacking, with the notable exception of HFCs. The reduction of HFCs is mandated by the Kigali Amendment to the Montreal Protocol.[20] As a consequence, the deployment of these measures remains largely at the discretion of states. The human right to resilience, however, seeks to limit this excessive voluntarism and discretion, by imposing specific obligations that are science focused.

The obligation of effective mitigation also takes into account the right of future generations to resilience. Therefore, it also entails adopting all necessary measures to ensure the resilience of key elements of the climate system that are essential to avoid activating tipping points and feedback loops that could compromise resilience for all life on Earth. These key elements of the climate system include the Arctic sea ice and land-based snow and ice, the Antarctic ice sheet, the Amazon, coral reefs, and the global ocean circulation.

Achieving the 2050 net zero CO_2 target is essential for stabilizing the climate, but it cannot by itself prevent global temperatures from exceeding 1.5°C above pre-industrial levels.[21]

The obligation of effective mitigation to protect the human right to resilience requires implementing strategies both to reduce short lived climate pollutants by 2040 and to achieve net-zero CO_2 by 2050. Both CO_2 and non-CO_2 climate pollutant strategies must be mandatory, complementary, and not exchangeable. The obligation of effective mitigation also entails re-

[17] IPCC, 2022: AR6 WGIII, *supra* note 16, at 17.

[18] *Id*.

[19] IPCC, 2018: Global Warming of 1.5°C, *supra* note 6, at 12. NB: black carbon reductions rely on the IPCC's findings in its 2018 Special Report, but this is an evolving area of research.

[20] Kigali Amendment to the Montreal Protocol (Kigali, Rwanda, 2016).

[21] Dreyfus, *supra* note 15, at 5.

fraining from any action that can affect the resilience of key elements of the climate system, including for example the Amazon and other forests that draw CO_2 from the atmosphere and help stabilize the climate.

The test for compliance with the effective mitigation obligation would be whether the action is adequate and timely to reduce the rate of warming in the near term and keep the temperature below 1.5°C with limited overshoot in the future. National plans focusing solely on CO_2 reductions without addressing methane by 2030, for example, would fail this test. Similarly, international financial institutions and major polluting private sector entities that do not implement concrete methane mitigation targets alongside their CO_2 reductions targets would also fail this test.

2.2 The Obligation *of Effective Adaptation*

The obligation to ensure effective adaptation requires States, international financial institutions, and private actors to take all necessary actions to enable present and future generations to adapt to climate impacts.

When investing in adaptation, it is vital to consider whether the measures being implemented practically enhance or sustain the resilience of the communities impacted. The human right to resilience does this by clarifying the scope of adaptation obligations. The content of these obligations is guided by the science that tells us time is short and the risks to human life from current and future climate impacts by failing to adapt adequately are great. Adaptation measures must be deployed promptly and be capable of withstanding climate risks and impacts with minimal or negligible damage to all people, including vulnerable groups. Additionally, adaptation measures should not accelerate the climate emergency, and must consider the impact on short-term temperature rise and include compensatory measures for affected communities if necessary.

The obligation of effective adaptation also requires mandatory climate impact assessments of adaptation measures.

The test for compliance involves assessing whether the adaptation measure is timely and effective, and whether it exacerbates the current emergency or strengthens resilience. At a minimum, States, international financial institutions, and major private sector polluters should avoid actions that undermine resilience and prioritize investments that build and enhance it.

Increasing the debt of developing countries to pay for infrastructure projects that cannot withstand climate risks or that will exacerbate temperature rise will fail this test.

2.3 The Obligation of Effective Restoration

To manage risks and build effective resilience we must urgently avoid breaching critical thresholds and irreversibly altering key elements of the climate system. As the IPCC recognizes, ecosystem stewardship is a critical part of near-term climate action that builds resilience.[22]

In some cases, we can still preserve ecosystem resilience through mitigation alone. However, in other cases, mitigation alone will not suffice; we must also undertake restoration efforts to ensure ecosystem resilience.

This obligation entails urgently restoring essential elements of the climate system to enhance our collective resilience. Given the existing damage to the climate system, restoration is crucial for effective long-term mitigation and adaptation efforts.

The following examples illustrate the vulnerability of several key elements of the climate system, their importance to humanity's collective resilience, and the need to ensure their restoration.

– Arctic ice sheets and sea ice form a "great white shield" reflecting solar radiation safely back into space. If all the Arctic sea ice were lost for the sunlit months, it would add the equivalent of 25 years of emissions at the current amount of warming.[23] If current warming trends continue, the Arctic summer sea ice will disappear by mid-century or sooner.[24] Once global warming surpasses the Greenland Ice Sheet's tipping point (estimated at 1.5°C) for sustained periods, irreversible melting of the ice sheet is inevitable.[25] The potential consequence of complete Greenland melting could yield up to 7 meters of sea-level rise. While the loss of Arctic summer sea ice would exacerbate this risk.[26]

[22] IPCC, *AR6 Synthesis Report*, *supra* note 13, at 97, 114.

[23] K. Pistone, I. Eisenman, & V. Ramanathan, Radiative Heating of an Ice-Free Arctic Ocean, 46 *Geophys. Res. Lett.* 7474, 7477 (2019).

[24] IPCC 2022, AR6 WGII, *supra* note 6, at 2324; Y.-H Kim et al., Observationally-constrained projections of an ice-free Arctic even under a low emission scenario, 14 *Nat. Commun.* 3139, 1, 5 (2023).

[25] Armstrong McKay, Exceeding 1.5°C, *supra* note 4, at 7; *and* Earth Systems Tipping Points*, supra* note 4, at 12; *and* A. G. Stroeve J., & C.-F Schleussner, Only halving emissions by 2030 can minimize risks of crossing cryosphere thresholds, 13 *Nat. Clim. Chang.* 9, 10 (2023).

[26] Earth Systems Tipping Points, *supra* note 4, at 101.

– At 1.5°C, coral reefs are projected to decline by a further 70-90%.[27] As coral reefs support around 25% of our ocean's marine life, and an estimated 1 billion people benefit from coral reef ecosystems, mass die-offs of coral reefs would result in widescale food insecurity.[28]
– The Amazon rainforest is currently shifting from a critical carbon "sink" into a "source" of carbon dioxide. There is a risk that when 20-25% of the Amazon is destroyed, the forest will be committed to turning into a savanna, which would have devastating impacts for resilience efforts worldwide.[29]

Compliance with the obligation of restoration is measured by whether actions are timely, science-based, and aimed at maintaining the resilience of critical elements of the climate system.

We still have the opportunity to preserve much of what remains and to restore some of the damage already inflicted. However, this should not be seen as optional but as a legal obligation rooted in the human right to resilience.

4. Conclusion

Recognizing the human right to resilience is not only a moral imperative but a strategic necessity in the fight against climate change. It serves as a guiding principle for all actors, demanding accountability and informed, effective action. Policies and investments must be evaluated against their ability to uphold this right, ensuring that mitigation, adaptation, and restoration efforts are not only ambitious but also aligned with the urgent demands of our time. This approach will help stabilize the climate system, protect human life, and safeguard the planet for future generations.

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[27] IPCC, *AR6 Synthesis Report*, *supra* note 13, at 71.
[28] U.S. EPA, *Basic Information about Coral Reefs* (11 May 2023).
[29] Thomas E. Lovejoy & Carlos Nobre, *Amazon's Tipping Point,* 4 Sci. Adv. 1 (2018); IPCC, 2018: Global Warming of 1.5°C, *supra* note 6, at 263.

YOUTUBE PRESENTATION

Soaring Methane: Risk for Accelerated Natural Releases, Opportunities for Mitigated Anthropogenic Releases

Örjan Gustafsson
PAS, Stockholm University, Sweden

https://youtu.be/x7Sw7bV0JdY?si=N9gM4kuw6uN8GgAx

SESSION IV – FOOD

Energy vs. Food Security: The Aquavoltaics Case of Taiwan

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Abstract

Facing the global climate emergency, the Intergovernmental Panel on Climate Change (IPCC) consistently emphasizes that the current decade is crucial for global climate action. The gradual decarbonization of energy systems is critical and forms the foundation for achieving the 2050 net-zero emissions target. Taiwan initiated its energy transition plan in 2016, aiming for a 20% share of renewable energy by 2025, including solar photovoltaics (PV). However, due to geographical constraints, Taiwan has explored aquavoltaics as a primary source. Although this innovative combination of solar PV systems and aquaculture offers long-term benefits, it causes short-term disruptions in fisheries and raises environmental and social controversies, implicating food security issues.

To reconcile potential conflicts between renewable energy development and traditional fisheries, this study proposes using the Analytic Hierarchy Process (AHP) to optimize the decision-making process. Through quantitative assessments, a localized multi-tier decision-making framework can be established among diverse stakeholders. This framework enables decision-makers to accurately identify key concerns of fishermen, balancing energy development and food security based on scientific foundations and necessary transparency. Furthermore, this study suggests that this decision-making approach can evolve into an AI-assisted decision support system, making policies more aligned with actual needs.

1. Introduction

1.1 Critical Timeline for Net-Zero 2050

Achieving net-zero emissions by 2050 has become a universally shared objective following the signing of the Paris Agreement. Scientific research, notably from the IPCC, underscores the critical importance of the coming years in accelerating efforts to achieve this goal (IPCC, 2023). Jim Skea, co-chair of the IPCC, stressed, "It's now or never, if we want to limit global

warming to 1.5°C (2.7°F). Without immediate and deep emissions reductions across all sectors, it will be impossible".

The IPCC further highlights that even to limit warming to around 2°C (3.6°F), global greenhouse gas emissions must peak before 2025 and decrease by 25% by 2030. Commitments made at international climate summits, such as COP meetings, reinforce this urgency. The message from COP28 is clear: transitioning away from fossil fuels in an equitable manner and accelerating actions in this critical decade are essential to achieving net-zero by 2050.

1.2 The policy implication of Renewable Energy development to Food Security

The relationship between energy and food security is increasingly impacted by extreme climate events, from droughts to floods, which directly threaten the stability of the food supply chain (Brown et al., 2015; Mal et al., 2018; Sá et al., 2017). By promoting carbon neutrality policies and practices using renewable energy, we aim not only to reduce the threat of global warming but also to establish a core strategy for ensuring sufficient and safe food for all (IPCC, 2022).

Increasing biomass for food, feed, and renewable energy, along with promoting sustainable agriculture and integrating renewables into agricultural practices, can foster significant synergies. These synergies can support sustainable food production and contribute to a more resilient food system, yielding substantial long-term benefits (Majeed et al., 2023).

However, there are immediate challenges to consider. Renewable energy sources such as bioenergy, solar, and wind require significant land use, which can directly compete with the cultivation of food crops. Although these energy sources reduce dependence on fossil fuels, their substantial demand for land may limit food production, thereby impacting food security (Zhuang et al., 2022). UNCCD (Fritsche et al., 2017) highlights that Sustainable Development Goal 2 (SDG 2), which focuses on ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture, has high land relevance. This indicates that energy production and land use are deeply embedded in SDG 2, thus requiring careful management to ensure that neither compromises the other. Managing the balance between energy production and land use is essential to ensure that both are sustainable and do not interfere with each other, particularly concerning the agricultural and fisheries use of land for food production.

Effective policies must address both the long-term benefits and the immediate challenges of renewable energy development to safeguard food

security while advancing towards carbon neutrality. In formulating energy development policies, governments must incorporate food security as a central consideration, ensuring that the development of new energy sources is balanced with food production. This approach will help maintain a sustainable balance between energy needs and agricultural productivity, ultimately contributing to both climate resilience and global food security.

2. Energy and Food Dilemma: A Case Study of Taiwanese Fisheries

2.1 Energy Policy

From 2018 to 2023, Taiwan's energy dependency on imports remained extremely high, with 98.06% of energy imported in 2018 and 96.7% in 2023. Addressing the challenge of Taiwan's low energy self-sufficiency has thus become a crucial and pressing policy objective.

In response, Taiwan's 2018 Renewable Energy Policy set ambitious targets, including installing 20GW of solar power by 2025. This target comprises 17GW of ground-mounted systems and 3GW of rooftop installations. Additionally, the policy aims to establish 6.5GW of wind power and promote other renewable energy sources. By 2025, the goal is for renewable energy to account for 20% (27GW) of Taiwan's total power generation.

To achieve this goal, Taiwan, as an island nation, faces significant challenges in developing renewable energy due to limited land area and land fragmentation. These conditions make it difficult to deploy large-scale ground-mounted PV systems. To address this issue, Taiwan has prioritized the dual-use of land, integrating the aquavoltaics systems as a key focus for solar power development.

2.2 The Challenge Under the Energy Policy

The fisheries sector holds a significant position in Taiwan's economy and has a substantial impact on the global fish supply. Consequently, the implementation of Taiwan's aquavoltaics policy has led to significant impacts on the sector, especially inland water aquaculture. These include reduced production, rising fish prices, and the monoculture of crops, as species that coexist more easily with PV panels are chosen.

Pursuing net-zero emissions has become one of the most critical national objectives today. The energy sector, thriving in this era, has become a "blue ocean" of immense potential benefits. Consequently, energy development often benefits from comprehensive policy planning, and the viewpoints of energy stakeholders receive considerable attention and importance. As a re-

sult, fishermen directly impacted by these policies typically need to take to the streets to voice their demands and fight for their rights, often leading to a stagnation of overall policy implementation.

From this, it is evident that national policies must consider all potential impacts at the planning stage and involve public participation and stakeholder discussions to prevent overlooking crucial factors. Otherwise, unforeseen consequences post-implementation can reduce the efficiency and success of developments, potentially damage public trust in the government, and trigger more conflicts, thereby delaying project timelines.

3. Application of the Analytic Hierarchy Process (AHP)

3.1 The Main Barrier of Discussing Energy Issues

Energy issues typically encompass various aspects. Different perspectives can lead to diverse and sometimes conflicting viewpoints. These issues are often referred to as "wicked problems," characterized by their complex and poorly structured nature, with interconnected causes and impacts, and usually lacking clear solutions (Rittel & Webber, 1973). Therefore, traditional methods of stakeholder communication often fail to highlight these multifaceted values and frequently result in a zero-sum dilemma. It is difficult to truly reflect the diversity of opinions in the final policy decisions using conventional stakeholder communication approaches.

3.2 Analytic Hierarchy Process (AHP)

This study aims to address the challenges of traditional stakeholder communication by applying the AHP, which is a structured technique for tackling complex decision problems. It breaks down the decision problem into smaller components, establishes a multi-level hierarchy to decompose decision goals, criteria, and conducts pairwise comparisons and quantitative evaluations. This method is particularly effective in accommodating conflicting, multidimensional, immeasurable, and incomparable sets of objectives, making it suitable for situations involving multiple interest groups and extensive participation (Sellak et al., 2017).

Thus, employing the AHP to address complex issues in policy implementation facilitates effective communication between policymakers and stakeholders and integrates and balances multiple interests through formalized public participation in the decision-making process. This approach increases the transparency and credibility of the entire procedure with scientific data. Consequently, it ensures that while pursuing new energy development, the importance of food security is not overlooked.

4. Empirical Study: AHP Analysis of Aquavoltaics Policy

4.1 Localized Framework for Analyzing Objective and Factors

This study develops a framework (e.g. Fig. 1) tailored to the local context of Taiwan to analyze all factors influencing the implementation of the aquavoltaics policy. In this empirical research, experts from academia, industry, government agencies, and environmental protection groups participated. The backgrounds of these 30 experts include economics, aquaculture, environmental science, and energy. They completed the AHP survey, ensuring a comprehensive perspective was achieved.

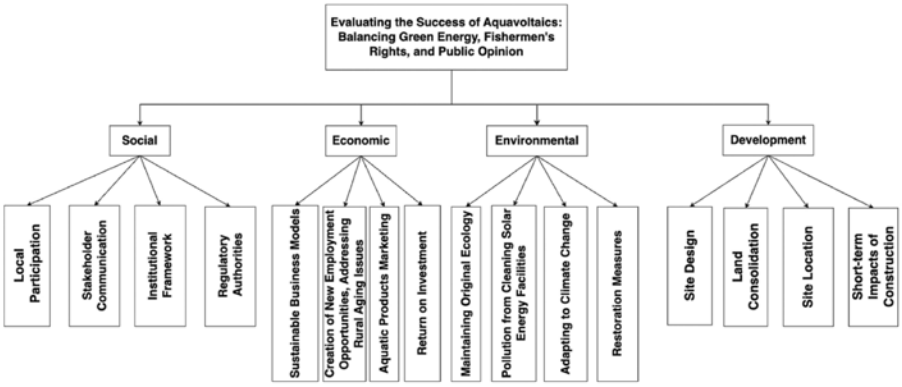

Figure 1. AHP Structure.

4.2 Discrepancy Between Stakeholder Opinions and Policy Implementation

In categorizing and analyzing different stakeholder groups of the AHP results, this study observed a significant finding regarding the "Return on Investment" (ROI). The PV groups value ROI more than three times as much as the aquaculture groups or the overall results of the analysis (e.g. Fig. 2). Currently, the PV groups are the primary implementers of the aquavoltaics policy in Taiwan, with extensive policy measures designed to address their emphasis on ROI.

In contrast, compared to the significant attention given to the voices of the PV groups, the aquaculture the place more than twice the importance on "Aquatic Products Marketing "than both the PV groups and the overall results of the analysis (e.g. Fig. 3). There is a need for more detailed planning and arrangements to support the emphasis of the aquaculture groups on "Aquatic Products Marketing."

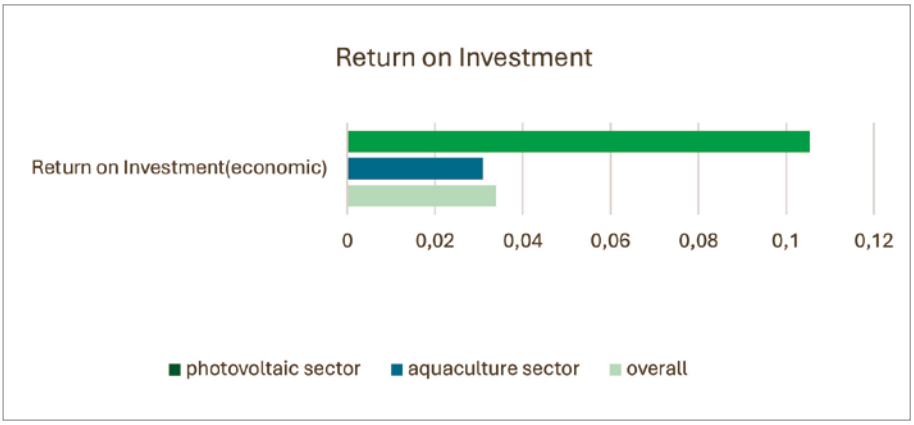

Figure 2. Return on Investment Results.

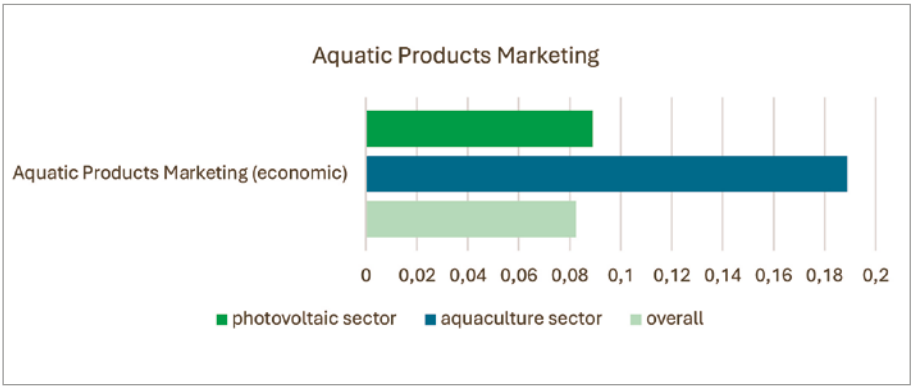

Figure 3. Aquatic Products Marketing Results.

4.3 Overlooking the Food Security Issue

The concept of "Aquatic Products Marketing" encompasses "food security," which involves the livelihoods of fishermen, the supply and demand of the fish market, and thereby affects the overall economy of the nation and even the international supply of fish. Observations from the single factor perspective show that the aquaculture have specific and meaningful demands regarding "Aquatic Products Marketing" (e.g. Fig. 3). From an overall perspective, "Aquatic Products Marketing" (ranked 5th) (e.g. Fig. 4) should receive at least as much attention as the investments of PV operators (ranked 13th) (e.g. Fig. 4) when implementing the aquavoltaics policy.

It is evident that traditional stakeholder communication methods may inevitably lead to a focus predominantly on specific viewpoints or majority decisions, potentially resulting in the underrepresentation of other significant opinions and less comprehensive planning within the policy.

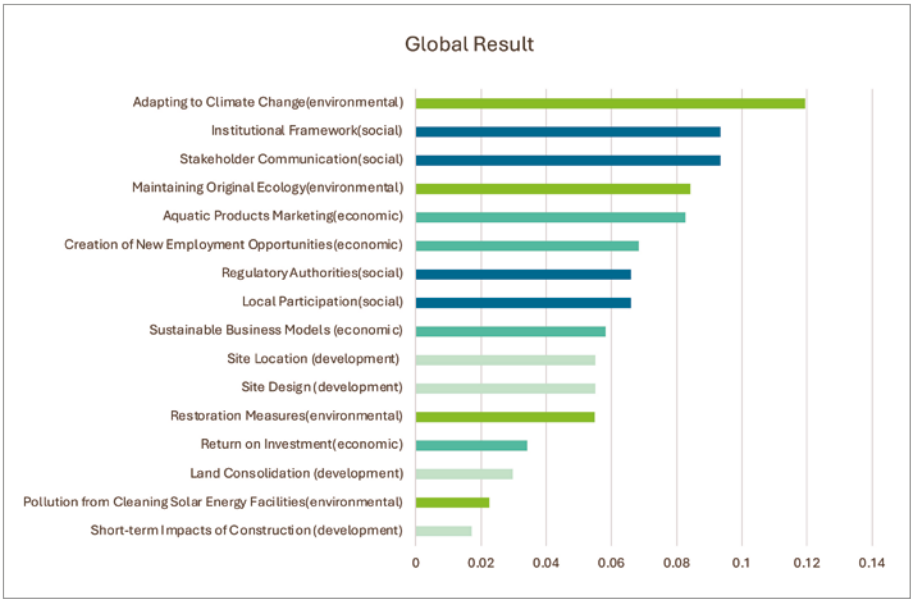

Figure 4. Global Result.

4.4 Address The Current Predicament: An AHP Approach

This study addresses above dilemma using the AHP approach to clearly present the opinions of different stakeholders in a quantifiable manner. The key features include:

- Identifying key factors that need attention.
- Measuring and assessing weights from different dimensions and perspectives.
- Understanding the concerns and priorities of different stakeholders regarding these factors.

This method enables policy designers to achieve coherence among different stakeholders. "Stakeholder Communication" and "Institutional Framework" are both ranked second in importance from an overall perspective

in the aquavoltaics policy (e.g., Fig. 4). The findings support the use of the AHP to address complex policy issues.

By presenting results from different dimensions and perspectives this approach ensures all viewpoints are reflected. This scientific method facilitates effective communication between policymakers and stakeholders, ensuring immediacy, transparency, and interactivity of information. Establishing these opinions within a clear institutional framework provides the necessary legal and policy guidance for implementing policies, thereby enhancing policy acceptance and execution efficiency.

5. Conclusion and Future Prospect

This study integrates humanistic issues into our aquavoltaics policy and leverages technology to harmonize these elements. This approach promotes sustainability and serves as a model for future renewable energy policies. By balancing diverse perspectives and considering all factors comprehensively, this study not only enhance policy effectiveness but also ensure governmental transparency and public engagement, propelling us towards a sustainable and resilient future.

Looking ahead, we acknowledge that the AHP method, while effective, is complex and time-consuming, presenting a higher barrier to entry for participants. In this study, we have created a localized framework for the aquavoltaics policy, providing an excellent structure for discussion. In the future, this framework will evolve into an interactive platform allowing users to engage directly in discussions on various themes and cases. Each criterion or factor will be treated as an independent topic of discussion, with user interactions – such as clicks and participation – informing the importance weights of each factor.

By integrating AI technology, this platform can dynamically adjust these weights, reducing the tediousness of traditional AHP surveys and increasing accuracy in reflecting public opinion. Additionally, AI can recommend related case studies and topics that interest users, promoting better understanding and communication. An AI-assisted platform will make the decision-making process more transparent and scientific, allowing the results to accurately express public sentiment and the perspectives of all stakeholders.

Acknowledgments

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YOUTUBE PRESENTATION

Realigning Economic Incentives to Foster Climate Resilience

David Laborde
Agrifood Economics and Policy Division, FAO (UN)

https://youtu.be/jKyFRyS5B-Y?si=jEehdtSagRpZrs39

SESSION V – ENERGY

Real Success in Meeting the Climate Change Challenge: Foundations for a Just Energy Transition

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Author's Note

Daniel C. Esty https://orcid.org/0000-0001-9980-1147. The content of this paper was presented at the PAS-PASS Vatican joint symposium *From Climate Crisis to Climate Resilience* Summit Meeting in May 2024. I have no known conflicts of interest to disclose. Correspondence concerning this article should be addressed to Prof. Dan Esty, Email: daniel.esty@yale.edu

Climate change presents an existential threat to the global community. It poses a risk of increased intensity and frequency of hurricanes and typhoons, changed rainfall patterns leading to both more droughts (and thus wildfires) and floods as well as potentially reduced agricultural productivity. The scientific evidence of trouble ahead is mounting. Temperature records suggest that the summer of 2023 was the hottest one in a millennium.[1] Ocean warming, which is connected to rising sea levels and loss of habitable land, appears to have gone even further off the charts.[2] Beyond climate change, the scientific team tracking planetary boundaries now believes that, for six of nine essential Earth Systems, human-caused disruptions may have pushed us beyond critical limits, meaning that the safe operating space for the planet has been transgressed.[3] And yet, world leaders dither and the policy response to the looming threat remains inadequate.

[1] Esper, J., Torbenson, M. & Büntgen, U. (2024). 2023 Summer warmth unparalleled over the past 2,000 years. *Nature*, *631*, 94-97. https://doi.org/10.1038/s41586-024-07512-y

[2] Cheng, L., von Schuckmann, K., Abraham, J.P., Trenberth, K.E., Mann, M.E., Zanna, L., & Lin, X. (2022). Past and future ocean warming. *Nature Reviews Earth & Environment*, *3*(11), 776-794.

[3] Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S., Donges, J.F., Drüke, M., Fetzer, I., Bala, G., Werner von Bloh, Feulner, G., Fiedler, S., Gerten, D., Gleeson, T., Hofmann, M., Willem Huiskamp, Matti Kummu, Mohan, C., Bravo, D., &

The elements of a successful response to climate change are well understood. Simply put, we need a new foundation for the global economy, which ends the build-up of greenhouse gases (GHGs) in the atmosphere. This transformation requires a shift the energy underpinnings of society from fossil fuels to clean and renewable energy sources.

But the policy process to deliver this shift has been tortuous. The global community clearly understood the challenge as of 1992 when world leaders gathered at the Rio Earth Summit to sign the UN Framework Convention on Climate Change. That treaty committed nations to avoid dangerous anthropogenic global warming and set out initial targets and timetables for action. And while the 120 Presidents and Prime Ministers at the Rio Summit celebrated this perceived *success*, the Canadian diplomat and businessman Maurice Strong who served as the Secretary General to the United Nations Conference on the Environment and Development (as the Rio gathering was formally known) observed at the time that the ultimate test was whether the Rio commitments produced *real success* in the years that followed – gauged by whether GHG emissions were reduced and the threat of climate change avoided.[4]

As decades have passed, further claims of *success* have been made, but there is little evidence of the broad-scale transformation required to mitigate the negative impacts of climate change. At the COP28 climate summit meeting in 2023 in Dubai, government officials representing nearly 200 countries agreed that the world must "transition away from fossil fuels."[5] Negotiators also established a *Loss and Damage* mechanism to provide funding for nations affected by climate change-caused disasters, representing an important commitment to equity and to the principle that the victims of climate change (who often bear very little responsibility for the build-up of emissions in the atmosphere) should have resources for recovery available.

Petri, S. (2023). Earth beyond Six of Nine Planetary Boundaries. *Science Advances*, 9(37). https://doi.org/10.1126/sciadv.adh2458

[4] Conversation with the author at the US Environmental Protection Agency, March 1992.

[5] *Report of the Conference of the Parties on its twenty-eighth session, held in the United Arab Emirates from 30 November to 13 December 2023*. United Nations Framework Convention on Climate Change, March 15, 2024. https://unfccc.int/sites/default/files/resource/cp2023_11a01_adv.pdf

1. Hard Realities Emerging

But the real story of the Dubai convocation was the Global Stocktake meant to assess progress on the climate change action commitments of each party to the 2015 Paris Climate Change Agreement. The review, which added up all of these action elements (formally known as Nationally Determined Contributions or NDCs) revealed that overall emissions are rising, not falling. The Stocktake made clear that, while investments in alternative energy reduced GHG emissions in a number of nations,[6] only a few are on a trajectory to meet the target of net-zero GHG emissions by mid-century established in the 2021 Glasgow Climate Pact.[7] More troublingly, in a number of developing nations (including many of the most dynamic economies of the Global South) emissions continue to rise – highlighting the simple fact that *real success* in meeting the climate change challenge requires a just energy transition that moves all nations together toward net-zero GHG emissions in 2050.

The disappointing Global Stocktake outcome forces us to clarify the *theory of change* previously advanced in the Paris Agreement and to rethink the world community's response to the looming climate crisis. In this regard, we must consider a critical set of questions: What comes next? How do we shift the GHG trajectory? What should we do differently to meet the demands of the moment? And most critically: how do we structure policies to deliver transformative change and bend the emissions trajectory downward at the speed and scale required?

To meet the 21st century *Sustainability Imperative*,[8] we must identify the elements of a just transition to sustainable energy future and the pathways for delivering them. The following section provides a sketch of what will be required.

2. Delivering a New Energy Foundation for the Global Economy

Climate science continues to evolve, but the scientific consensus on the need to stabilize atmospheric concentrations of GHGs – which will require dramatically reduced emissions in the coming decades – has been broadly ac-

[6] *Global Stocktake Synthesis Report*. United Nations Framework Convention on Climate Change: Bonn 2024. https://unfccc.int/documents/638443

[7] Environmental Performance Index. (2024). Yale School of the Environment. https://epi.yale.edu/measure/2024/EPI

[8] Lubin, D., & Esty, D. (2010) The Sustainability Imperative. *Harvard Business Review*. https://hbr.org/2010/05/the-sustainability-imperative (spelling out the environmental logic and business implications of sustainability as a core 21st century value).

cepted.[9] The 2015 Paris Agreement establishes an over-arching goal of holding the change in global average temperatures to well below 2 degrees Celsius above pre-industrial levels with a further commitment to try to limit global warming to 1.5 degrees Celsius.[10] The 2021 Glasgow Climate Pact sharpens this target and sets the timetable for net-zero GHG emissions at mid-century.[11]

The endpoint is straightforward: a comprehensive shift to clean and renewable energy across the globe. The challenge arises from the scope and pace of the change required, which involves every person and enterprise in the world while taking into account the diversity of circumstances that must be accommodated. While the policy challenge can seem daunting, a good bit of what will be required to deliver the requisite build-out of the sustainable energy infrastructure for the future is known. Indeed, we can specify four critical policy elements: (1) innovation, (2) finance, (3) business engagement, and (4) equity (which is essential to the legitimacy of the policy framework).

2.1 Innovation

One of the keys to a successful transition will be continued innovation to ensure a relatively smooth and ever-cheaper shift from a past powered by fossil fuels to a sustainable energy future. While a central focus of innovation efforts has been – and should continue to be – technology breakthroughs, the push for creative new approaches to energy challenges must be much wider. It should include efforts to promote: (a) new policies and incentives for changed behavior (including a push for greater energy effi-

[9] IPCC. (2023). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Intergovernmental Panel on Climate Change (IPCC). https://doi.org/10.59327/IPCC/AR6-978929169164; Kikstra, J.S., Nicholls, Z.R.J., Smith, C.J., Lewis, J., Lamboll, R.D., Byers, E., Sandstad, M., Meinshausen, M., Gidden, M.J., Rogelj, J., Kriegler, E., Peters, G.P., Fuglestvedt, J.S., Skeie, R.B., Samset, B.H., Wienpahl, L., van Vuuren, D.P., van der Wijst, K.-I., Al Khourdajie, A., & Forster, P.M. (2022). The IPCC Sixth Assessment Report WGIII climate assessment of mitigation pathways: from emissions to global temperatures. Geoscientific Model Development, 15(24), 9075-9109. https://doi.org/10.5194/gmd-15-9075-2022

[10] Conference of the Parties, Adoption of the Paris Agreement, Dec. 12, 2015.

[11] *COP 26: The Glasgow Climate Pact,* UN Climate Change Conference: UK 2021 (Nov. 2021) https://ukcop26.org/wp-content/uploads/2021/11/COP26-Presidency-Outcomes-The-Climate-Pact.pdf. Note: the deadline established is "about mid-century," which most nations accept as 2050. But China has indicated that it will achieve net-zero GHG emissions by 2060. India has defined the target as 2070.

ciency); (b) fresh thinking and new strategies for public engagement; (c) redoubled commitments to capacity building that highlight the opportunities in the emerging clean energy economy and the training required to transition workers in all nations toward jobs of the future; (d) innovative finance to make it possible for a wide swath of individuals, companies, and communities to replace their existing energy-consuming devices and equipment with cutting-edge alternatives; and (e) strategic partnerships that convene industry, NGO, and government actors to bridge gaps in the pathway from the energy past to the clean energy economy of the future.

Innovation can be spurred with a variety of policy tools. Of particular importance will be efforts to put a price on GHG emissions and thereby making those responsible pay for the harm they cause.[12] Essentially, every time a purchase is being made, buyers should be confronted with price signals that steer their choices toward the socially preferred clean energy alternative. This financial incentive helps to promote care in the decisions being made, but also ensures – as a matter of climate justice – that those whose choices inflict harm on others pay for these impacts. By making those responsible pay fully for the damage being done by gasoline-powered cars, coal-fired electricity, steel derived from GHG-intensive coke ovens, and every other source of GHG emissions, we create powerful incentives for innovators to develop clean cars, electricity, steel, and more.

Although GHG pricing offers the most effective climate change policy and the greatest spur to innovation, similar incentives for innovation can be generated by providing *subsidies* for clean energy alternatives. While such incentives are generally considered to be a second-best policy alternative as they drive change more narrowly, sometimes a subsidy-based approach may be preferred as the only politically viable option available or because it permits investments in innovation to be targeted to specific problems.[13]

Finally, regulations that require adoption of new technologies may be the most useful – and, perhaps, the most efficient (and cost-effective) way to move the energy transition forward in some circumstances. Indeed, while

[12] Baranzini et al. (2017), Carbon pricing in climate policy: seven reasons, complementary instruments, and political economy considerations. WIREs Climate Change, 8: e462. https://doi.org/10.1002/wcc.462

[13] Kalkuhl, M., Edenhofer, O., Lessmann, K. (2013) Renewable energy subsidies: Second-best policy or fatal aberration for mitigation?, *Resource and Energy Economics*, *35*(3), 217-234; Meckling, J. et al. (2022) Busting the Myths around Public Investment in Clean Energy, *Nature Energy* 7, 563-565.

long derided as inflexible and thus inefficient, performance standards and other *command and control mandates* might be the best option where the purchaser has little capacity or incentive to make an informed choice or society would benefit from network effects or other economies of scale in a shift to new technologies. We have witnessed, for example, dramatic energy efficiency improvements from the shift away from incandescent and fluorescent bulbs to LED lighting. Similar government-mandated building efficiency standards may be essential to overcome information deficiencies and other market failures that would otherwise slow the move toward low-carbon homes, offices, factories, and commercial buildings.

Ultimately, the energy transition will be advanced by having a portfolio of incentives and policy tools available, from price signals to subsidies to regulatory mandates – providing *green lights* that tell individuals and businesses when and where to go and *red lights* that signal the need to stop certain activities.[14] In addition, the presence of a diverse set of policy instruments is fundamental to a just transition insofar as the wealthiest segments of society may invest in strategies of evasion that allow them to dodge any narrowly defined set of transition strategies and even legal requirements – and thus become *free riders* on the efforts of others.[15] But a portfolio approach that casts a wide net is likely to catch these potential free riders and ensure that they align their business models and energy choices with the societal commitment to deep decarbonization.

2.2 Finance

Fundamental to a successful energy transition are policies that ensure all nations, communities, enterprises, and individuals move together toward the clean energy future. As I discussed briefly above and in more depth in the *Business Engagement* section below, some corporate entities may seek a competitive advantage by shirking their responsibility to develop low-GHG-emissions business models and thus bring products to the marketplace at lower cost than others in their industry. But in other cases, un-

[14] Esty, D.C. (2017). Red Lights to Green Lights: From 20th Century Environmental Regulation to 21st Century Sustainability. *Environmental Law*, *47*(1), 1-80. http://www.jstor.org/stable/44219037

[15] Heitzig, J., Lessmann, K., & Zou, Y. (2011). Self-enforcing strategies to deter free-riding in the climate change mitigation game and other repeated public good games. *Proceedings of the National Academy of Sciences 108* (38), 15739-15744. https://www.pnas.org/doi/abs/10.1073/pnas.1106265108

derperformance is more a function of circumstances than design. In this regard, many companies and communities (especially in the Global South) lag behind in the push toward a clean energy future because they lack the capacity to invest in their own transition.

A successful and comprehensive (not to mention *just*) transition thus will require scaled-up commitments of capital to fund clean energy projects, equipment, and infrastructure – especially in the developing world. Some of these investments can be financed on a market basis. For example, clean energy power generation facilities produce electricity at costs that are competitive with fossil fuel alternatives. In these cases, the market-based returns on the project will justify the investment made.

But in many other cases, the shift to clean energy alternatives will be at some cost disadvantage compared to the status quo, particularly in jurisdictions that do not make GHG emitters pay for the harm they cause. In these cases, investments in new technologies may require *blended finance* – which means that some part of the project can be done on a market basis, but that subsidies (through some combination of Green Banks, Green Bonds, and other creative finance structures) will be required to make up the difference in cost between the status quo and the new clean energy approach.[16]

From a theoretical perspective, we must recognize that clean powerplants are what economists call a *mixed good*, meaning that they are, in part, *private goods* to the extent that the electricity generated can be sold for a price and consumed by specific people just like any other unit of power. But they have a *public good* dimension to extent that GHG-free electricity offers benefits to society above and beyond the value received by the individuals who use the power to run their machines, appliances, or devices. To ensure an optimal level of these clean energy goods (providing what economists call *positive externalities*), society must provide support to overcome the market failure.[17]

Creative clean energy financing at the national, regional, and global levels therefore emerges as a key policy lever for advancing a just and speedy transition to a sustainable energy future. In the United States, the Infla-

[16] Leonard, W.A. (2014) Clean is the new green: Clean energy finance and deployment through green banks. *Yale Law and Policy Review, 33,* 197-229. https://yalelawandpolicy.org/sites/default/files/YLPR/leonard_-_note_final_pdf.pdf

[17] Beeks, J.C., & Lambert, T. (2018). Addressing externalities: An externality factor tax-subsidy proposal. *European Journal of Sustainable Development Research, 2*(2), 19, https://doi.org/10.20897/ejosdr/81573

tion Reduction Act offers substantial clean energy subsidies.[18] Europe has begun to make similar investments through its Green Deal – and China has long subsidized its clean energy sector.[19] But to advance clean energy projects across the world at the requisite pace and scale, similar funds need to be made available across all nations with particular emphasis on blended finance strategies for countries lacking the resources or financial infrastructure to make large and long-term investments.

This need has long been recognized with calls for $100 billion/year in climate change capital for the Global South having been under discussion for decades.[20] What has become clear is that reaching the scale of finance needed will require substantial flows of private capital. In this regard, the finance world is beginning to get mobilized through initiatives such as the Glasgow Financial Alliance for Net-Zero (GFANZ), which brings together 400+ financial institutions under the leadership of former Bank of England Governor Mark Carney. But, as noted above, the willingness of private capital to finance clean energy infrastructure will not occur at scale unless there is parallel public funding to offset the risk of investing in emerging but risky climate-smart solutions. Support for these investments must be undergirded by expanded flows of capital through government-backed Green Banks (such as the one set up by the State of Connecticut in 2011)[21] and aid agencies as well as by new commitments of climate finance through the World Bank and other multilateral development banks as well as the International Monetary Fund.

[18] H., Larsen, J., Levin, A., Mahajan, M., Marcy, C., Mayfield, E., McFarland, J., Haewon McJeon, & Orvis, R. (2023). Emissions and energy impacts of the Inflation Reduction Act. *Science*, 380(6652), 1324-1327. https://doi.org/10.1126/science.adg3781

[19] Leonard, M., Pisani-Ferry, J., Shapiro, J., Tagliapietra, S., & Wolff, G.B. (2021). *The geopolitics of the European green deal* (No. 04/2021). Bruegel policy contribution.; Lin, B. & Jiang, Z. (2011). Estimates of energy subsidies in China and impact of energy subsidy reform, *Energy Economics, 33*(2), 273-283. https://www.sciencedirect.com/science/article/pii/S0140988310001143

[20] Copenhagen Accord, United Nations Framework Convention on Climate Change, December 18, 2009; Nhamo, G., & Nhamo, S. (2016). Paris (COP21) Agreement: Loss and damage, adaptation and climate finance issues. *International Journal of African Renaissance Studies – Multi-, Inter- and Transdisciplinarity*, *11*(2), 118-138. https://doi.org/10.1080/18186874.2016.1212479; Falkner, R., Stephan, H. & Vogler, J. (2010), International Climate Policy after Copenhagen: Towards a 'Building Blocks' Approach. *Global Policy, 1*: 252-262. https://doi.org/10.1111/j.1758-5899.2010.00045.x

[21] *Connecticut Green Bank,* https://www.ctgreenbank.com

2.3 Business Engagement

Ultimately, the sector most critical to a sustainable energy future is the business world. Indeed, it is the everyday decisions of hundreds of millions of corporate leaders in small and large enterprises in every nation that determine what products get offered in the marketplace and whether these goods and services are produced on a sustainable basis. Thousands of CEOs and executives across industries gathered at recent COP climate change summit meetings Dubai in 2023 and in Sharm el-Sheikh in 2022 and expressed their readiness to restructure their business models for a sustainability future.[22]

But *real success* in decarbonizing the global economy requires businesses at all scales in every industry and in every corner of the world to regear their activities in alignment with the commitment to a net-zero GHG world by 2050.[23] Against this test, the signals on the ground are quite mixed. On the positive side, thousands of companies have made net-zero emissions pledges in recent years – and significant effort is going into the innovation processes required to deliver deep decarbonization in almost every business sector with plans being drawn up for substantial investments in new technologies, transformed human resources, and more resilient supply chains. But the depth and breadth of the business world's commitment to transformative change remains uncertain.[24] In fact, many of the executives, who declare themselves ready to transition to a sustainable energy future, hedge when pressed – indicating that their willingness to go forward depends on their competitors moving in parallel and not seizing a competitive advantage in the marketplace by ducking commitments to a net-zero future. This re-

[22] Companies Taking Action data set, *Science Based Targets initiative*, July 14, 2023, https://sciencebasedtargets.org/companies-taking-action#table; A message from Starbucks CEO Kevin Johnson: Starbucks new sustainability commitment. January 21, 2020, https://stories.starbucks.com/stories/2020/message-from-starbucks-ceo-kevin-johnson-starbucks-new-sustainability-commitment/; Krauss, C. (2022, January 18) Exxon sets a 2050 goal for net-zero greenhouse gas emissions, *The New York Times*, https://www.nytimes.com/2022/01/18/business/exxon-net-zero-emissions.html; Microsoft, *FY22 additions to Microsoft's carbon removal portfolio data set*, July 14, 2023, https://app.powerbi.com/view?r=eyJrIjoiZTU5OTYwN2EtOTI3Ni00NGE0LThjNWItZTUzZTFlNWIxNzFhIiwidCI6ImMxMzZlZWMwLWZlOTItNDVlMC1iZWFlLTQ2OTg0OTczZTIzMiIsImMiOjF9

[23] Esty, D. & Cort, T. (2020) *Introduction to Values at Work: Sustainable Investing and ESG Reporting*. Palgrave Macmillan.

[24] Esty, D. & Menz, A. (2024), From pledge to practice: Delivering corporate net-zero emissions, *Management and Business Review 3(*4).

action makes it clear that the greatest threat to a just transition toward a clean energy future comes from the risk of what economists call *free riders* – companies or countries will not do their part to respond to the inescapably worldwide challenge of cutting GHG emissions to hold off the worst effects of climate change.

2.3.1 Disciplining Free Riders

Economic theory and practice are very clear on what results from free riding: defection from the commitment to action. Business leaders, faced with the prospect of competitors gaining market share and greater profitability by shirking emissions reduction obligations, fall back from their own commitments to transformative change.[25] And the policy structure framework quickly unravels in the face of this competitiveness dynamic.

Thus, the key to climate change progress is to keep the business community – across all countries, scales, and sectors – moving arm-in-arm toward net-zero GHG emissions by 2050. Of course, in our global economy of about $105 trillion/year, the top 1000 companies in the world generate about half of this annual value. So, these multinational companies must be put under particular pressure to adhere to the Glasgow Climate Pact targets and timetables.

2.3.2 New Ethical Foundations for all Economic Activity

To harness the power of enterprise as a force for sustainability, corporations must be held to a new ethical foundation that prohibits private gain at public expense.[26] Fundamentally, this means leaving behind the long-standing Friedman Doctrine[27] of *shareholder primacy* in favor of a new core principle of Stakeholder Responsibility that mandates a corporate duty of care toward employees, customers, suppliers, communities, and society as a whole. Of course, this ethical baseline is not really new. Indeed, the *polluter*

[25] Wood, P.J. (2011) Climate change and game theory. *Ecological Economics Reviews, 1219* (1): 153-170, https://nyaspubs.onlinelibrary.wiley.com/doi/abs/10.1111/j.1749-6632.2010.05891.x; Nordhaus, W.D. (2013, Chapter 21). *The climate casino*. New Haven, Yale University Press.

[26] Esty, D.C. (2022), Mastering the labyrinth of sustainability: Toward a new foundation for the market economy, *RED Journal,* (4), https://geopolitique.eu/en/articles/mastering-the-labyrinth-of-sustainability-toward-a-new-foundation-for-the-market-economy/

[27] Friedman, M., & Snowden, P.N. (2002). *Capitalism and freedom*. University of Chicago Press.

pays principle has been recognized for years – and has been reiterated in dozens of international agreements.[28]

In advancing a foundational business principle forbidding spillovers of harm, the world community would also be building on the animating spirit of Pope Francis's *Laudato Si'* Papal Encyclical with its call for care for the Earth as our common home. And, of course, the idea of a duty of care to others and to Nature is common to all the world's major religions. So, it is not unreasonable to insist that business follows the same golden rule of "do unto others as you would have them do unto you." The shift of this norm into law has begun as corporate *duty of care* principles have been advanced in a number of jurisdictions in recent years – most notably, in the European Union.[29]

To address successfully the existential threat of climate change and the need for a just transition to a clean energy future, the world community must come together behind the principle that business models that depend on spillovers of harm for their success (or what economists would call *uninternalized negative externalities*) are no longer acceptable.[30] Going forward, all pollution up a smokestack or out an effluent pipe or releases of GHGs into the atmosphere would all need to be stopped or paid for in full. Simply put, while pollution may once have been seen as the inevitable price for industrialization and economic progress, this logic no longer holds. Inflicting harms on others must now be seen for what it is – an exercise of special interest privilege and an injustice that must not be allowed to continue.

2.3.3 Harnessing the International Trade System to Enforce Sustainability Standards

Having identified the need to undergird the economy of the 21st century going forward with a commitment to end uninternalized externalities (beginning with, but ultimately not limited to, GHG emissions), we must confront the risk that global efforts to advance this principle will be under-

[28] Esty, D.C. (2021). Should Humanity Have Standing? Securing Environmental Rights in the United States. *S. Cal. L. Rev.*, *95*, 1345.

[29] Proposal for a Directive of the European Parliament and of the Council on Corporate Sustainability Due Diligence and Amending Directive (EU) 2019/1937, February 23, 2022, https://commission.europa.eu/business-economy-euro/doing-business-eu/sustainability-due-diligence-responsible-business/corporate-sustainability-due-diligence_en#documents

[30] Elliott, E. & Esty, D. (2021) The end externalities manifesto: A rights-based foundation for environmental law, *New York University Environmental Law Journal, 29*(1), 506-542. https://www.nyuelj.org/wp-content/uploads/2021/10/Elliott_Esty-Post-Proof.pdf

mined by corporate free riders who seek marketplace advantage by evading this obligation. Thus, we must ask how best to enforce the no-spillovers-of-harm requirement.

In this regard, national regulations must play a role. And pressure from sustainability-minded investors might also provide an incentive for corporate care.[31] But these elements of discipline have long proven inadequate to the challenge of constraining free riding in the international marketplace. The one institution that has a track record of success in defining and implementing ground rules for traded goods (albeit an imperfect one that is now under threat from rising geopolitical tensions) is the World Trade Organization.

Launched in 1995 with a mandate to advance *sustainable development*,[32] the WTO could prove to be the key policy lever for implementing sustainability standards broadly and GHG emissions limits in particular.[33] But to fulfill this role, the WTO will need to be reinvigorated and its rules tightened. In this regard, the *Villars Framework for a Sustainable Trade System,*[34] spells out a reform agenda that would allow the international trade system to deliver on its sustainability mandate – and position the WTO to become the backbone of global efforts to hold the business community's feet to the fire when it comes to climate change commitments.

2.4 Commitment to Equity as a Foundation for Climate Change Policy Legitimacy

As has been signaled through this article, good climate change policy must be underpinned by a commitment to equity. But what constitutes fairness in context of a just transition toward clean and renewable energy future has become highly contested. In this regard, a number of different dimensions of climate change justice can be identified. I highlight below seven such elements which should be considered, while recognizing that these competing visions of equity will sometimes in tension with each other.

[31] Esty, D. & Cort, T. (2020) *Introduction to values at work: Sustainable investing and ESG reporting*. Palgrave Macmillan.

[32] Marrakesh Agreement Establishing the World Trade Organization, Apr. 15, 1994, https://www.wto.org/english/docs_e/legal_e/04-wto_e.htm

[33] Esty, D.C. (2024) Sustainability policies complicate the WTO's work–and make it more indispensable than ever. *Fortune*. https://fortune.com/2024/02/26/sustainability-policies-complicate-wto-work-trade-environment-politics/

[34] Trachtman et al. (2024) *Villars Framework for a Sustainable Trade System (Policymakers summary)*. https://drive.google.com/file/d/1j_tpw-C6gOMu-g1IAlHBW6Vg_ZpQJK-dD/view

2.4.1 Participation – Procedural Fairness

Simply put, the process of defining the pathway toward a transformed clean energy economy matters. Sometimes discussed as a question of *inclusion* or *voice*,[35] the opportunity to participate in policymaking has often been available only to those who are well-organized, politically connected, or economically advantaged. A just transition to a sustainable energy future cannot be achieved absent basic standards of procedural fairness that make broad participation in the process possible and give historically marginalized communities a chance to shape the policy framework and the priorities it reflects.

2.4.2 Protection of Low-Income Citizens and Communities

At the most basic level, a just transition requires attention to the needs and circumstances of the poor. Policies that help low-income nations, communities, and citizens (including the poor in wealthy countries) with the energy transition will be essential to climate change progress. Of particular concern is the fact that with GHG pricing emerging as a core policy priority, there is a risk that such strategies will burden economically disadvantaged people – unless accompanied by additional policy interventions that redress their regressive nature.[36] Beyond concerns about equity, the politics of advancing a clean energy agenda become much harder if the costs of the transition fall disproportionately on those who are least able to pay as developing nations and low-income communities are capable of exerting political influence that can either advance or derail the transformation efforts needed to secure a clean energy transition.

2.4.3 Transition Assistance for Old Economy Workers

Another critical point from a political and fairness perspective is the need to focus on the citizens whose livelihoods will be disrupted or destroyed by the shift from a fossil fuel past to a clean energy future. Transformative change often creates losers as well as winners. The process of moving forward will be much easier if support for those whose jobs and communities

[35] Few, R., Brown, K., & Tompkins, E. L. (2007). Public participation and climate change adaptation: avoiding the illusion of inclusion. *Climate Policy*, *7*(1), 46-59; Kuhn, S., (1999). Expanding Public Participation is Essential to Environmental Justice and the Democratic Decision-making Process. *Ecology Law Quarterly* 25 (1998-99) 647.

[36] Page, E.A. (2008). Distributing the burdens of climate change. *Environmental Politics*, *17*(4), 556-575.

were tied to the Old Economy is taken seriously.[37] The challenge in this context is deepened by the reality that many coal miners, oil riggers, and natural gas pipefitters earned a very good living that they may find hard to replicate. The embedded expectations of these workers and their families presents a serious obstacle to change and their dim view of the future beyond fossil fuels may become a political rallying point.

2.4.4 Frontline Communities Bearing the Brunt of Climate Change Impacts

While the costs of taking action and shifting the energy foundation of the economy fall unevenly across society, so too do the costs of inaction. Coastal communities affected by rising sea levels – particularly those in low-lying cities or small-island developing nations – will need adaptation support. Likewise, farmers and agricultural regions facing changed rainfall patterns may need help in regearing their choice of crops and livestock as well as farming practices.[38]

2.4.5 International Equity

Fairness across nations – sometimes discussed as a matter of *burden sharing* – represents another important consideration in developing strategies for a just transition. In this regard, several factors may play into what is considered *equitable*. Some observers would argue for a principle that wealthier nations should pay more than ones at the lower end of the development spectrum – reflecting an *ability to pay* principle.[39] Others would focus on the *historic responsibility* for past emissions – effectively creating a *liability* principle that would hold those who put more GHGs into the atmosphere accountable.

In the climate change context, there has been a great deal of discussion about the principle of *common but differentiated responsibility* across nations. But in too many circumstances, emphasis has been allowed to fall on the *differentiation* of action obligations, resulting in little progress being made as there is deep disagreement about what is fair. To overcome this potential obstacle to progress, we would do well to remember that the core vision of

[37] Rosemberg, A. (2010). Building a just transition: The linkages between climate change and employment. *International Journal of Labour Research*, *2*(2), 125.

[38] Billah, M.M., Sarker, M.A., Miah, M.A.M., & Kabir, K.H. (2015). Adaptation of farming practices by the smallholder farmers in response to climate change. *Journal of Agricultural Extension and Rural Development*, *7*(2), 33-40.

[39] Anderson, B., Bernauer, T., & Balietti, S. (2017). Effects of fairness principles on willingness to pay for climate change mitigation. *Climatic Change*, *142*, 447-461.

Pope Francis's "On Care of our *Common* Home" centers on our *commonality* rather than our differences – and that all of us must contribute to a just transformation in line with our capacities.

2.4.6 Intergenerational Equity

Fairness to future generations and their need for a habitable planet requires special attention[40] – particularly as these future citizens of the Earth are not here to defend their own interests. Once again, we should recall the Pope's moral logic in arguing for care for all creation present and future. In this regard, we must recognize the need for ramped-up efforts not just to limit the damage from climate change but also to stop the loss of our planet's biodiversity, which has emerged as another existential threat to life on Earth.[41] This priority argues for a broad Nature Positive agenda and a commitment to fundamental change in our land use including a focus on regenerative agriculture and sustainable food systems – so as to leave our progeny a planet with fully functioning Earth Systems[42] and ecosystems that are as productive and diverse as the ones we inherited from prior generations.

2.4.7 Balancing Across Dimensions of Sustainability

Finally, a just transition must balance the competing values and priorities that fall within the concept of *sustainability*. In this regard, we must be careful that climate change progress does not come at the expense of biodiversity loss or greater levels of air pollution[43] – nor at price of increased poverty or inequality. But while a broad view of what matters is required in constructing a successful response to climate change and a just transition, we must remember that the greatest inequity comes from inaction, which inevitably burdens the poor and those unable to assert themselves in policy debates – including future citizens and the world of Nature.

[40] Brown Weiss, E. (1992). In Fairness to Future Generations and Sustainable Development. *American University Law Review,* 8(1) 19-26.

[41] Schmitz, O.J. (2019). Sustaining Humans and Nature as One. In Esty, D.C. (Ed.), *A Better Planet* (pp. 11-19). Yale University Press.

[42] Rockström, J., & Klum, M. (2015). *Big world, small planet: abundance within planetary boundaries*. New Haven, CT; London, Yale University Press; Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S.E., Donges, J.F., & Rockström, J. (2023). Earth beyond six of nine planetary boundaries. *Science advances*, *9*(37), eadh2458.

[43] Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W., & Courchamp, F. (2012). Impacts of climate change on the future of biodiversity. *Ecology letters*, *15*(4), 365-377.

3. Conclusion

Advancing a just transition to a sustainable energy future at a speed and scale that responds to the threat of climate change presents a transformational challenge like few others that the human species has faced. It requires systemic change across all economic sectors and geographies and many realms of everyday life – with initiatives at the local, regional, state-provincial, national, and global scales.

Realigning the global economy with the Sustainability Imperative demands a multi-dimensional strategy[44] based on sound science, long-term thinking, and hard-nosed analysis backed by political leadership of the sort the world has rarely seen. Unprecedented policy creativity and cooperation across existing divides will also be needed to deliver the requisite shifts in behavior, commitment to new ways of doing business, and investments in an updated global energy infrastructure.

As Pope Francis has indicated, we must be willing to move beyond the "logic of self-interest and calculation"[45] and focus on our common cause of ensuring the ongoing vitality of life on Earth. Given the inescapably worldwide scale of the challenge, particular effort will need to be put into strengthened global governance through revitalization of the Bretton Woods institutions – that defines new roles and improved performance at the World Bank, IMF, and WTO.

Real success in delivering on the many vectors of this transformation agenda will not be easy, but the alternative is unthinkable.

Acknowledgements

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[44] For a sense of the range of elements required, see Esty, D.C., & Burke, I.C. (2019). *A better planet: 40 big ideas for a sustainable future*. Yale University Press.

[45] Mares, C. (2023, February 19) Pope Francis: God Asks Us to Love Beyond 'the Logic of Self-Interest,' to Love Like Christ. *National Catholic Register*. https://www.ncregister.com/

Pathway to Net-Zero Emissions. Taiwan's Experiences

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Global Energy Sector's Net Zero Blueprint

In 2021, the International Energy Agency (IEA) released the "Net Zero by 2050: A Roadmap for the Global Energy Sector" report, outlining the pathways for the global energy sector to achieve net-zero emissions by 2050. Achieving this goal requires unprecedented development of clean technologies by 2030. Although the pathway is narrow, it remains achievable through the immediate and large-scale deployment of all available clean and efficient technologies.

A key aspect of achieving net-zero emissions in the global energy sector by 2050 is the realization of a zero-emission power system by 2040, with 70% of energy supply coming from renewable sources. To meet this target, sectors must rely on new infrastructure development after 2030, including carbon capture, utilization, and storage (CCUS), hydrogen, and the integration of electric technologies. Looking ahead to 2050, the focus in the building sector will be on banning the sale of fuel boilers, promoting heat pump technology, and implementing renovations for both new and existing buildings to achieve net-zero emission standards. In the transportation sector, the adoption of electric vehicles or fuel cell vehicles will be crucial, although the electrification of aviation and maritime transport still faces significant challenges.

NDC Outlines a More Ambitious Blueprint

The UAE consensus reached at COP28 outlines a more ambitious blueprint for future generations. This blueprint aims to achieve decarbonization goals and sends a clearer political signal to reshape and enhance the ambition of Nationally Determined Contributions (NDCs) for the next round until 2035. NDC 3.0 will mark a transformative shift, shaping economic transformations and national investment plans for the planet's overall future.

2050 Net-Zero Pathway Promotion Process

On April 22, 2021, President Tsai Ing-wen announced Taiwan's 2050 net zero transformation target. Subsequently, on August 23, 2021, the Executive

Yuan initiated amendments to the "Greenhouse Gas Reduction and Management Act" and incorporated the 2050 net zero emission target into the new "Climate Change Response Act." On March 30, 2022, Taiwan began planning its pathway to achieve net zero emissions, and by the end of 2022, the Executive Yuan officially released 12 key strategies to achieve the 2050 net zero transformation goal, adopting these strategic action plans in April 2023.

Planning a practical and feasible pathway to achieve net zero emissions by 2050 is a significant challenge for Taiwan. The government aims to establish a clear and comprehensive decarbonization pathway and strategies to promote green growth. Taiwan's 2050 net zero pathway requires promoting transformations in four key areas: energy, industry, lifestyle, and society. Achieving these transformations relies on two foundational governance pillars: technological development and climate legislation.

Taiwan's 12 Key Strategies for Net Zero

Based on Taiwan's 2050 net zero pathway, the government has proposed 12 key strategies, including the promotion of advanced energies such as wind power, solar power, hydrogen, geothermal, and biomass energy; power system and storage; energy conservation; carbon capture, utilization, and storage (CCUS); electrification and decarbonization of transportation; resource recycling; natural carbon sinks; green lifestyle; green finance; and just transition. Nearly half of these strategies are related to energy.

Taiwan's Long-Term Roadmap for GHG Reduction

Taiwan's annual greenhouse gas emissions are approximately 300 million tons CO_2e, accounting for about 0.5% of global emissions. According to Taiwan's updated NDC, the 2030 target is to reduce greenhouse gas emissions by 23% to 25% compared to 2005 levels, aligning closely with the reduction trends of advanced Asian countries. Taiwan has made significant progress in managing greenhouse gas emissions, with recent data showing a gradual decoupling of emission growth rates from economic growth rates.

However, the energy transition remains crucial. With 83% of Taiwan's electricity generated from fossil fuels, of which over 90% is imported, promoting low-carbon and non-carbon energy sources while ensuring a stable power supply and maintaining energy security presents a significant challenge.

Development of Renewable Energy

Following the outcomes of COP28, achieving a threefold increase in renewable energy capacity and doubling energy efficiency by 2030 has be-

come a global priority. Taiwan has also achieved rapid development in renewable energy, particularly solar power. In 2023, Taiwan's installed solar capacity reached 3.8 times that of 2005. Additionally, Taiwan leads the development of offshore wind power in Asia, with nearly 300 offshore wind turbines installed in the Taiwan Strait by April 2024, accumulating a total installed capacity of 2.25GW.

Enhancing Energy Efficiency

Enhancing energy efficiency is another key task. The IEA identifies improving energy efficiency as the "first fuel," a priority measure equivalent to the most important energy resource. Since the early 1980s, Taiwan has implemented the "Energy Management Act" to guide industries in gradually improving their energy-consuming equipment, ranking Taiwan eighth in international energy efficiency rankings. The new "Climate Change Response Act," as part of overall climate governance, further regulates energy efficiency improvements, covering buildings and household appliances and encouraging nationwide behavioral changes.

Innovation and Green Competitiveness

As previously mentioned, NDC 3.0 aims to encourage transformation plans, with the turning point for achieving transformation being the development and widespread application of innovative technologies. Taiwan's "green competitiveness" will be defined by low-emission industries, including the application of advanced technologies and support from green finance. Proper management will promote all emission scopes and value chain industries towards low-carbon production modes, contributing to global greenhouse gas reduction. For example, TSMC's dominance in global semiconductor production highlights Taiwan's industrial contribution and the potential for reducing global scope 3 emissions. Given the energy efficiency improvements brought by chips, each kilowatt-hour of electricity used in chip production by TSMC can help save 6.8 kilowatt-hours globally. Additionally, Taiwan is actively expanding new energy sources, collaborating with domestic and international academic and research institutions, and investing in geothermal, biomass, and ocean energy deployment opportunities.

Climate Legislation Strengthens Greenhouse Gas Reduction Management

As previously mentioned, climate legislation is one of the two foundational supports for Taiwan's transformation. The "Climate Change Re-

sponse Act" (the Act) delineates the responsibilities of different government agencies and levels, focusing on both mitigation and adaptation.

Regarding mitigation, the Act strengthens the promotion of greenhouse gas reduction management. Notably, the Act provides two carbon pricing tools: carbon tax (i.e., carbon fee) and an emissions trading system. In the short term, priority will be given to implementing the carbon fee, with the emissions trading system possibly being introduced in the long term.

Carbon Pricing Instrument: Carbon Fees

Taiwan is currently drafting the implementation details of the carbon fee. The carbon fee will be gradually introduced in stages, initially targeting the manufacturing and power sectors with emissions exceeding 25,000 tons CO2e, including direct and indirect emissions. This threshold will gradually be lowered to expand the coverage. The rate of carbon fee will be determined by a carbon fee rate review committee composed of various stakeholders, and the revenue will be included in the "Greenhouse Gas Management Fund" for legally specified uses, including developing low-carbon and negative emission technologies, subsidizing and incentivizing investments in greenhouse gas reduction technologies, promoting climate change adaptation efforts, carbon footprint management mechanisms, education and outreach, and supporting a just transition.

Voluntary Reduction Mechanism

The "Climate Change Response Act" also establishes a voluntary reduction mechanism, allowing for voluntary reduction projects to apply for and be reviewed for carbon credits based on project baselines. These approved carbon credits can be used to offset carbon fee obligations. To ensure the quality of carbon credits, the government is referencing the "Core Carbon Principles" (CCP) proposed by the Integrity Council for the Voluntary Carbon Market (ICVCM) and amending relevant regulations to ensure the promotion of carbon credit projects aligns with environmental sustainability goals.

Climate Change Adaptation

In promoting climate change adaptation, the Executive Yuan approved the "National Climate Change Adaptation Action Plan" in 2023. In summary, Taiwan's climate change adaptation focuses on three strategic areas: (1) Capacity Building: Developing industry risk assessment guidelines and

collecting necessary adaptation information, (2) Identifying Risks: Assisting industries in identifying climate risks, including state-owned enterprises and the private sector, and (3) Adaptation Measures: Proposing adaptation strategy guidelines and a database of related measures for public use. Through these tools, the government aims to strengthen communication and coordination with various groups, helping Taiwan smoothly progress towards the goal of net zero emissions by 2050.

Governing in the Time of Climate Disruption: A Blueprint for Transformative Change

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Meeting the Moment – Aligning the Work of State Government with the Reality of Climate Change

Each day, as government leaders, we are presented with opportunities to make different kinds of choices, choices that are aligned with the reality of our current circumstances, choices to listen carefully to, rather than turn away from, the voices of millions of people around the world, and here at home, already suffering from climate change, environmental degradation, and crashing biodiversity. Every tenth of a degree of warming avoided matters. And so, as the philosopher Donna Haraway invites, it is our privilege and our obligation to "stay with the trouble."[1] We can take courage and strength from the fact that each day we are joined by more and more people awakening to the preciousness, indeed, the sacredness, of all that sustains and inspires us on the living Earth, and working together to protect our common home, as Pope Francis has urged.[2]

Government leaders in this time of climate disruption must develop the necessary skills to rigorously interrogate the purposes and processes of their organizations to determine whether the outcomes – services provided, monies allocated, incentives offered, laws enforced, policies enacted, physical structures maintained and operated – are aligned with the realities of climate change. They must manage transformational change across their organizations, change that may not always be welcome. They must become nimbler in responding to changing conditions (both physical, like increased heat and flooding, and socioeconomic, like insurance market failures), and rapidly shift away from siloed thinking to systems thinking approaches. As

[1] Haraway, D. *Staying with the Trouble, Making Kin in the Chthulucene* 1-4 (Duke Univ. Press 2016).

[2] Pope Francis, *Laudato Si': On Care of Our Common Home*, Encyclical Letter 11-14; 17-43 (2015).

we undergo further destabilization of our climate system, much of the relative predictability we have depended on in the past – stability of natural systems, economies, insurance and financial markets, agricultural productivity – will erode. Because climate change impacts different geographic areas in very different ways, there will be a variety of responses to the systemic instability and disruption induced by climate change.

The single most important skill a government leader can cultivate and model in this time is imaginative capacity.[3] That requires leaders, first, to truly understand and reckon with the vast and unprecedented (for humans) nature of the climate and biosphere transformation currently underway. Second, leaders must be able to imagine possible futures, including those resulting from continued failure to take necessary action, and the "solution pathways and visions of … sustainable futures."[4] Leaders must pose to each other, and to their staffs and constituents, questions that engage imaginative capacity, specifically exploring what the world might look like if our decisions and policies reflected our scientific understanding of climate change and the fact that human well-being depends on the health of the natural world.

A difficulty inherent in imagining possible futures is the fact that "the way societies, economies and cultures are organized and experienced today … serves as a major constraint on the imagination of alternative future realities."[5] As Manjana Milkoreit has written, "[t]hings *that exist* heavily shape what we understand to be possible, desirable, and ultimately, what is mentally conceivable … Where are alternative models supposed to come from? Whose mind is capable of constructing them?"[6] Leaders must create the conditions that cultivate and encourage imaginative capacity, both within and outside of their institutions.

Most of us were educated in a system that prioritized specialization, and many in government have spent their lives mastering a particular discipline, typically within the confines of a highly siloed institution. Special-

[3] See, e.g., Milkoreit, M. Imaginary politics: Climate change and making the future. *Elementa: Science of the Anthropocene* 5:62 (Univ. Cal. Press 2017). https://doi.org/10.1525/elementa.249 ("Imagination lies at the heart of social change, … the ability of individuals and groups to envision possible, likely, and desirable futures that can guide decision-making and direct social change in collectively determined directions is an essential capacity for securing social well-being and prosperity in times of rapid and often unpredictable global change…") (internal citations omitted) (emphasis supplied).

[4] Id.

[5] Id.

[6] Id.

ized knowledge will remain critically important, but it is no longer enough. Governments need generalists focused on the intersections between and among policy disciplines, such as economic development, climate, health, and transportation. Fiscal management must be aligned with carbon pollution reduction and resilience mandates.

In plain terms, what that looks like is a graceful de-siloing, putting in place administrative structures that drive interdisciplinary teams across government agencies to solve the urgent new problems presented in the Anthropocene, among them how to accelerate exponentially development of technology that can mitigate emissions and modernize the electric grid, dramatically reshape past approaches to land use to maximize carbon draw down, create the finance innovation necessary to cover the scale of investment needed fully to transition away from fossil fuels by 2050 or sooner and – this is critical – do all that while building the capacity of our communities to navigate disruptive climate change and strengthening the resilience of ecosystems and the built environment.

It is indeed a tall order for subnational governments that often lack sufficient resources. And indeed, individual governments cannot do this work alone; for that reason, state government leaders must develop an unprecedented level of partnership with other states, private sector companies, universities and colleges, communities, local governments, non-governmental organizations, philanthropy, and, where possible, subnational governments in other countries. In doing so, the momentous technical and infrastructure challenges presented by climate change can be leveraged to drive a new wave of economic development and job creation that is aligned with, and does not undermine, the scientific imperative to zero out greenhouse gas emissions in the next twenty-five years or sooner.

Woven into all this work is the urgent project of communicating authentically to the public and all stakeholders about the reality of our circumstances, and the new ways in which we can and must now work together to imagine a better future and navigate this transition. We have a responsibility to those we serve to learn the essential lesson of the Anthropocene: that we are connected to each other, to the natural world, and our challenge, our opportunity, is to recognize that and reorder our societies and harness our economies to *protect* our communities and the ecosystems that make human life possible.

This paper will describe the rationale for and outline the elements of Governor Healey's whole-of-government blueprint to drive the institu-

tional change necessary to meet the urgent climate challenges we face. Our nascent effort is still very much a work in progress. Like all endeavors that seek to create deep institutional change, the work is not easy. Yet one can see its promise – in the creativity unleashed through cross-agency collaborations such as the one that established the Massachusetts Community Climate Bank, the first green bank in the U.S. focused solely on decarbonizing affordable housing, and the Climate Careers Fund, a green workforce training program to be funded, in part, by impact investment. In this way, Massachusetts is a microcosm of the dynamics that will play out in institutions around the world as physical and transition climate risk and impacts force innovation in governance.

Why the Climate Crisis Demands New Forms of Governance

As the economist W. Edwards Deming said, "every system is perfectly designed to get the results it gets."[7] Design in this sense need not implicate any malign intent, and yet, exploitative labor practices, ecosystem destruction, climate destabilization – these results are produced by systems *designed to yield such results*. In other words, these outcomes are features, not bugs. These conditions are typically byproducts of systems designed primarily to achieve other ends (*e.g.*, mass production of inexpensive goods); in the case of climate change, greenhouse gas (GHG) pollution is a negative externality – largely a cost of fossil fuel production and use that is not paid by producers or consumers of fossil fuels.[8]

For example, U.S. Environmental Protection Agency (EPA) economists have developed estimates of the social cost of greenhouse gases – that is, "the monetary value of the net harm to society from emitting a metric ton of that GHG into the atmosphere in a given year."[9] For gases emitted in 2030, and using the mid-tier discount rate of two percent, EPA determined that the social cost of emitting one metric ton of carbon dioxide is $230

[7] Kazzaz, Y. The Lens of Profound Knowledge. *Global J. Qual. Safe Healthcare* 6(3), 96-98 (2023). 10.36401/JQSH-23-X3

[8] See, e.g., Neeley, C. How Do Economists Think About the Environment and Climate Change. Fed. Res. Bank of St. Louis (2022). https://www.stlouisfed.org/publications/regional-economist/2022/dec/economists-environmental-issues-climate-change#:~:text=Climate%20Change%20as%20an%20Externality,the%20world%20through%20climate%20change

[9] U.S. Environmental Protection Agency, Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances 1 (2023). https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf

dollars; one metric ton of methane, $2,400 dollars; and one metric ton of nitrous oxide, $66,000 dollars (all in 2020 dollars).[10] Putting a price tag on the damages caused by uncontrolled GHG emissions allows us to see with crystal clarity the exceptionally high cost the public – not polluters – is already paying for these harms *our current systems are designed to produce*.

State governments are no exception to Deming's theorem in that they are also designed to yield the results produced. Further, legal (statutory and regulatory) and policy frameworks have as a central aim predictability. This is for good reason – the ability to carry on one's business, finance, insure and invest in projects, construct facilities, render services and market products – in short to carry on all lawful forms of economic activity requires confidence in the future existence of relatively certain legal frameworks and governance structures. Predictability of these processes – sometimes understood as path dependency – is a feature and is often beneficial.[11]

Laws, regulations, and policies can change over time to respond to new circumstances – those might include evolving social norms recognizing expanded rights frameworks, for example, or more protective pollution controls when scientists identify new risks. But as we have seen for decades in the case of climate in the U.S., at both the state and federal level, efforts to reduce greenhouse gas emissions are often undermined by powerful stakeholder opposition, usually by incumbent fossil fuel and related interests.

Even when we do manage to pass such laws or change regulations, those laws, standing alone, often do not immediately or ever fully yield the desired outcomes – and that is because the existing systems are not designed to produce the result required by the law. Massachusetts passed its Global Warming Solutions Act, which established economy-wide limits on greenhouse gas emissions, in 2008,[12] but it wasn't fully implemented until after 2016, when the state's highest court ruled that the relevant environmental agency had to follow the letter of the law.[13] Today, Massachusetts, like most states, does not yet have adequate market signals or the requisite level of investment in necessary infrastructure (*e.g.*, a modernized electric grid,

[10] Id., 4 & Table ES-1.

[11] Dryzek, J. & Pickering, J. *The politics of the Anthropocene* 23 (Oxford Univ. Press 2019).

[12] An Act Establishing the Global Warming Solutions Act, Chapter 298 of the Acts of 2008.

[13] Kain v. Department of Environmental Protection, 474 Mass. 278 (2016).

adequate electric vehicle charging infrastructure) to achieve net zero emissions by 2050.[14]

Similarly, when new climate-related circumstances arise, for example, the need to implement innovative nature-based solutions, government agencies may find they must work to overcome institutional barriers and ensure regulatory and policy frameworks are flexible enough to respond effectively.

In *The politics of the Anthropocene,* the authors describe entrenched systems that impede climate and health protective outcomes as "pathological path dependencies."[15] How do governments break this cycle in a way that balances other critical needs, for housing, transportation, and employment opportunities that open the door to a better quality of life for all? The ability to step back, observe honestly how and why programs are failing adequately to reduce GHG emissions and enhance resilience, and *change course* is a critical skill. The authors refer to this capacity as reflexivity, "the self-critical capacity of a structure ... to change itself after scrutiny of its own failures, or indeed successes."[16] And that requires the ability to imagine doing things very differently.

This is not a muscle most governments exercise frequently, if at all, and indeed, there is often resistance to such efforts, a dynamic that is discussed in more detail below.[17] Put simply, the wheels of government – the programs, systems, structures – must be recalibrated to produce beneficial path dependence, *i.e.*, outcomes compatible with the imperative to rapidly reduce emissions and build resilience. This is beyond what any single environmental or energy agency – typically responsible for addressing climate change in the past – can do alone. This work of systems re-design must therefore be accomplished by government-as-a-whole as all agencies incorporate mitigation and resilience into their core missions.

Being the Change We Wish to See: The Commonwealth's Blueprint. Executive Order 604 and Administrative Structure

Her first day in office, Governor Healey signed Executive Order 604 (Order) creating the Office of Climate Innovation and Resilience and establishing the position of Climate Chief, the first state cabinet-level climate

[14] Massachusetts Climate Report Card (Dec. 2023). https://www.mass.gov/report/massachusetts-climate-report-card

[15] Dryzek & Pickering, 23.

[16] Id., 35.

[17] See generally, Heifetz, R., Grashow, A., & Linsky, M. *The Practice of Adaptive Leadership* 22 (Harvard Bus. Rev. Press 2009).

officer in the U.S.[18] The Governor's action – both in timing and substance – signaled to the public and stakeholders that Massachusetts was making climate change a top priority, and that all cabinet secretaries are responsible for integrating climate change into all relevant policy.

Key to the success of this approach is that the executive – here the Governor – must fully empower and adequately resource the responsible climate official. Governor Healey's Order did that by providing that the Climate Chief is mandated to "marshal all resources and authority available to the Governor and the executive department in support of advancing the Commonwealth's climate innovation, mitigation, adaptation, and resilience policies," including those set forth in the state's Clean Energy and Climate Plan.[19]

The Order ensures a whole-of-government approach by requiring all cabinet secretaries to "appoint a Secretariat Climate Officer (SCO)" responsible for implementing climate guidelines and directives.[20] These SCOs were in place within the early months of the administration and have actively worked with their secretariats and the Climate Office over the past eighteen months to develop agency-specific plans and actions to advance the administration's climate policies. One of the first actions led by the finance SCOs, for example, was developing a process to ensure climate change was considered in each agency's capital investment plan for 2023.

The Order directed the Climate Chief to prepare recommendations for the Governor.[21] In consult with the cabinet secretaries, the Climate Chief issued 39 initial recommendations (Report) in October 2023, focusing on seven substantive areas: (1) funding and financing; (2) state capital investment, asset management, grantmaking, procurement and environmental justice; (3) emissions mitigation; (4) public health and resilience; (5) workforce; (6) economic development; and (7) education.[22] Teams responsible for implementing the recommendations meet regularly and update their progress through a software application that allows teams to view each other's progress.

[18] Governor Healey, Executive Order 604 (Jan. 2023). https://www.mass.gov/executive-orders/no-604-establishing-the-office-of-climate-innovation-and-resilience-within-the-office-of-the-governor

[19] Id. § 1 (a) & (f).

[20] Id. § 4.

[21] Id. § 3.

[22] Hoffer, M. *Recommendations of the Climate Chief Pursuant to Section 3(b) of Executive Order 604* (Oct. 2023). https://www.mass.gov/files/documents/2023/10/24/CLIMATE%20REPORT.pdf

Climate Office and Guiding Principles for Whole-of-Government Approach

The Report described the purpose of the Climate Office as a catalyst for innovation, emphasizing that effective climate change solutions require systems thinking, and cross-disciplinary problem-solving strategies:

The creation of the Climate Office, and its work, can be thought of as intentionally disruptive. It should break down siloes, align agency action with the Commonwealth's legislatively mandated emissions reduction requirements and Administration climate policy, and create opportunities for cross-pollination among agencies and with stakeholders and partners, including municipalities, labor, advocates, and the private sector. It should drive collaboration, spur different ways of defining problems and opportunities, lift up innovation and successful models, interrogate conventional wisdom, and, at all times, ensure policy choices are informed by the best available climate science.[23]

The Report presented the following principles for whole-of-government climate action:[24]

- Adopt a systems thinking approach.
- Incorporate climate science and data into decision-making.
- Center equity and environmental justice.
- Consider resilience and adaptation in decision-making.
- Implement comprehensive planning and project management for cross-agency priorities.
- Align discretionary state spending with climate mandates.
- Deploy innovative funding and financing strategies for decarbonization, adaptation, and resilience.
- Focus on multi-solving.
- Enhance transparency.

The report calls for economic analyses, now underway, of the investment needed to achieve net zero emissions by 2050 and key resilience measures. Estimates of the global cost of the net zero transition are in the trillions,

[23] Id., 8.
[24] Id., 8-11.

and all governments are lagging behind,[25] though recent U.S. legislation has sparked significant investment in both the public and private sectors.[26]

It is critically important to place these numbers in context, however. Potsdam Institute researchers recently estimated that *even if carbon dioxide emissions were to be drastically cut starting today*, the world economy is already committed to an income reduction of 19 percent until 2050.[27] Their analysis concluded that climate change will cause massive economic damages over the next 25 years, including in highly developed nations, and *the cost of ongoing climate damages from past emissions is six times larger than the cost of the mitigation we need to limit global warming to two degrees C*.[28] The total damages were estimated to be on the order of $38 trillion U.S. *annually* by 2050.[29] Governments, working with their private sector partners, urgently need to understand the economics of climate change and identify innovative funding and financing strategies *now* to reduce the cost of future damages by accelerating mitigation and resilience, in particular, by protecting the economic value of the ecosystem services yielded by natural and working lands, including by forests that, on the East Coast, have recently been found to be cooling land surface 1.8-3.6 degrees F annually.[30]

Climate Cabinet and Cross-Agency Convenings

During the first month of the administration, the Climate Office established a monthly meeting of the full cabinet, focused exclusively on climate. Over the course of the first year, climate cabinet heard presentations from a range of experts on topics including health impacts of climate change, financial market risk, and opportunities for private sector companies to lead

[25] Golden, J. Dynamic Sustainability: Implications for Policy, Markets, and National Security, 201 (Cambridge Univ. Press, 2024).

[26] For example, the Center for American Progress estimates that, over the first three quarters of 2023, the Inflation Reduction Act spurred $178 billion in clean energy and transportation investment. CAP, The Inflation Reduction Act Still Reduces the Deficit (June 2024). https://www.americanprogress.org/article/the-inflation-reduction-act-still-reduces-the-deficit/

[27] Kotz, M., Levermann, A., & Wenz, L. The economic commitment of climate change. *Nature* 628, 551-557 (2024). https://doi.org/10.1038/s41586-024-07219-0

[28] Id.

[29] Id.

[30] Barnes, M.L., Zhang, Q., Robeson, S.M., Young, L., Burakowski, E.A., Oishi, A.C., et al. A century of reforestation reduced anthropogenic warming in the Eastern United States. *Earth's Future* 12, e2023EF003663 (2024). https://doi.org/10.1029/2023EF003663

on climate. This time is also used for the secretaries to share project updates and work on policy issues at the intersection of housing, economic development, climate and environment.

Climate Office has prioritized opportunities to hear from staff and build cross-agency networks. For example, the Office recently convened multiple secretariats and external stakeholders to discuss the creation of a comprehensive state land use map that will serve to inform policy and deconflict competing land use priorities central to multiple secretariats' key goals, *e.g.*, siting renewables and grid infrastructure; conservation of forests and wetlands; housing production; and economic development, including climatech.

Communications and Public and Stakeholder Engagement

Administration leadership has prioritized a high level of public and stakeholder engagement on the issue of climate. We are also actively working to develop new ways to partner with the private sector. By convening and supporting these conversations, state government can learn from the private sector, foster learning among the private sector, and help keep climate change front and center.

The Heart of the Matter – Managing Change

This type of change asks people who have done certain things a certain way – and been successful at that – to now do things differently. In *The Practice of Adaptive Leadership*, the authors observe that the disequilibrium caused by such change "can catalyze everything from conflict, frustration, and panic to confusion, disorientation, and fear of losing something dear," because "[w]hen you raise a difficult issue or surface a deep value conflict, you take people out of their comfort zone."[31] Leaders must "live into the disequilibrium" and "help people tolerate the discomfort they are experiencing," while advancing necessary change.[32]

Government leadership must understand, anticipate, and prepare together for the range of likely responses across their institutions to the types of deep organizational change called for by the climate crisis. A formal structure that communicates that a high value is placed on reflexivity, imaginative capacity or "thinking outside the box," and codifies leadership's

[31] Heifetz et al., 28-29.

[32] Id., 29. Change leaders must have large reserves of patience and persistence and be able to anticipate and respond effectively to the ways in which resistance to change may manifest. Id., 31.

expectation that climate change will be thoughtfully prioritized across all relevant government policies and actions is essential. Equally essential, however, is the need to foster a shared understanding of these human dynamics of organizational change, and a commitment to continual learning and intentional reflection so that the gravitational force of known, status quo systems does not overwhelm the propulsion of the transformational change necessary to meet the challenge – and realize the opportunity – presented by the climate crisis.

YOUTUBE PRESENTATIONS

Accelerating Energy Transitions: Scale, Business Models, Supply Chains

Dr. Arunabha Ghosh

Founder-CEO, Council on Energy, Environment and Water, India

https://youtu.be/UGzKFc4XMF8?si=tlWIm9ljhRXEPDih

Protecting People and Nature: California Adapting to Climate Change

Wade Crowfoot

Secretary Natural Resources Agency, California

https://youtu.be/NC2QZcJPWug?si=V31Rdo3OnUrT5uP8

Kristina Costa

The White House

https://youtu.be/ergQv-s6JTY?si=FlUmzOXF26g9UKiY

H.E. Dr. Wilber K. Ottichilo E.G.H.

Governor, Vihiga County, Kenya

https://youtu.be/uOH2DEjzkB4?si=MrKYaUXZ03TDG0P0

SESSION VI – CLIMATE RESILIENCE LEADERSHIP

Chair's Remarks

Hon. Deanne Criswell
Federal Emergency Management Agency
U.S. Department of Homeland Security

Good morning. I want to first extend my gratitude to His Holiness Pope Francis and the Pontifical Academies of Sciences and Social Sciences for not only convening this gathering, but for inviting me to speak.

I'm proud to be here today as the Administrator of the Federal Emergency Management Agency, or FEMA, but also as a concerned Catholic, mother, and grandmother. As the head of the nation's response, recovery, and resilience agency, I see the effects of the climate crisis each and every day.

Gone are the days of disaster seasons – we, like all of you, are witnessing and working through a year-round disaster landscape that doesn't seem to stop. Which is why this convening is so important. It's a reminder that we are not alone in our battles. That we are united by a common calling, a common faith, and a common understanding that the time to fight for the future of our world is now.

I am inspired by the words of Mayor Hidalgo, Governor Hochul, and Governor Newsom. Thank you for your wisdom and for sharing your perspectives from Paris, New York State, and California. It's astounding to me that we can live oceans apart from one-another yet face similar challenges.

I want to spend the next few minutes dissecting the words of our speakers – and placing their arguments into the context of the work we do at FEMA. We have a saying at FEMA, that all disasters start and end at the local level. Local governments, as Mayor Hidalgo so eloquently argued, are on the front lines of responding to and recovering from climate-driven disasters. Which means they are equally well-positioned to lead the charge in combatting climate change. For cities across America, and around the world, that means investing in resilience. It means building capacity. It means understanding risk at the local level, taking steps to mitigate that risk, and – in turn – creating safer communities.

Cities like Paris, Boston, and London have taken this charge in stride – investing in climate mitigation and strategizing to prepare their communities before a disaster strikes. But not all cities have the resources, the tools, and the political leeway to make these investments. To fund these projects.

To push back on powerful lobbies. That's why capacity building at the local level is so critical. We need the right people sitting at the tables where decisions are being made. We need emergency managers and climate change experts to ensure local governments are positioning their communities to not just survive, but thrive in our changing world. We also need leaders that reflect the communities they serve. Because that's how we build trust. That's how we learn about community-specific barriers, so we can then break them down and uplift our neighbors as we chart a path forward.

At FEMA, we are committed to rooting our work in equity – in justice. To designing programs with diverse communities in mind. To leveraging partnerships to meet people where they are. We are working to understand the distinct barriers that different communities face when it comes to accessing our programs, and rewriting our policies to lessen the burden for those who need assistance. We are proposing legislation to get more assistance to underserved and historically disenfranchised communities faster than ever. We also have an amazing Director of Faith-Based and Neighborhood Partnerships, Marcus Coleman, who helps reach communities who bear the brunt of climate disasters. Marcus is here with me this week, if you haven't met him!

We are trying – really trying – to do our part to create a more just world. Where the communities we serve have equitable access to the resources they need, and an equal seat at our table.

Now I know FEMA isn't a local government entity – but I think it's important to demonstrate our commitment to this work at the federal level. Because if we are going to ask our counterparts to make big bold changes – then we should be walking that path with them, helping to create these tools, and making sure they are usable at the local level.

Now, when I think about big, bold change, Governor Newsom comes to mind. And I want to thank him for his remarks, but also for the partnership we've had since I've been in my role at FEMA. I've stood by the Governor's side as California experienced devastating wildfires and historic atmospheric rivers.

California is a unique state – one that provides a snapshot of both extreme ends of the climate crisis. From flooding to fires. From blizzards to extreme heat. It is also a state that is leading the effort to combat climate change – pushing back against industries that are driving up the earth's temperatures.

I think we can all learn from the work California is doing to invest in climate mitigation and resilience – and we at FEMA are proud to partner with

them as they make these monumental changes. Like in Mendocino, a county in Northern California, that suffered catastrophic losses during the 2020 wildfire season. The fires left burnt homes and ruined businesses in their wake – an experience far too many communities from around the world can resonate with, unfortunately. So, FEMA is working with them to help build more resilient infrastructure that will withstand future fire events. Or in San Francisco where we're working together to enhance coastal defenses in one of America's most endangered historic districts. Together, we're raising seawalls and reducing flood-risk for future generations.

I give you these examples because, as His Holiness laid out in *Laudato Si'*, combatting climate change requires balancing the environmental and the social. Yes, we need to get our climate back on track. But we also need to set our communities up for success. We need to be doing what we can to keep them safe from the threats of tomorrow, today. These are two sides of the same coin. Because at the end of the day, this work – all of our work – must be about people, about equity, about justice.

We must commit ourselves to reaching everyone in our communities – especially those who are underserved, harder to reach, and most vulnerable. We must take steps to protect strangers as if they were our neighbors, friends, and loved ones. We must consider their children and grandchildren as if they were our own, and ensure they too are protected from the effects of climate change.

The time to leverage the partnerships in this room is now, because the climate crisis is not just on our doorstep, but here – in our homes. And while there are those who deny this crisis, I look around today and I'm inspired by the speakers who are here to prove them wrong.

We are here to share stories. To paint the picture. To create new partnerships. To effect real, palpable change. Because this is not a problem that any one of us can solve on our own. It will require a coalition, a true partnership, like what we have in this room.

I want to thank Mayor Hidalgo, Governor Hochul, and Governor Newsom for crystalizing the importance of local and state-level involvement in this work.

And I want to thank the Holy See, again, for hosting this event. For actively bringing together faith-based, academic, and governmental partners from around the world so we can march forward, together, toward a cleaner, brighter future. I look forward to the rest of this week's events, and to joining hand-in-hand in the fight for a better tomorrow.

YOUTUBE PRESENTATIONS

How Do We Adapt to the Climate Crisis?

Hon. Anne Hidalgo

Mayor of Paris

https://youtu.be/LXmHP7DYm7A?si=0JgpG1L9eBtAWFHA

The Gold Standard – Climate Leadership in the Golden State

Hon. Governor Gavin Newsom

State of California

https://youtu.be/sLZ4pHer5dc?si=RRkdWlRwpN234Ns9

Climate Leadership in the Empire State: Building Resiliency for All

Hon. Governor Kathy Hochul

New York State

https://youtu.be/jaVox5uMNDg?si=rZkmXYCfgVTB6sN8

SESSION VII-VIII – IN THE FRONT LINES: CLIMATE HOTSPOTS/BEST PRACTICES IN GOVERNANCE

Climate Crisis in Santiago: The New Face of Territorial Inequality

Claudio Orrego Larraín
Governor of Santiago, Chile

Patricia Pastén Valdés
Architect Mg. Urbanism – Universidad de Chile

Abstract

The Metropolitan Region of Santiago faces important challenges related to sustainable urban development, such as environmental quality, urban territorial balance in distributing goods and services, decent housing, attention to migratory movements, and the fight against climate change.

The climate emergency forces concrete adaptation and mitigation actions to address the existing challenges. In Santiago, the water emergency, atmospheric pollution, and rising temperatures have become conditioning factors that increasingly affect the population's quality of life and health, especially in the most vulnerable communities.

In this sense, the Government of Santiago seeks to recover the city for the people since it is an urgent task and a citizen's demand. It plays a fundamental role in leading the debate on Climate Change in an integral manner, in which it "decides, acts and articulates" the different sectors of the state, the private sector, and civil society to face the future challenges of the Region effectively and early.

Keywords

Climate Change – Inequality – Governance.

Climate Crisis in Santiago – The New Face of Territorial Inequality

To understand the climate crisis in Santiago and, with it, the advantages and disadvantages to which the 52 communes that comprise the Metropolitan Region are exposed, exacerbated by the effects of the climate crisis and with the challenge of advancing in an integral region, the Metropolitan Regional Government of Santiago prepared and approved in April 2024 the first Climate Change Action Plan, which consists of a document containing the climate diagnosis for the region, based on the technical analysis of the

present and projected situation (Government of Santiago 2024 – Regional Climate Change Action Plan).

From the above analysis, it is expected that, in the coming years, the rural area of the Metropolitan Region will suffer loss of productive land and damage to ecosystems due to temperature increase. Droughts and fires will also result from climate change, significantly impacting the vulnerable population of the territory (Government of Santiago 2024 – Regional Climate Change Action Plan).

On the other hand, urban centers are expected to be impacted by extreme heat waves, which will increase the risk to the population's health, droughts, and floods, which will make the infrastructure gap between the city and the Region more evident.

In the same sense, the basins and aquifers of the RM show that in the coming years, there will be a deficit in their water supply to sustain the demand, generating a scenario of water insecurity. This future scenario is projected to have a lower supply and higher water demand, so it is necessary to make urgent progress in water security, especially in vulnerable groups such as rural sanitation services, irregular settlements, and women. The analysis of climate risk indicators is complemented by the work of citizen participation, where the main concerns are the threats of drought, fires, and extreme heat (Government of Santiago 2024 – Regional Climate Change Action Plan).

Regarding Greenhouse Gases, Scope 1 emissions (generated by industries) are around 20,907 $ktCO_2eq$ in 2020 and are estimated to be around 32,236 $ktCO_2eq$ (measured in tons of carbon footprint) in 2050. The primary sources of emissions at the regional level will be land transport (32.7% share in the 2020-2050 period), landfills (17.4%), and the residential sector (13.4%) (Source: PARCC).

An increase in historical and projected temperatures can be observed regarding the current climate and projections. Heat waves and Urban Heat Islands (UHI) in the Central Valley can also be observed.

The most significant changes in the average temperature in the Metropolitan Region of Santiago will be in the mountain range area, based on data from the Quinta Normal station, which shows an increase of 0.19°C per decade in the average temperature. When reviewing the ranking of the warmest years, it can be seen that the five years of the last decade are within the ten warmest years since this station has been recorded. When analyzing by decades, the decade from 2001 to 2020 is the warmest decade since 1971, with an average increase of 0.7°C.

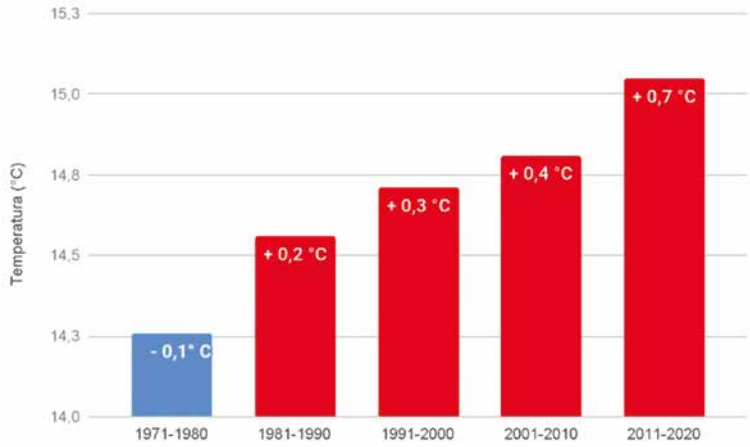

Figure 1. Average per decade of mean temperature at Quinta Normal station. Source: (DMC, 2016).

However, heat islands impact the local population in several ways. On the one hand, they generate an increase in energy demand, especially during the summer, which leads to higher energy consumption for air conditioners. This, in turn, leads to a rise in greenhouse gas emissions due to the high energy generation, which contributes to more significant environmental pollution. On the other hand, this higher energy consumption implies increased living costs for people, as they have to face additional expenses in their energy bills, which means an economic inequality that affects mainly the vulnerable population.

The most significant danger is that heat waves increase the incidence of diseases and mortality related to extreme heat. They also negatively affect water quality. Rising temperatures cause increased evaporation and decreased water availability in rivers and reservoirs, which can lead to a higher concentration of pollutants in the remaining water. In addition, water warming can disrupt aquatic life and affect the availability and quality of water resources for human consumption and other uses. According to the spatial distribution of surface soil temperature (LST) and the UHI index, maximum temperatures are located in the northern part of the region, specifically in Chacabuco and Santiago, reaching maximum values over 40°C. For the Chacabuco province, the Tiltil and Colina communes have the highest values, close to 45°C. Concerning the province of Santiago, the communes most affected by heat islands correspond to the northwestern

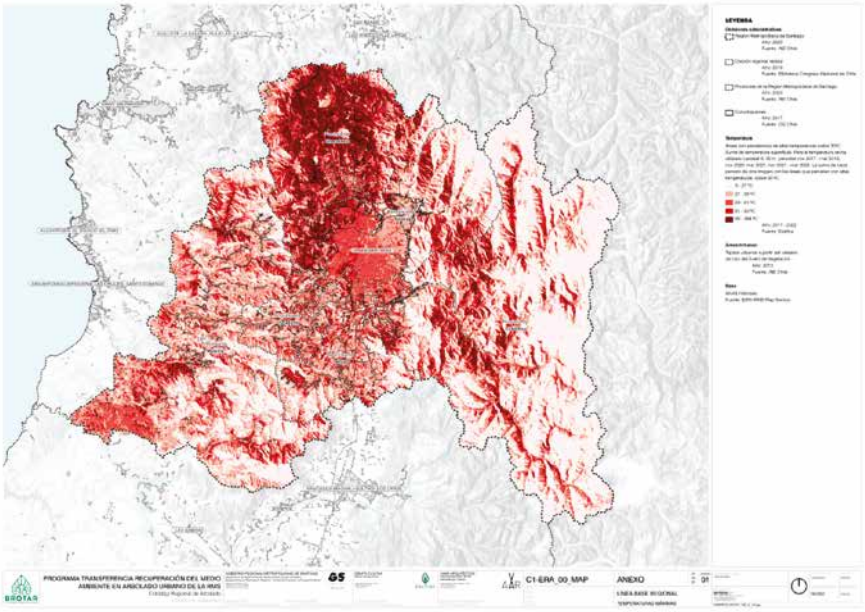

Figure 2. Cartography of areas with high temperatures in the Santiago Metropolitan Region. Source: Government of Santiago – Brotar Program.

sector of the province; within the urban area of Santiago, the communes of Quilicura, Conchalí, and Quinta Normal stand out.

The urban areas with the highest population concentration in the capital city of Santiago have surface soil temperatures above 35°C within the north-south strip in the region's center. In parallel, a second band above 35°C runs through the east of the area within the Cordillera province.

Another critical aspect that influences the increase in temperatures inside the city is the impermeability of the soil in urban areas, i.e., the large urbanized surfaces and construction materials amplify climate change. So much so that there are more and more cases of severe illnesses due to high temperatures and even deaths attributed to heat stroke. In the Universidad Autónoma de Chile study, five categories are established concerning the trend of surface temperatures: warming, stable, stable-cold, stable-warm, cold, and overheating. Analyzing the status of each commune attributed to one of these categories, we can observe that 21% of them are overheating, and 26% are in a situation of stable warming. This generates a new territorial inequality gap since half of the communes, located in the western part

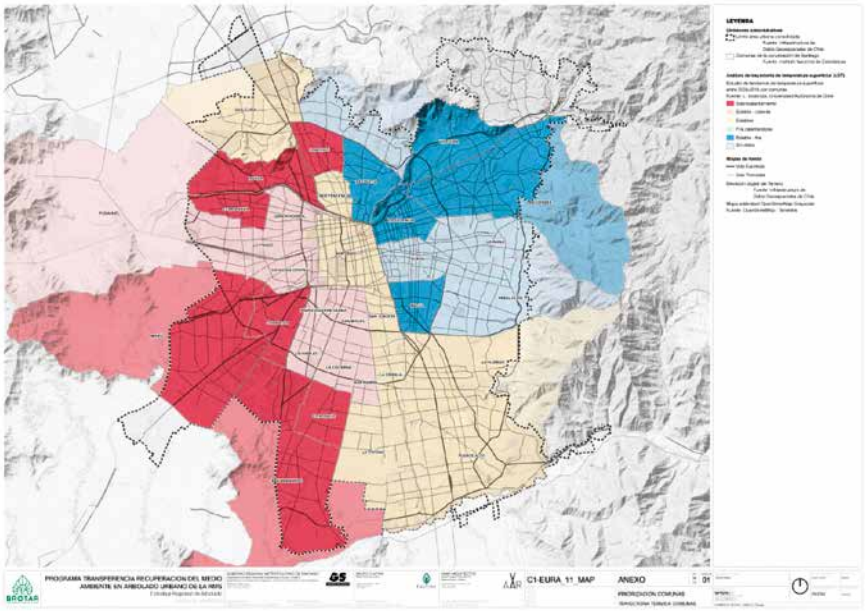

Figure 3. Surface Temperature Trend. Source: Luis Inostroza, Researcher - Universidad Autónoma – BROTAR progam. Government of Santiago.

of the urban area of Santiago, present a trajectory of hot or overheating surface temperature.

Last summer, for the first time, a red alert was declared for extreme heat in the Metropolitan Region, as communicated by the Ministry of the Interior through SENAPRED on 29/01/24, according to information provided by the Meteorological Directorate of Santiago, which marks an unprecedented milestone in climate change in the Region.

Coincidentally with the above, when analyzing the indices of vegetation cover in the Region, we can observe an urban wound without vegetation cover, that is, that in the areas where there is a lack of it corresponds to the communes in which there is a greater incidence of heat waves, being also the most vulnerable communes in economic terms in the Region, an example of this can be seen in the lack of urban trees that play a scarce role in the construction of green infrastructure, of the communes located in the western sector, as well as the lack of consolidated green areas; squares, urban parks, roadside trees, metropolitan parks, etc.

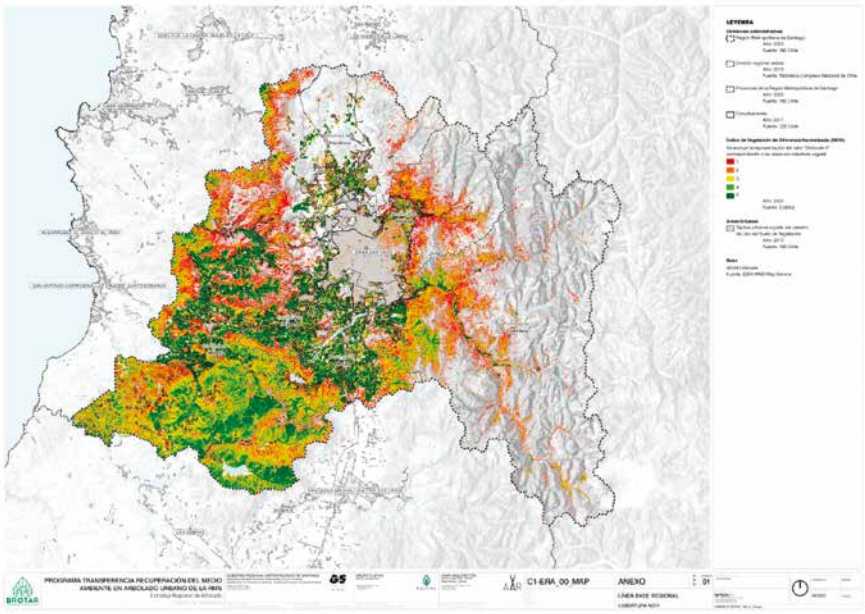

Figure 4. Normalized difference vegetation index coverage. Source: Government of Santiago – Brotar Program.

The four communes with the highest incomes concentrate 32.2% of the total surface of green areas, while the four poorest communes have only 4.1%. This leads to the identification of much higher pollution levels and high temperatures in the most vulnerable communities. Therefore, there is a need to take action to conserve this arboreal heritage.

All of the above should be treated integrally and not in isolation since the city corresponds to an articulated organism that should preserve the life of its inhabitants and provide social and ecological services according to its distribution, surface area, and accessibility.

To reinforce the above, this is also reflected in the vulnerability map of the Region, which shows the communes of the western sector lacking goods and services of the city, which is reflected in a lower quality of life for its inhabitants, some aspects of vulnerability are: access to essential public services and equipment, access to sustainable mobility, the quality of the urban environment, social integration and quality of neighborhoods and housing.

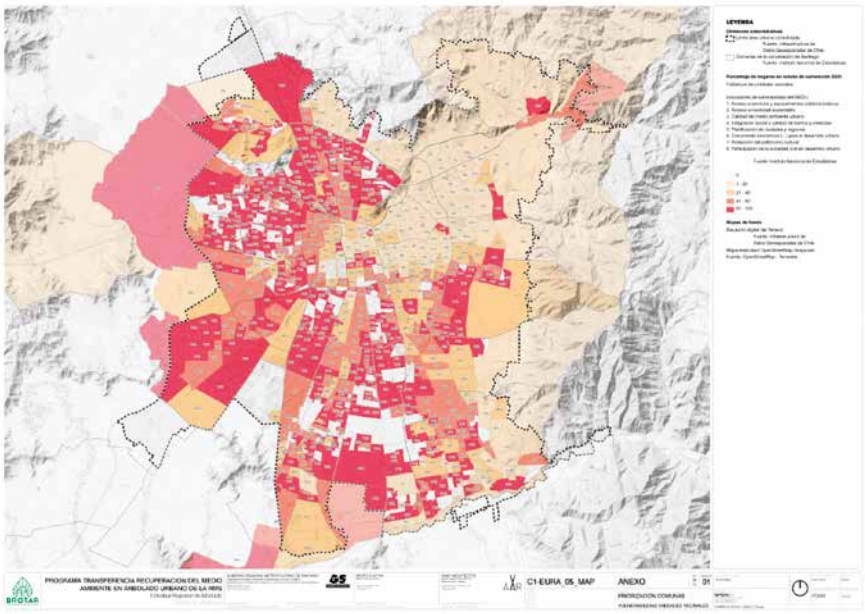

Figure 5. Mapping of the distribution of vulnerable households according to SIEDU vulnerability indicators. Source: Government of Santiago – Brotar Program, based on National Institute of Statistics data.

Conclusions

As a result of all the above, the Government of Santiago is facing climate change through short-, medium-, and long-term adaptation measures. The objective is to make Santiago a resilient city in the face of climate change and extreme heat, improving the quality of life of its inhabitants through the fair and equitable distribution of vegetation cover.

What have we done to face climate change in the Metropolitan Regional Government of Santiago?

a) We developed the first extreme heat protocol, called "Code Red," to protect the population from the effects of heat on people's health, especially the most vulnerable people, through effective communication.

b) We are developing the improvement and conservation of the most crucial axis of the Metropolitan Region of Santiago, called the Nueva Alameda Providencia axis, incorporating urban tree infrastructure through the

"Brotar" program (M$1,990) in great magnitude, which considers trees of low water consumption with a high planting standard.

With Brotar, we have planted 21,000 of the 30,000 trees in different sectors of the RM, such as streets, avenues, urban forests, community plantations with a deficit of green areas, etc. We have also raised awareness about the climate crisis through courses for 12-year-old children in vulnerable schools, neighborhood councils, and municipalities.

c) We were awarded the first part of the tender for 33 Pocket Forests (M$ 4,686) in 33 different communes, with Miyawaki-type planting. This project breaks the historical trend in the Region by incorporating fast-growing vegetation cover in vulnerable sectors of the city, which will cushion the adverse effects of climate change.

d) Bloomberg Philanthropies of the Rockefeller Foundation recently selected us to execute a project to mobilize young people for climate action. The project will include training and the planting of low-water-consuming trees (ThCh$150,000).

e) We implemented a green roof at the Dr. Exequiel González Cortés Pediatric Hospital. This reduced the temperature in the sector by 1.5° (M$100,000).

f) In summer, we executed the Oasis project, which provided water to passers-by who circulated through the most crucial axis of the Metropolitan Region, mitigating the extreme heat in this place.

g) 69 air-conditioned ambulances were purchased, benefiting 28 communes (M$4,690).

h) Communities against fire program to protect 12 nature sanctuaries and surrounding communities (US$400,000 million).

i) Water management: we executed an agreement with the MOP for rural drinking water and 30 local water strategies; we worked with the incorporation of sustainability criteria in all projects; we worked in 7 schools on gray water recycling systems and in the design and implementation of a basin organization for the Maipo River that will allow us to advance in the construction of agreements and the implementation of measures, actions, and solutions to advance water security.

Long-Term Actions

a) New Santiago Metropolitan Regulatory Plan:

The planning instrument of the Region Santiago Metropolitan Regulatory Plan has been in force since 1994, and its subsequent modifications are being addressed to update them to incorporate all aspects impacting the current climate crisis.

To carry out this new Regulatory Plan, it will be necessary to modify the current regulations in force since there are matters that are outside the regulatory scope, consisting of 17 urban planning regulations by Article 116 of the General Law of Urbanism and Construction, such as land use, land transfers, grouping systems, constructability coefficient, land occupancy coefficient, minimum property surface, maximum building heights, terraced houses, distances, front gardens, squares and ground levels, maximum densities, parking lots, strips subject to declaration of public utility and risk or protection areas.

b) Within the framework of Climate Change Law No. 21,455, information is being compiled on the process of preparing the Communal Climate Change Plans in the 52 communes of the Metropolitan Region of Santiago to support the local management of the municipalities in the face of climate change.

Finally, the Government of Santiago is in the determined task of addressing climate change at the regional level through systematic support of those vulnerable areas to recover the city for the people, which involves overcoming gaps of territorial inequality, climate and, above all, protect the population, for which international cooperation is essential in this fight, as it contributes with experiences and knowledge from different parts of the world to adopt good practices and strategies that have proven to be effective, as well as it is also of great support to implement new public policies to advance in a city resilient to climate change.

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A Different Kind of Energy

Mayor Michelle Wu
Climate Summit Remarks As Delivered

Thank you so much. I am so honored to be here. Buon pomeriggio!

Eminences, Excellencies, Mayors and Governors, academicians, and members of the diplomatic corps – good afternoon.

I am deeply grateful to his Holiness, Pope Francis, for opening the doors of this sacred place to these essential conversations…

And for the inspirational leadership in championing the health of our planet – urging "care for our common home," and catalyzing change across the globe.

To my friend and Council Member Chancellor Marcelo Suárez-Orozco; Council Member Professor Veerabhadran Ramanathan; and all the members and leaders of the Pontifical Academies: Thank you for convening this summit, and for the honor of joining so many global leaders shaping our future everyday.

* * *

I am blessed to be here as part of Team Boston – and Massachusetts. We have a big crowd in the house. Go Celtics!

We have our Green New Deal Director Oliver Sellers-Garcia here.

And, of course, I couldn't be more blessed to have a partner at the State level in Governor Maura Healey – our Green Governor – and her Climate Chief, Melissa Hoffer.

In addition to being Mayor of Boston I am also a mom of two boys.

I am also a daughter of immigrants. I grew up as the oldest child to parents who did not speak English for most of my childhood. And so I grew up with a clear sense of not only the invisible barriers we all face, but also a sense of how small the world is and how interconnected we all are.

If you had said to that young immigrant daughter that she'd be sitting here with all of you, it would've been beyond her wildest imagination… and maybe beyond that of others as well.

One of my first official acts in my capacity as Mayor was quite weighty.

We were renovating City Hall Plaza, and it turns out that when major renovations occur, it's tradition to create a time capsule.

And the job of the Mayor is to write a letter to the Mayor who will open the time capsule a century or more into the future.

And just a couple weeks into that job, that was quite intimidating for me.

What should I say a hundred years into the future?

So I did some research and pulled the three time capsules that were found in recent times: There was one from 1830, one from 1930, and one from 1981.

And they shared two things:

First, each of the Mayors wrote a letter to their future predecessor sharing their wildest imagination – in medical advances, technology, alternative energy sources, flying cars, all that they dreamed might happen.

But for all of that bold imagination, the second thing that those letters shared was a very specific constraint in who they thought might be opening that letter one day:

The first letter read, "Sir," as a salutation. The second letter read, "Dear Sir," and the third letter read, "Dear Mr. Mayor" in 1981.

So, for all that they could imagine, they never thought that one day it might be a mom and a woman sitting in that seat opening that letter.

Now, I share this to double down on what His Holiness shared earlier today:

That the solutions we enact must imagine a future that includes all of us.

And it must include all of us thinking and taking action beyond even our current wildest imagination.

* * *

Our goal in Boston is to make our city a home for everyone – from every background, every generation, every walk of life.

And for me, home is where your basic needs are met – where you're healthy, happy, and safe.

Home is also where your dreams can grow, where you're with the people you love.

And for me, it has been a treasure to represent the jewel of our home: 40 square miles, with 47 miles of coastline. Our three major rivers – the Charles, the Mystic, the Neponset – crisscross our city and, every summer, their grassy banks are packed with people enjoying the beautiful weather.

Each of our many neighborhoods has its unique character and culture, from Jamaican jerk chicken in Nubian Square and pho in Little Saigon, to soup dumplings in Chinatown and arancini in the North End. Cobblestone streets and cutting-edge labs, old granite churches and glistening glass towers.

But where I feel most at home is in the nine square miles of parks, green spaces, and urban wilds – an essential part of our common home that is only ours today because of careful stewardship and leadership from generations ago:

Nearly 400 years ago, Boston's townspeople came together and agreed that each household would pay six shillings more in taxes to turn private farmland into a public park – the very first public park in America.

To be clear, Americans don't often volunteer to pay more taxes.

But Boston has always understood the connection between healthy green spaces and the health of our communities.

So, in an era when nowhere else on the continent were municipal governments thinking about open space as a public good, we established the Boston Common.

* * *

I don't get much free time, but when some precious slice of time opens up, my family and I slip away to Boston's biggest park: Franklin Park.

With its winding paths, rolling hills, and dense forest, it's a sanctuary of stillness and beauty. And it's among the very first spaces in America where there was a commitment that parks should be open to everyone from every economic background.

It's also the place where I'm most reminded that to truly be good stewards of our world, we must recognize the earth not only as our one and only home, but as God's creation – and therefore treat it as sacred, with the care and reverence it deserves.

So it's this intersection of personal connection, faith – and faith in our future – and Boston's proud tradition of innovating public goods for healthier communities – that shapes our approach to tackling the challenge of climate change.

* * *

Just as Boston led the way in the United States around public parks as public infrastructure for health, today that next frontier is around clean energy as necessary infrastructure.

And we've been taking action to align our financial incentives with our values.

Which is why the very first bill I signed as Mayor was an ordinance requiring the City to fully divest from fossil fuels by the end of 2025.

But, as I was proud to write in a shared op-ed with Mayor Sadiq Khan ahead of the U.N. Climate Summit last fall: Not only do we need to be divesting; we need to be actively investing in our future.

Which is why, since 2021, the City has invested $400 million in environmental, social, and governance – or "ESG" – funds.

And, in the next several months, the City will – for the first time ever – invest money from our trust fund into an ESG portfolio through a sustainable investments manager co-founded by former United States Vice President and longtime climate leader, Al Gore.

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Of course, as a local government determined to build clean energy infrastructure in support of healthier communities, the most intuitive levers for us to pull are legislative.

And that's why, last year, I signed an executive order eliminating fossil fuels in all new municipal construction and renovations.

Now, in Boston, our buildings account for 70% of our total emissions citywide.

When in this eternal city, I feel like I have to speak a little more softly about how old and historic Boston's buildings are… but whether you're counting the structures in millennia or in centuries, the scale of retrofitting that needs to be done is vast.

If we're serious about dramatically reducing our carbon footprint, focusing on the building sector is targeting the sole of the shoe.

So, not only did the city several years ago adopt landmark legislation that set standards for the largest buildings to come into compliance and reporting… but more recently we upped those standards with transformative amendments to ensure that this benchmarking tool would actually reduce emissions and take action.

The new Building Emissions Reduction and Disclosure Ordinance (BERDO) explicitly shifts our goals and expands building eligibility.

Today, the buildings that meet BERDO's criteria account for just 5% of total buildings in Boston, but more than 40% of our total emissions.

More than any other tool, BERDO stands to make the biggest impact on helping us meet our net-zero emissions goal.

And it also creates opportunities for us to invest in social determinants for health, as well: As building owners strive to meet their emissions tar-

gets, they'll need skilled workers capable of monitoring, maintaining, and updating their energy systems.

Last year, we added a new building operations career pathway to our PowerCorps green jobs program that provides young people with a roadmap to livable wages, good benefits, and emerging green jobs.

I joined our most recent PowerCorps graduates at their commencement in December, where I spoke with a young man named Slader.

Slader came to the US from Haiti when he was just seven years old.

His family eventually settled down just outside of Boston, but things were rocky at home. He and his stepmom didn't get along, and when he turned 18 he left and began living on the streets.

Then he heard about the PowerCorps program. He applied, and found his groove in the building operations track.

Today, Slader is a full-time maintenance engineer – optimizing temperature, electricity, and air flow – in a big, beautiful building downtown.

Our planet, our downtown, and young people like Slader are healthier because we are determined to share every benefit clean energy brings, across all our communities.

★ ★ ★

And while large commercial buildings offer the greatest opportunities for us to cut overall emissions and create new jobs, we're making it easy to decarbonize residential buildings as well.

We've launched two green energy retrofit pilot programs that offer owners of small, multi-family homes as well as affordable housing units funding to electrify their buildings.

So far, the estimated energy savings for the projects we're funding range from 43% to 72% cost savings – and similar reductions in operational emissions.

And at least one of the projects will add rooftop solar panels – taking a cue from Boston's Archdiocese, which, in 2017, installed a solar field in its parking lot capable of generating a megawatt of electricity.

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We've also recognized that, for many of our residents, there's a perception that "going green" isn't for everyone – that it's a luxury reserved for a certain class who can afford to pay a lot more to minimize their impact.

But alongside colleagues, environmental groups, and organizing from the ground up, Boston passed our Community Choice Electricity program – or "BCCE:" A municipal energy aggregation program that leverages the City's collective buying power to purchase cleaner, locally-sourced electricity in bulk.

We then provide that power to residents and businesses in the form of three different packages – including one that provides 100% renewable energy – all at lower cost than the utility-provided alternative.

Since launching in 2021, BCCE has saved customers more than $160 million on electricity bills, all while accelerating our climate goals.

One of those customers is a man named Lewis.

Lewis has lived in Boston for 54 years, and retired on disability a while back – now living off less than $27,000 a year.

Lewis's electricity rates were unpredictable, and some months he was paying as much as $300. Since switching to our municipal aggregation program, his bills have gone down by ⋆more than half.⋆

That's money in his pocket for medical expenses, groceries, housing, toys for his four grandkids. And it's not just Lewis:

Today, more than 70% of all residential, commercial, and industrial electricity accounts in Boston are enrolled in this aggregation – protecting our planet and improving residents' financial health in ways that enable more investments in mental and physical health.

⋆ ⋆ ⋆

And while we know that planetary health and personal wealth are deeply connected to individual physical health ...

I want to be clear that we see, every day, the direct and immediate impact that our energy infrastructure has on residents' wellbeing:

Asthma rates among Boston public housing residents are more than double that of homeowners. And we know that gas stoves are responsible for more than 15% of all childhood asthma cases in Massachusetts.

Thanks to $1 million in federal funding, we are replacing gas stoves with electric ones across some of our largest public housing developments – one of which will be the site of Boston's first-ever networked geothermal pilot project.

⋆ ⋆ ⋆

So we've aligned our financial incentives with our climate goals; taken legislative action to decarbonize our building sector – and created good green jobs along the way; we're making it easier for homeowners to electrify their buildings, replacing gas stoves that cause respiratory illness, and helping residents and businesses go green *and* save money with Boston Community Choice Electricity...

But I want to close with a reflection on a different kind of energy:

This winter was the first winter I didn't buy my boys new snow boots.

They're six and nine and they grow so fast that every year usually means a new pair of boots.

They didn't grow any slower this year, but we were projected to get so little snow that it didn't seem worth it to buy two new pairs of boots to wear once before they'd outgrow them.

The year Blaise was born was the hottest in Boston's history. He's almost ten now, and the past ten years have been the hottest ten years on record.

It's something we all *have* inside ourselves – it gets us out of bed every morning and sustains us in the work to make the world a better place for the people we love.

And it's *that* energy that will power the future we need. Thank you for the opportunity to share Boston's story with all of you.

May God grant us the energy to do the work ahead well.

Valencia, European Green Capital 2024. A Collective Success Story

María José Catalá
Mayor of Valencia

First of all, I would like to thank the Holy Father and the Holy See for bringing together mayors and governors from all over the world at this Summit entitled *From Climate Crisis to Climate Resilience* to continue talking about sustainability and looking after the environment, as a huge concern that is central to the agenda of large cities.

So why is Valencia here today? Valencia is the third largest city in Spain in terms of population, but there is a reason why we are at this Summit. Valencia is European Green Capital 2024. Our city was chosen by the European Commission as the Green Capital of Europe because of a very beautiful story that I would like to tell you. It started with a tragedy, but later became a success story thanks to the people of Valencia.

In October 1957, my hometown was hit by a natural phenomenon, a huge flood. The River Turia used to run right through the city. During the flood, the water rose to a height of over five metres in some places. As a result, businesses, houses and homes were swept away, and hundreds of people died in Valencia and in other nearby towns. At that time, Valencia had to make a decision. The choice was to change the course of the river and divert it outside the city. And as citizens we had to make a decision about what to do with the former riverbed.

At first, the idea was to divert the River Turia and turn this area into a motorway, but the Valencian people protested and, finally, we managed to turn the former riverbed into the marvellous garden it is today, a green haven for culture, sport and leisure.

The Turia Garden in Valencia, one of the mainstays of our European Green Capital status, is currently the longest park in Europe, with nearly ten square kilometres of green parkland. It is a vibrant, healthy area, which is the backbone and the heart of the entire city, running its entire length.

This success story that started in 1957 and has blossomed over the years, has another component. We are lucky and privileged to also have the Albufera, a wonderful freshwater lake beside the Mediterranean Sea, for which

we are seeking Biosphere Reserve status from UNESCO. These initiatives have made us a European benchmark in the field of sustainability.

That is why Valencia is here today, because we are the European Green Capital. And we sense the responsibility that comes with this very clearly. This year, we must make policies, strategies and continue to make good decisions, Valencian decisions, as our predecessors did, like the one Valencia took in the flood.

We are the first Mediterranean city to receive European Green Capital status. And this is why our much-loved Mediterranean Sea has to be at the heart of our transformation. We must try to take care of the Mediterranean, the seas and the oceans. We wish to lead this transformation by adopting measures to protect marine species and recover them; to clean up the sea; to prevent waste; and also to prevent polluting plastic.

My city, Valencia, has the largest peri-urban agricultural area in practically all of Spain, with magnificent rice fields and orange groves. It is our mission to nurture and promote zero-kilometre produce, as it is the duty of government to promote healthy food and this type of production, as well as to encourage sustainable agriculture.

It is all very well to talk about zero-kilometre produce and healthy eating, but we need to focus on and promote just how valuable agriculture and farming is for it to take its rightful place at the heart of our policies. And that is one of the issues that we also have to address.

As part of this commitment, this morning I gave Pope Francis a tree, an orange tree, because Valencia is the land of rice and oranges. The Valencia City Council has adopted an orange tree for His Holiness with the name *Laudate Deum,* the name of the Pope's Apostolic Exhortation on the climate crisis given on 4 October 2023. The fruit of this tree will be sent to the Vatican every year.

Tree adoptions enable us to tend our fields using an ecological and regenerative approach, and at the same time prevent land from being abandoned. These agricultural sustainability strategies to help the economy and farming must continue to proliferate in our cities, in our policies and in our daily lives.

We want to continue to be the marketplace of the Mediterranean, to invest in quality agriculture and to convey the responsibility to future generations of how important it is to look after agriculture and crops.

Valencia is already working on very ambitious projects to become a lead-

er in sustainability, in keeping with its responsibility as European Green Capital 2024. I would like to give you just a few examples:

Firstly, we will gain an extra 355,000 square metres (the equivalent of 35 football pitches) of green belt thanks to a series of initiatives. The most emblematic project, the Parque de Desembocadura (or river mouth park) will be drafted by the end of the year. This will be the culmination of the Turia Garden, our green backbone, finally connecting it to the sea. The section will be called the Europe Stretch, thus ensuring that our city's involvement in the European Green Deal will live on forever in the history of Valencia.

We have a goal: we want all our citizens to each have at least 10 square metres of green belt. It is an ambitious target, though we believe it is attainable and we are going to do our best to achieve it.

Secondly, may I say that sustainability applied to urban transport is one of the most complex issues for all mayors, especially those in large cities. We have to try not only to promote electric and hybrid vehicles to manage excellent public transport in cities, but we also have to try to provide incentives so that citizens have access to less polluting vehicles. We have to help people change their vehicles and offer them alternatives, such as efficient public transport, if we want to apply the low-emission zones which restrict the use of the most polluting vehicles. If governments are not aligned with citizens, we are sending out an inconsistent message: if we do not take the side of those who have less, we are telling them that they cannot achieve sustainability. And that is unfair. Improving the environment concerns us all.

And thirdly, the latest example of one of the most ambitious projects we are undertaking as European Green Capital is the *Requiem in Power* project.

Valencia is building the largest public urban solar plant in Europe, installing over 6,600 solar panels in municipal cemeteries, which will reduce CO_2 emissions by nearly 1,000 tonnes per year.

How are we going to use this energy? In addition to supplying these municipal facilities, we aim to use the energy generated to help 800 vulnerable households, i.e., 800 families who are currently living in poverty, who cannot pay for electricity or water, in line with the objectives of mission cities to ensure a fair social transition.

In conclusion, I would like to endorse what the Pope has said: sustainability and social equity. We cannot make progress in sustainability if we do not improve social equity.

I would like to leave this reflection here today: cities must move towards climate neutrality, but they must do so hand in hand with their people,

taking into account their conditions; otherwise, we run the risk that all the deals reached by cities will be worth little more than the paper they are printed on. If our citizens do not feel we are by their side and listened to in this transition, we will never succeed in our mission.

That is why Valencia is also moving forward with an energy vulnerability action plan to protect the most disadvantaged from having their electricity supply cut off by paying bills for our citizens who cannot afford to do so, with personalised monitoring of some homes and, as I have told you, with the installation of the largest solar power plant on urban land in Europe, which will help these 800 families.

We shall also be opening up climate shelters and spaces in the city because we are not immune or oblivious to the climate stress that we all suffer and are living with. We will also be creating safe school playgrounds because we believe that these spaces are good places to protect our children from the heat in summer.

Finally, I think there is something very important that we all share: we are here to work together in the fight against climate change. And to do so, we must put people at the centre of our decisions. Always.

The Holy Father, in his speech at the Dubai Climate Summit, warned that "the future of us all depends on the present that we now choose". He also stated: "Let us leave behind our divisions and unite our forces".[1]

And this is the crux of the matter. Sustainability is not a question of ideologies, and it is not a question of neighbourhoods, regions, countries or states. Sustainability affects us all. It concerns us all. It matters to all of us. And we must all stand together on this.

As a public official and a member of this group of peers that is committed to the future of our children and our cities, I would like to thank the organisers for bringing us together here in the Vatican. It is the right place, it is a place that works for the present and the future of our citizens to live in kinder, more caring, more sustainable cities.

Thank you for supporting sustainability and social justice, and for helping us to always put people at the centre of our public policies.

Thank you very much.

[1] *Address of His Holiness Pope Francis to the Conference of Parties to the United Nations Framework Convention on Climate Change (COP28)*, Expo City, Dubai, 2 December 2023, https://www.vatican.va/content/francesco/en/speeches/2023/december/documents/20231202-dubai-cop28.html

Decarbonization with Yokohama's Citizen Empowerment

Takeharu Yamanaka
Mayor of Yokohama, Japan

Thank you very much, Honorable Chair. Your Holiness Pope Francis, Mayors and Governors, Ladies and Gentlemen, good afternoon. It is my great honor to join this conference, and to share the initiatives of our city, Yokohama, which is the largest city (municipality) in Japan.

My message today is simple: Citizen empowerment and City government's convening power. These two are important for Societal Transformation raised in the protocol.

Firstly, let me give you an example of how Yokohama is successful in empowering nearly 4 million citizens. Between 2001 and 2010, our city succeeded in reducing "household waste" by 43%, by almost half, despite the population growth. This tremendous reduction of waste, followed by the reduction of CO_2, was achieved by applying new waste separation. How did we succeed in applying this complex way of separation? The solution was partnering with citizen empowerment.

In our city, "neighborhood volunteer-clubs" are very active to improve their communities. For example, they engage in voluntary activities for each residential area, such as safety patrol for kids, daily cleaning of streets & parks, etc. There are more than 2,800 volunteer-clubs, and we understand the city is supported "on volunteer-club basis" substantially. The neighborhood clubs are also the pivotal driving force for waste management. In fact, the volunteer-clubs are well-motivated and they participate in cleaning and managing of 75,000 waste collection points across Yokohama. City government, on the other hand, hosted 15,000 workshops for residents on how to separate household waste in collaboration with volunteer-clubs. The combination of the community power and the government passion like this enabled a behavioral change of residents, resulting in reducing waste by almost half.

Currently, we have introduced more detailed separation of plastic waste in order to increase plastic-product recycling. This new way of separation will contribute to 15% CO_2 decrease from "plastic incineration" by next year. We are now reducing CO_2 from plastic-product quickly, by borrowing citizen empowerment AGAIN.

Figure 1.

I believe that empowering citizens is the key to "Societal Transformation with Behavioral Change" toward carbon neutrality.

Next, let's take a look at how City Government is working with business sectors. Firstly, let me introduce our initiatives on the Center of Yokohama, named MM21 District (Figure 1). The MM21 District is the cluster of large companies, with about 200-hectare, 130,000 working population, and 80 million annual visitors. Notably, it accounts for 10% of business sector's energy consumption in the city. We are now expecting 100% decarbonization of this district in upcoming five years, by working aggressively with the business sector here. In five years, this district is going to be a unique model in the world on the complete decarbonization of urban area. This is a selected good story, but the reality is, we have to tackle on SMEs urgently.

Seventy per cent of Emissions come from businesses. And 99% of businesses is SMEs, but 60% of them is still not doing climate change actions. This is because SMEs are challenged by their limited expertise and limited funding for decarbonization. So, there is urgent need to boost a large number of SMEs to action.

Here is where the City Government steps in. The current fraction of SMEs with climate change action remains at 40%. We are boosting this fraction to 60% in two years. This corresponds to a 20% increase in two years,

Figure 2.

which needs 14,000 companies. We are dispatching city officers to SMEs in order to provide city-involved support. The menu of the city-involved support is we (1) publicize registered companies, (2) prioritize in City biddings, (3) provide energy diagnosis followed by detailed consultation, and (5) provide capex subsidy for capital investment. Through sure and steady efforts like this, we are seeking to have most SMEs join in the climate change action by 2027. I believe City Government has convening power to bring SMEs together to GO GREEN.

Lastly, I will talk about partnering with Asian Cities. For over ten years, Yokohama has established partnerships with Asian Cities. For example, we are supporting them to formulate climate change action plans. Also, environmental technologies are being introduced in those cities. As just one example of our support, let me show you the case of Mandaue in Metro Cebu, Philippines. "Final waste disposal" has been a significant challenge for Mandaue City. Yokohama has continuously provided expertise that helped Mandaue to increase "waste separation" and "plastic recycling". As a result, annual waste was reduced by over 4,500 tons in year 2023, enabling around 3,000 ton decrease in carbon emissions. After these initiatives in Asia, last November, representatives from 44 cities and governmental organizations across Asia gathered in Yokohama: Mayors, Governors, City Officers from

Indonesia, Malaysia, Philippines, Thailand, Vietnam, etc. gathered in Yokohama, and issued Yokohama Declaration toward Carbon-Neutrality with them. Following this Declaration, Yokohama and Bangkok will host a climate change workshop in Bangkok next month. We will continue to lead Asia on the way to zero carbon society.

Finally, let me finish my talk by reaffirming Yokohama's commitment to achieving inclusive growth for the well-being of all people around the world (Figure 2). Thank you.

Address

Henriette Reker
Mayor of Cologne

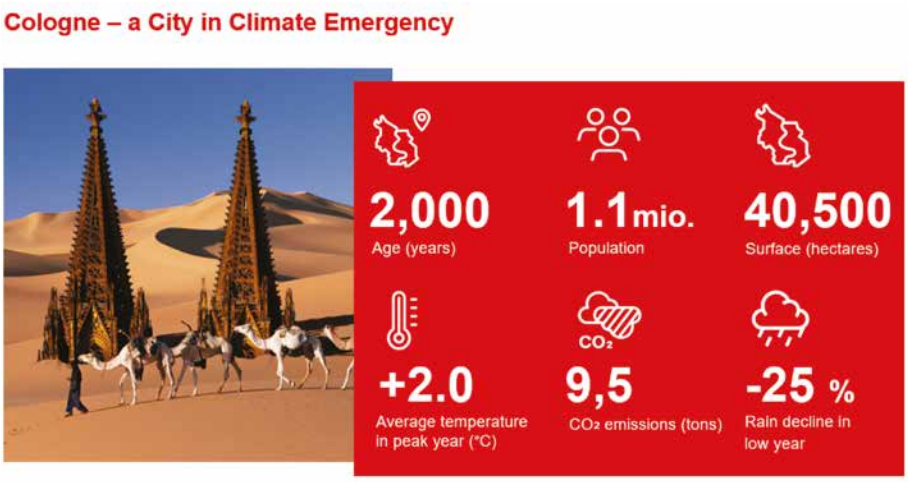
Your Eminence, dear Cardinal Turkson,
dear Ms McCarthy,
dear colleagues, experts, dear ladies and gentlemen,

Thank you for the impressive input so far – I am grateful for the opportunity to speak to you.

Ladies and gentlemen, Cologne is my hometown. Its history spans across 2,000 years, and it is roughly as old as the Roman Catholic Church itself – and its roots also lie in Rome.

1.1 million people now live in Cologne, which stretches across 40,500 hectares on both sides of the Rhine, and at the heart of which is Cologne Cathedral. The average annual temperature over the past 25 years has constantly been up to 2°C above the longtime mean. We are witnessing a decrease in precipitation of up to 25 per cent. Like all metropolises around the world, our emissions are far too high: over nine million tons of CO_2 per year in the city!

The statistics are concerning! In addition to this is the danger to health and the environment: temperatures over 40°C, withering parks, deaths

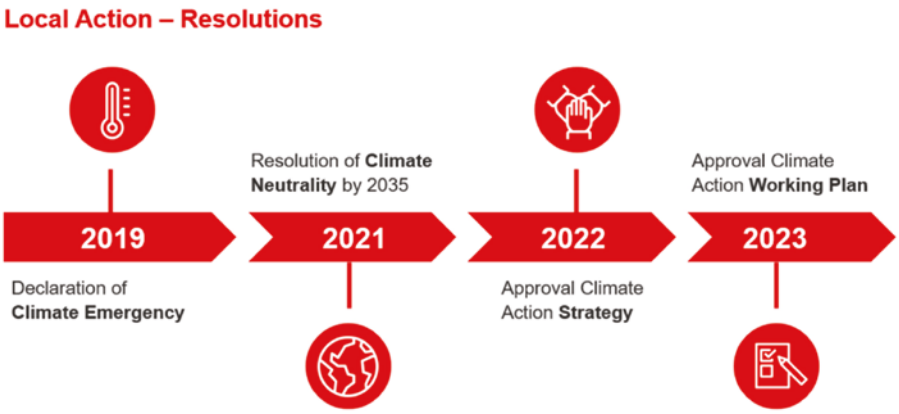


from heat, and a disastrous flood just outside the city in 2021 that resulted in over 130 people dead or injured, and left immense damage in its wake.

We all have an idea of the disasters that the climate crisis will bring about. And yet it takes great effort to change our course!

The following data illustrate Cologne's shift toward becoming a Net Zero City: In 2019, the City Council issued a state of climate emergency, partially due to pressure from the "Fridays for Future" protests.

This was followed by the decision to strive for climate neutrality in Cologne by 2035. The following year, the City Council worked with businesses and civil society to draft and adopt a climate strategy that will be implemented with an action plan.

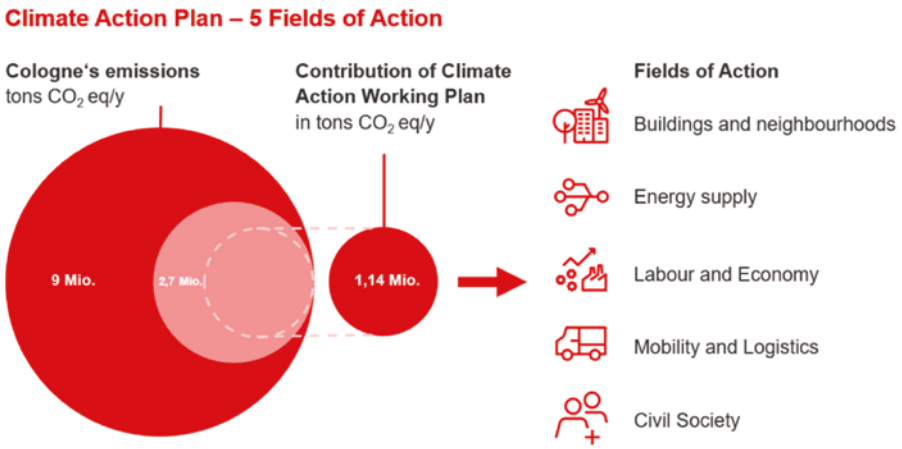


Parallel to this, we have made structural revisions to the city administration: We established a special Department for Climate, Environment, Urban Greenery (and Properties). We implemented a review of climate-related consequences for all decisions made by the City Council. And we require our large municipal group of companies to conduct business in a climate-neutral manner. These companies include the municipal energy providers, public transit, waste disposal companies, logistics providers, and a telecommunications company.

Cologne has a plan, the tools, and the expertise. Yet we are also aware of our limits! Our influence on our total emissions as a municipality is limited, and we are not even able to directly impact one third of the total emissions that Cologne generates. The City of Cologne's action plan directly targets 15 per cent of the emissions.

This includes the energy-saving renovations of buildings, climate-friendly energy supply, sustainable mobility, helping businesses move toward a green economy, environmental education, and so on. However, this is not enough, even if we as a city impose additional measures on top of these.

The big question is, how will we be able to conserve 9 million tons of CO_2 emissions every year?



I believe there are two key approaches to this, both of which are immensely challenging.

The first: getting society actively involved! We are striving to achieve this with a large-scale campaign, among other approaches. Yet we are also facing resistance. I see three major obstacles for Cologne in this regard:

Residents, in particular young people, distanced themselves from our state following the restrictions on freedoms imposed by the state during the coronavirus pandemic. Many of them perceived this as the state regulating even the most private aspects of their lives, and compensating risks with transfer payments. Now the public budgets are strained. More private and entrepreneurial engagement for the climate is needed, and yet the willingness is low.

Cologne was and is prepared to take in refugees who are fleeing crises around the world. International solidarity is extremely important to our diverse city!

I believe that this is one of Cologne's strengths. And yet here, too, we are inhibited. Debates around distribution of refugees are stoked, and

right-wing populists in particular approach migration and climate policy as though they were fronts in a culture war.

The mood in Germany has worsened. Many no longer trust society to solve the challenges of the present. These people lack a positive perspective, confidence and trust, partially due to the narrative of societal downfall expressed by populists on the right.

We now come to the second challenge: Cologne's climate neutrality is contingent on decisions made in Berlin, Brussels and the UN. Because we do not want to give up on our Net Zero target, we need even more lobbying at these levels of government. Municipalities and all other willing and influential institutions must now put pressure on decision-makers at the higher levels.

Ladies and gentlemen, I would not be the Mayor of Cologne if I were not aware of my city's potential, including with regard to the climate crisis and climate resilience. Two of our strengths are cohesion and cosmopolitanism!

Number one – cohesion: Cologne is diverse, and thus resilient and strong. Our city's residents come from 180 countries. I am the Chairwoman of the Council of Religions, which promotes religious diversity in Cologne with people from over 140 faith communities.

In this committee, we mediate conflicts and seek out common ground. One commonality is the integrity of creation, the need for a way of life that considers the generations to come. This conference in the Vatican inspires me to further emphasise the issue of "climate-friendly conduct" and place it on the agenda of the Cologne Council of Religions, thereby reaching our city's many communities.

Number two – our international responsibility: There is probably no city in Germany more interconnected than Cologne. We have 22 partner cities around the world as well as three climate partnerships, and are active in city networks such as the EU Net Zero Cities.

For these climate partnerships, experts and volunteers from Cologne work on site with civil society and municipalities. These projects include protecting a coastal city in Nicaragua from flooding, and establishing a recycling management system in Rio de Janeiro. These projects also teach us how climate protection can help combat poverty. We will use these approaches in the future to establish another international partnership in sub-Saharan Africa.

For me, this is a logical approach. As a municipality that will be heavily affected by climate-induced migration, we have to play our part in counteracting the circumstances that cause people to flee their homes. We in Cologne are aware that our responsibility for the climate does not end at the city limits.

Ladies and gentlemen, Cologne has its strengths: its diversity, its interreligious dialogue, its acceptance of responsibility at an international scale. Yet we are also faced with challenges that are beyond the city's administration:

In order to achieve climate neutrality by the year 2035 we need national, European and international frameworks that promote climate-friendly action at both the individual and institutional levels. I would like to continue working toward this goal, and am pleased that we have the opportunity to discuss this matter today.

We need new faith in our ability to manage the current situation. This faith is lacking in our current discourse, but is critical to motivating humanity. The Roman Catholic Church has been spreading a message of joy for 2,000 years. We cities have much to learn from one of the world's most resilient institutions.

Thank you very much for listening. Let us keep working together!

Speech at the Climate Crisis to Climate Resilience Summit – Vatican

Ricardo Nunes
Mayor of São Paulo City, Brazil

May 15th – Session I – Setting the Stage

My city, the fifth biggest metropolis in the world, with 12 million inhabitants and my country Brazil, can now be a good reflection of the importance of this meeting promoted here in Rome at the Vatican. Rio Grande do Sul, which is a state amongst the 27 states from the South of my country, today has a dozen cities that are flooded, suffering due to climate change. Therefore, the threats to the environment that sensitize the people and mobilize the governments of the whole world, require vigorous, planned and urgent actions. They start from the data the scientific community presents, as Professor (Hoesung) Lee has presented today, and they involve efforts from all of society, the public sector, private initiative, civil entities, local and religious leaderships, families and the population as a whole.

But before I speak about my impressions of this meeting and the actions of the city of São Paulo, it is very important to register the relevant and vital work of this summit and the work of the Church along the decades for the people, putting the ecological problems in a more profound, human and supportive perspective, as well as to make a record to our Pope Francis, faithful to this tradition and to his personal trajectory as a religious leader, which has emphasized in his writings and dedications the intrinsic relations between nature and society, exercising an ever more important political role in the articulation of the global initiatives capable of bringing a response to the great socio-environmental questions of the present day.

The City of São Paulo thanks the Pontiff and the Vatican for the zeal which they have been dedicating to the protection of life, the planet, and the construction of a more fraternal and just world.

I would like to very objectively shed light on some fundamental points of this mega city, fifth biggest metropolis in the world, on the theme of climate change. First, I wish to share with you, in this select meeting, with government leaders from all around the world, that São Paulo is one of the few cities, which I believe there are only three in the world, that has a Department of Climate Change. Therefore, a department that specifically

cares for this theme and articulates with the other departments, and, as such, the results have been coming out. We know from the impeccable work that has been presented here that the scholars, the scientists, the people from the academy have been bringing about this theme of climate change and SDGs. However, it is up to us, the governments, to implement public policies.

Four years ago, we intended to reach 50% of vegetation coverage area in our city of São Paulo and now, four years later, we have achieved 54% of vegetation coverage area. We have our municipal climate plan, PlanClima, which gives us all the guidance and guidelines of what we must do, with responsibility and in an articulated manner with all the departments.

We have now arrived at 114 parks. I inaugurated five in these past years I have been in the city hall and this year I will inaugurate five more. But there is some very important data, we have been working hard to maintain our forests, remembering that São Paulo is an Atlantic Forest area, and we have 15% of forest area which are the municipal parks, state parks and the indigenous areas. I made a decree, and I am expropriating 11% of the city territory, which represents 175km², bigger than Paris, and we will go, therefore, to 26% of all the territory of the city of São Paulo, which is a preserved forest area, evidently a public area, consequently being permanent. This has been giving us a condition in these meetings we have been doing all around the world, in which discussing climate change questions is having effective and positive results.

I have spoken about the real actions of the municipal plan for climate change, the Department of Climate Change, the vegetation coverage area, but from everything we could hear in this conference I would like to share a very important piece of data, which is the carbon dioxide question. In the city of São Paulo, 64% of the carbon dioxide emissions originate from the 7 million vehicles that circulate per day in the city. Half of these emissions come from diesel vehicles, especially buses. We have twelve thousand buses in the city of São Paulo. Thus, what would be fundamental? To replace these diesel buses, which greatly contribute to the carbon dioxide emissions, for non-polluting buses. What do we have as an option today? The electric buses. Maybe, in some time, we will have hydrogen buses, but now we have the electric ones. I am currently replacing this fleet from diesel buses to electric buses. A diesel bus costs 700,000 reais (approximately 130,000 dollars in current quotation) and an electric 2.5 million reais (approx. 470,000 dollars), in other words, four times more than a diesel bus.

Thus, I think it is up to us that have spoken about the financing questions to make a front against climate change, so that we may talk about it. Governor Maura (Healey) has spoken a lot about financing; therefore, we also need to address this for the replacement of bus or truck fleets and that really have a big impact in the global warming issues.

I would like to thank you for the opportunity of being here. Every time we reunite, we learn a lot. I thank you for all the learning that was provided to us. This commitment remains with us, that together all the world, all the continents, and now in this special moment of our meeting, with the support of Pope Francis, of the Vatican, the importance of the participation of the Church, so we may transform ever more in front of this necessity of facing the climate change issues, take care of our environment and our sustainability.

May 16th – Session VII – In the Front Lines: Climate Hotspots

I would like to initiate my speech remembering what we have heard just now from the Holy Father, Pope Francis, that 80% of the emissions of greenhouse gases come from the 20 countries from the G20 and 1% from the forty-six poorest countries of the world. I think it's some data for us to reflect upon, because if we have more than 80% of the greenhouse gases from the richest countries that integrate the G20 and 1% is from the 46 poorest ones, all our efforts need to be put into this context of each one having their responsibilities.

Before I talk about the actions from the city of São Paulo, it is also important to recall some data with relation to the climatic migration. In 2022, of the 60.9 million displacements around the world, 32.6 million, in other words 53%, were related to natural disasters according to the World Migration Report of 2024 from the International Organization for Migration. International organisms, such as C40 affirm that climate change already is the main cause of migrations in the planet. The IOM, International Organization for Migration, predicts that until 2050, 1 billion people are going to migrate inside their countries or will cross borders due to the consequences of the global warming, such as droughts, floods and the rising of the sea level.

My country, Brazil, accounted today in Rio Grande do Sul the death of 148 people to the floods in that state. I have taken to the Holy Father, Pope Francis, a flag from Rio Grande do Sul for his blessing, which I will be returning to Brazil and give it to those brothers of ours. Therefore, for each one of us that are here present and through the presentations from yester-

day and today, we are already very conscious of the climate change issues and of our role. Now, it is very relevant for us to have the context of the applicability of the actions. In the city of São Paulo, where we have twelve thousand buses, as I commented yesterday, we are replacing them with electric buses. The garbage trucks that use diesel are being changed to the ones moved by methane gas, incoming from the garbage landfills. We have reestablished OIDA (IOWD – Integrated Operation for Water Defense) which is fundamental in the control and supervision to maintain the forests from the spring areas preserved. In my city, the city of São Paulo, we have various springs and two big dams, the Billings Dam and the Guarapiranga Dam, and departing from the data of the migration issue, since it is the richest city in Brazil, in a country of much social inequality, it is very common for us to receive a lot of migration and pressure due to the housing deficit, which ends up leading to irregular constructions in the areas for environmental protection, in the spring areas. And this instrument, OIDA, brings together the Civil Metropolitan Guard, the Military Police of the State of São Paulo, the Environment Company, ultimately various municipal and state bodies to supervise and maintain these environmental protection areas preserved. We are also developing the biggest housing program of the history of the city, which helps in a way not to pressure the housing in the environmental protection areas.

From the data that the Pope highlights today, which I have emphasized here, the countries from the G20, the richest ones, generate a pollution of 80% of the greenhouse gas emissions. There is also data that we all know of that the poorest ones suffer the most with climate change. In parallel to all the actions we have been developing in the city of São Paulo in relation to the diesel buses and trucks replacement, the vegetation coverage areas, enlargement of preserved forest areas, the rain gardens, which is something very cheap and simple, where we get cemented areas, take out the cement and a pit of one and a half meters is made, crushed and a garden is built on top, which ends up being something quite fundamental for drainage and to have more green areas. We have now arrived at 337 rain gardens. Thus, there are many actions focused with relation to the environmental questions and the expansion of parks, which I have inaugurated 5 of, now we have 114, and we will inaugurate 5 more this year, and we also have the Director Plan, that is a law that gives us the urbanistic guidelines from the cities.

Another question of relevance are the actions for the poorest people, and we have a great job connected to food security. We distribute seven

thousand basic food baskets every day, we have many actions in relation to the provision of free meals inside the School Kitchen and Solidary Kitchen projects, we have the distribution of more than 2 million free meals per day in the city of São Paulo. For the people in street condition, we have the distribution of 86 thousand meals, which is a situation that has affected all the big cities in the world, including Rome with 22 thousand people in street condition, in this city that welcomes so well.

I think a very important message is left for us here in the Vatican from the meeting with the Pope today, from the invitation that was extended to each one of us, leaders of our states and cities, of two factors that greatly concern the Pope and all of us. The line of taking care of the environment and climate change, but parallel to that the questions aimed at the poorest and more vulnerable people. On the day I arrived at Rome, I visited the work of the Cardinal who takes care of the questions of the poor people here in Rome, Cardinal Dom Konrad, and he told me that here in Rome there was no bathroom for the people living on the streets, and that he and the Pope opened up a bathroom for them. He also told me there was no medical care and they opened a clinic close to here with 80 volunteer doctors. May this example stay with each one of us here at such an important and sacred place, in this very relevant event which will leave a mark on all of us, but may it also leave a mark for each one of the people that live in our cities and in our states, to take care of the resilience factor, the environmental and climate change factors, without leaving behind the most humble and poorest people, who are the main victims of all this process.

Agire ora. La lotta al cambiamento climatico: i sindaci in prima linea

Dario Nardella
Sindaco di Firenze

Voglio innanzitutto dire grazie per questo incontro, grazie per il potente richiamo a prenderci cura del nostro pianeta e gli uni degli altri, e per tutto quello che potrà nascere da questo Summit.

La cura della nostra casa comune e il bisogno di pace sono le questioni più urgenti del nostro tempo, sono le grandi sfide che ci troviamo ad affrontare come umanità, e sono intimamente legate.

La Terra ci sta dicendo che siamo vicini al punto di rottura, che il momento di agire è ora. Negli ultimi anni si sono moltiplicati gli eventi estremi, gli episodi di siccità, le ondate di calore, le inondazioni, con effetti diretti sulle nostre vite, l'ambiente, la salute, l'economia.

Ma possiamo ancora intervenire. È necessario, però, un radicale cambio di paradigma: nel modo di produrre e utilizzare energia e cibo, nel modo di spostarci, di consumare, di riscaldare gli edifici. Dobbiamo abbattere le emissioni di CO_2, riducendo l'uso dei combustibili fossili (primi responsabili della concentrazione di gas serra nell'atmosfera), a favore dell'efficienza energetica e dell'utilizzo delle rinnovabili.

L'Europa è il continente che si sta scaldando più rapidamente. Anche per questo, l'UE si è dotata di uno dei piani climatici più sfidanti al mondo, il Green Deal, che punta a un'economia carbon-free, circolare e a zero emissioni entro il 2050.

Ma non ci può essere cambiamento senza partecipazione, senza una vera e propria alleanza tra cittadini, forze politiche, economiche, sociali, culturali. Così, nel 2008, la Commissione Europea ha lanciato il Patto dei Sindaci (poi rinnovato nel 2015) per coinvolgere le città nel percorso verso la sostenibilità energetica e ambientale. Nel Patto dei Sindaci per il 2030, ai pilastri della Mitigazione e dell'Adattamento, si è aggiunto quello relativo alla Povertà Energetica, cioè l'impegno a fornire accesso a energia sicura, sostenibile e a prezzi accessibili a tutti.

A livello globale, le città consumano il 65% dell'energia mondiale e producono oltre il 70% delle emissioni di CO_2. Sono dunque il luogo in cui si può vincere questa sfida, costruendo un nuovo equilibrio tra progresso e sostenibilità, tra innovazione tecnologica ed equità sociale.

Firenze da vari anni lavora su questi temi: dalla realizzazione delle tranvie all'impegno sulla mobilità ciclabile e lo sharing, dalle azioni messe in campo per migliorare la qualità dell'aria (come lo 'scudo verde', che limita l'accesso al centro ai mezzi più inquinanti, gli incentivi al TPL e al ricambio del parco auto) al nuovo sistema di raccolta dei rifiuti, dalla riduzione della plastica e delle perdite idriche alla forestazione urbana, dalle semplificazioni per l'installazione dei pannelli fotovoltaici al rilancio della prossimità come dimensione urbana. Non solo, a Firenze stanno nascendo le prime comunità energetiche rinnovabili. A questo, si aggiungono progetti educativi nelle scuole, azioni di sensibilizzazione per rendere i cittadini protagonisti, come il progetto 'Firenze per il clima' che offre a un'assemblea popolare (con una bella rappresentanza di giovani e persone vulnerabili) il compito di elaborare idee e proposte per la sostenibilità ambientale da qui al 2030.

Firenze è stata infatti selezionata, con altre 100 città, per la Missione dell'EU '100 Climate Neutral and Smart Cities by 2030'. Per centrare l'obiettivo, servono però analisi adeguate, strumenti di pianificazione e programmazione ambiziosi, come il 'Piano d'azione per l'energia sostenibile e il clima', frutto di un lavoro condiviso, in cui la città si è messa in gioco e ha abbracciato una prospettiva più ampia. Perché siamo Acqua, siamo Aria, siamo Terra e Fuoco. Siamo vasi comunicanti. Non esiste forma di vita che non sia in relazione con le altre e con l'ambiente.

Questo è il momento di agire. Siamo qui per costruire un nuovo umanesimo in cui si incontrino e trovino cittadinanza i temi ambientali e sociali, le idee e soprattutto le persone. Ma tutto ciò sarà pienamente possibile quando il mondo intero sperimenterà la pace. Perché senza pace tra le nazioni e i popoli diventa difficile – se non impossibile – unire le forze per salvare l'umanità e proteggere la natura. Oggi affermiamo da qui che l'unica guerra che dobbiamo combattere è quella contro il cambiamento climatico e che tutti i nostri sforzi devono essere indirizzati a costruire un mondo di pace.

Unlocking Climate Actions: Managing Climate Impacts to Climate Resilience – Taiwan's Practice

Wen-Chen Shih
Deputy Minister, Ministry of Environment, ROC Taiwan

Trends of Climate Change Impacts in Taiwan

Our ministry and National Science and Technology Council (NSTC) jointly published the "Taiwan Climate Change Scientific report". This report shows that intensity and frequency of heavy rainfall in Taiwan are expected to increase due to warming. Currently, extreme events that occur in every 50 years may become more frequent. Under a 4°C global warming level scenario, such events may occur approximately every 10 years.

The projected increase in the number of hot days continues in the future: Under a high emissions scenario, the average number of hot days across Taiwan is expected to increase by 75 days. The longest consecutive dry spell per year is estimated to increase by 1 to 10 days by the end of the century, with the magnitude of the increase depending on the intensity of warming.

Extreme Climate in Taiwan

The Scientific Report illustrate the extreme vulnerability of Taiwan facing climate change. For example, in August 2009, Typhoon Morakot brought a record-breaking rainfall resulting in the worst flood in Taiwan in 50 years, causing flooding and landslides in many places. In April 2021, Taiwan experienced the worst drought in 50 years. The water storage capacity of many reservoirs fell to below 10-20%. The manufacturing and service sectors restricted water use, and more than 70,000 hectares of farmland stopped farming.

Climate Change – Mitigation and Adaptation

Facing the challenges brought by climate change, we recognize the urgent need for action. The 2023 Climate Change Response Act covers both mitigation and adaptation. In terms of mitigation, we ensure a gradual reduction in greenhouse gases by establishing a carbon budget approach. For adaptation, we consolidate national development priority through the

establishment of national climate change adaptation action plan. Sectoral Greenhouse Gas Reduction Action Programs are proposed based on carbon budget while Adaptation Action programs are developed based on the national climate change adaptation action plan.

Moreover, we focus on cooperation between central and local governments, with local governments participating and collaborating in the implementation of actions. To facilitate collaboration between central and local governments, the central government assists local governments in establishing Climate Change Response Promotion Committees, chaired by each mayor and governor, to ensure cooperation between local and central governments.

Legal Actions for Adaptation in Taiwan: the Climate Change Response Act

The act introduces a new chapter on adaptation. First, we focus on enhancing the national adaptation capacity. The government will promote adaptation capacity-building initiatives encouraging active participation from citizens and businesses to collectively address the challenges of climate change. Secondly, we strengthen climate change research and risk assessment. Central governing and technological agencies will regularly publish climate change scientific reports, establish risk assessment criteria, and assist all levels of government in formulating adaptation plans. The central governing agencies will regularly draft sectoral adaptation action plans and goals, hold public hearings, and integrate the formulation of national adaptation action plans. Lastly, we tailor adaptation strategies to specific regions. Local governments will formulate local adaptation implementation plans to address climate change challenges in various regions.

Adaptation Governance under the Climate Change Response Act

Building upon the foundation of the Climate Change Response Act, the National Development Council and the Ministry of Environment have jointly facilitated the establishment of a multi-level, multi-stakeholder climate change adaptation governance platform. This platform is led by several ministries, serving as the core drivers responsible for coordinating and integrating resources and capabilities to enhance climate change adaptation. Moreover, it is based on the collaborative foundation of local governments, further promoting the involvement of industries and the public in connecting resources and encouraging proactive participation in addressing climate challenges.

National Climate Change Adaptation Action Plan (2023-2026)

The latest National Climate Change Adaptation Action Plan has allocated a total of 411.6 billion NT dollars, aimed at strengthening our overall climate change adaptation capacity and promoting sustainable development in society, the economy, and the environment. These endeavors target areas in Taiwan that are vulnerable to impacts, with the goal of enhancing environmental adaptation capabilities, strengthening resilience among vulnerable groups, introducing diverse adaptation strategies in urban and rural areas, and enhancing water resource system management. These efforts encompass seven objectives:

1. Improving the resilience of critical infrastructures,
2. Increasing climate adaptation capacity and stabilizing water supply,
3. Ensuring homeland security and strengthening integrated management,
4. Preventing coastal disasters and ensuring sustainable marine resources,
5. Improving energy supply and industry adaptability,
6. Ensuring agricultural production and biodiversity,
7. Bolstering medical and disease prevention systems and health risk management.

Water Resource Aspects

I will be using water resources and health as two examples. The sourcing, conservation, scheduling, backup, and management of water resources have been prioritized. Taiwan has increased water supply by 20%. Upstream, we have utilized reservoir sediment removal facilities and ensured the conservation management of watershed areas.

In the midstream, we have promoted the interconnected reservoir pipeline projects for water distribution and increased artificial lakes and detention basins. We've also promoted the use of groundwater resources and established four seawater desalination plants.

Downstream, efforts have focused on reducing the leakage rate of the tap water supply and constructing four wastewater recycling plants. Additionally, we have increased the access rate of tap water and implemented water consumption fees for excess use. Furthermore, smart irrigation management has been promoted to effectively utilize water resources and enhance agricultural productivity.

Health Aspects

In terms of health, we are not only addressing the impact of climate change on health but also combating environmental pollution. We have placed particular emphasis on developing health education materials to enhance public awareness and preparedness for climate change. Additionally, we have established diverse support measures and channels to ensure that affected communities receive adequate care and support.

To better respond to extreme weather events, we have developed an extreme temperature warning system that issues high-temperature alerts in advance and provides relevant coping advice. We have also set up an adaptation recognition mechanism that integrates warning information into various platforms, such as meteorological information platforms. This mechanism offers features like location tracking, emergency calls, and linking to social communication software to help the public cope with extreme weather events promptly.

The Way Forward

We emphasize the importance of local government cooperation. We assist local governments in establishing Climate Change Response Promotion Committees and promoting local "Climate Change Adaptation Implementation Programs."

Moreover, we understand the importance of scientific research in this aspect. The MOENV and the NSTC jointly conduct research and development on climate change science and impact adaptation, serving as the basis for formulating and promoting adaptation programs. Through these collaborations between local and central governments, we hope to implement our adaptation policies in a climate-resilient way.

In the Front Lines: Climate Hotspots

Renzo Caramaschi
Sindaco di Bolzano

Dopo aver sentito tanti esempi di città impegnate per combattere il cambiamento climatico devo riconoscere che c'è un filo comune che unisce sindaci e governatori nella sensibilità, nella volontà e nella capacità di reagire al cambiamento climatico, nel mondo, in Europa dalle città di Parigi a quella di Valencia, così come in Italia da Bologna a Firenze.

Bolzano è una città di piccolissime dimensioni. Il territorio comunale si estende su 52,34 kmq alla congiunzione di tre valli (tra Val d'Isarco, Val Sarentino e Valle dell'Adige). La città sorge a 262 m s.l.m., nella conca delimitata da una serie di monti di altitudine fino a 1600 mt, tra cui è compresa la località montana Colle, parte del territorio comunale. Bolzano non è neppure un quarto del quartiere di Centocelle, è praticamente una strada di Parigi, di Madrid. Malgrado le dimensioni i problemi tuttavia sono equivalenti perché il cambiamento climatico non si arresta ai confini né tiene in considerazioni le dimensioni.

Occorre agire velocemente: il Comune di Bolzano ha aderito prima nel 2010 e poi nel 2017 al nuovo Patto Europeo dei Sindaci per il Clima e l'Energia. Il capoluogo altoatesino è diventato ufficialmente il primo ComuneClima Gold certificato in Italia, secondo i criteri del programma avviato nel 2016 dall'Agenzia CasaClima per sostenere e premiare i Comuni che si impegnano per una politica energetica ed uno sviluppo locale sostenibili. Il 5 novembre 2021 la nostra città a Ravensburg ha ricevuto il premio European Energy Award Gold, il premio europeo riservato ai comuni che si sono particolarmente impegnati nel settore della protezione del clima, dell'efficienza energetica e delle energie rinnovabili. La Città di Bolzano è tra le prime 100 città europee ad aver aderito nel 2021 al "Green City Accord" iniziativa della Commissione Europea per rendere le città più sane, più verdi e più pulite. Si tratta di un movimento di Sindaci impegnati a migliorare la qualità della vita della comunità cittadina e ad accelerare l'attuazione di leggi ambientali dell'Unione Europea legate al cosiddetto "Green Deal" europeo. Sono tutti programmi che prevedono obiettivi misurabili, che prevedono che si parta da una situazione e si arrivi ad un punto che possa accelerare il miglioramento... altrimenti restiamo sempre nell'ambito delle parole, delle intenzioni. E

noi italiani, spesso per vocazione, siamo bravi a parlare ma dobbiamo diventare anche più concreti.

A Bolzano la superficie edificata rispetto al 1981 è aumentata notevolmente: eravamo 107.000 abitanti nel 1981 e oggi siamo più o meno allo stesso numero di abitanti, però nel 2024 abbiamo consumato il 42% del territorio in più. Nel 1981 avevamo il 15% di famiglie con un solo componente e oggi siamo al 47%: ne consegue che una programmazione urbanistica che tenga conto della trasformazione della società è assolutamente necessaria.

Si fa forte la necessità della mitigazione del cambiamento climatico: il clima fuori non aspetta le nostre decisioni politiche.

Il monitoraggio costante e le azioni intraprese hanno permesso nei decenni di ottenere ottimi risultati nella riduzione delle polveri sottili e del biossido di azoto. Grazie alla centrale di teleriscaldamento di Bolzano ogni anno viene evitata l'emissione di migliaia di tonnellate di CO_2. Una volta portata a termine l'estensione della rete di teleriscaldamento a Bolzano riusciremo a evitare l'emissione di 50.000 tonnellate di CO_2 ogni anno. Una quantità di CO_2 pari a quella assorbita da 4 milioni di alberi. Anche se alcune azioni hanno dato dei frutti, noi siamo in ritardo.

C'è oggi però una grande variabile, e lo dico con molta amarezza: il Papa è rimasto solo a predicare la pace. La guerra significa armi, morti, distruzioni... si uccidono giovani e civili, si distruggono famiglie, beni, case, infrastrutture e, non dimentichiamo, si distrugge anche il clima. La guerra è il più grande nemico dell'ambiente.

Su questo tema dobbiamo avere la forza di confrontarci, perché l'Europa sta accumulando debiti per armarsi e fornire armi. Noi lavoriamo per uccidere, non per costruire strategie contro il cambiamento climatico.

Bolzano è una piccola città, ogni anno però attingiamo con continuità ai fondi europei, ai fondi statali, oltre che ai fondi dell'avanzo che proviene da un'oculata amministrazione della città. Investiamo il 30% delle risorse a favore del sociale, perché abbiamo sempre più problemi e necessità di intervenire per una società che invecchia e sta cambiando nella sua composizione sociale.

Stiamo investendo per tutti, ma le risorse non sono infinite: la variabile finanziaria diventa sempre più importante, perché se concentriamo gli sforzi per le armi, allora ci saranno meno risorse per il clima.

Questi convegni, e voglio esprimere che sono molto onorato di essere stato invitato, rappresentano sferzanti iniezioni di energia per convincere i Sindaci e le comunità locali a recuperare il ritardo accumulato sull'ambien-

te; le città sono più sensibili rispetto gli organismi di livello superiore perché sentono e vivono quotidianamente il problema.

Invito quindi tutti di accelerare e porre le nostre energie in questa direzione, accorciando i tempi degli interventi perché il clima non aspetta le nostre piccole e medie intelligenze, i nostri tentennamenti o decisioni, che oggi necessitano di rapidità e risolutezza.

YOUTUBE PRESENTATIONS

Governance in the Age of Climate Change

Hon. Sadiq Khan

Mayor of London

https://youtu.be/_9diq3MCsbs?si=B7WTIeVEj2_VxcMQ

Climate Leadership in Rome

Hon. Roberto Gualtieri

Mayor of Rome

https://youtu.be/CHKj9sT9j1M?si=F2lQRe36-CEuvXb0

Governance, Water

Hon. Luigi Brugnaro

Mayor of Venice, Governance, Water

https://youtu.be/anNONCHA9rg?si=0OzC68s1a6uLCccP

Hon. Haris Doukas

Mayor of Athens

https://youtu.be/h828gR7OWpg?si=XZR37jyGI0q1tC11

Hon. Matteo Lepore

Mayor of Bologna

https://youtu.be/BKr5W5pdqoA?si=YjXhXto0m3LUAUwY

Hon. Raúl Jalil

Governor, Catamarca

https://youtu.be/Bpmd-Pu2Y1A?si=9n3l98P43uf_9jNa

SESSION IX – SOCIAL TIPPING POINTS: FORCED MIGRATIONS

Climate Migration and Integration

Mary C. Waters
Department of Sociology, Harvard University

As climate changes across the world, we can anticipate large flows of migrants both internally and internationally. This is happening now in the natural world among plants and animals. About half of the species assessed globally by the sixth Intergovernmental Panel on Climate Change have shifted towards the poles or to higher elevations in recent years (IPCC 2023). Humans will also move as the environment changes, as we have done throughout our history as a species. In this paper, I will describe the types of climate migrants we should expect, and how we can best prepare for their integration into receiving communities. Climate migration will pose many challenges but can also be framed positively, with informed policies leading to positive outcomes for both migrants and receiving communities.

The State of the Field

Current research on climate migration is dominated by quantitative studies attempting to predict how many people will move and where they will go (Hunter and Norton 2015). These studies correlate migration with rainfall and temperature in a quest for models that predict human behaviors (Molina et al. 2023). This research also focuses on the link between climate change and conflict, such as the Syrian war, Arab Spring, and conflicts in Central American and sub-Saharan Africa (Abel et al. 2019). These studies demonstrate that at the aggregate level migration flows are correlated with climate indicators, but political, economic, and social factors interact with environmental factors to shape migration decisions. Migration at the individual level is influenced by many factors simultaneously, making it very difficult to identify someone as solely a "climate migrant".

Qualitative studies of people dealing with climate change demonstrate that migration is often a last resort. People will adapt in place if they can (Castro and Sen 2022). This is due to human psychology and to institutions which continue to reinforce the status quo, despite our changed world. Psychologists have identified loss aversion as a strong motivating factor for all kinds of human behavior (Kahneman 2011). The longer people hold on in a deteriorating situation the greater their fear of losing, and the more sunk

costs motivate them to try to recoup their losses. A farmer facing a drought will stay hoping that the rain will come back. The longer they remain in place the more they will lose as they sell off their animals and other resources to keep going. These individual motivations to avoid change are exacerbated by institutions which encourage a blind eye to climate change and exacerbate the tendency of people to stay in place. For instance, flood and homeowners insurance in the United States encourages people to rebuild in places damaged due to climate change (Elliott 2021). Emergency aid is also targeted towards rebuilding and not towards relocating to a safer spot (Arcaya, Raker and Waters 2020).

Climate Migration and Right-Wing Politics

Discussions of climate migration in the popular press are characterized by extreme projections and scaremongering. A recent widely cited report said that 1.2 billion people would be moving by the year 2050 (Institute for Economics and Peace 2020). This is obviously a very extreme and highly unlikely number; arrived at by assuming that anyone who lives in a low elevation coastal zone, which is described as any area under 10 meters in elevation within 100 kilometers of the coast, will have to relocate. This is interpreted as meaning that the populations of countries such as Bangladesh, Indonesia, Vietnam, Egypt and Nigeria will relocate (Neumann et al. 2015). These estimates are not a result of careful science. Perhaps they are put forward and spread because of a well-meaning desire to foment alarm about climate change. But dire predictions about the volume of climate migration can have negative feedback effects on support for both immigration and climate mitigation efforts.

In Europe and the United States, the rise of anti-immigrant parties and politics has increasingly overlapped with climate skepticism (Lockwood 2019). Voters who support right wing politicians fear the cultural and economic changes from immigration, hold skeptical views on climate change, and oppose climate change mitigation efforts (Kulin, Seva and Dunlap 2021). Right-wing parties in the U.S. and Europe accrue political capital from the fear of climate-driven immigration. Those who over-predict climate migration contribute to these fears.

Action on climate change requires trust in science, government and generalized social trust (Smith and Mayer 2018). Immigration, in the short run, decreases social trust, thus making it harder to deal with climate change (Ziller, Wright and Hewstone 2019). Climate change increases immigra-

tion, fueling a positive feedback loop that tends to undermine support for changes needed to reduce further damage. Migration is an integral part of climate change, and it interacts with our ability to manage it. Consequently, receiving countries need to manage not only flows of immigrants but their reception, in order to maximize integration and minimize the conflict and fear that leads to declining social trust.

The Realities of Climate Migration

Migration theory, rooted in a large body of empirical research, tells us that when people migrate there are three aspects to their moves. First, they follow social networks. People move to places they know people: where family or friends have already settled. The networked nature of migration is very helpful to the successful integration of migrants in their destinations, as previous migrants help new ones both find housing and jobs and provide social and material supports. Networks of migration predict many future immigration flows. New migrants to a country will likely come from the countries that have sent migrants who are already well settled in the receiving nation.

Second, the majority of migrants will move short distances. Long distance migration is the exception, not the rule, meaning most climate migration will be internal. Of course, as migration grows, even if only a small percentage of all migrants cross international borders, it will be a marked increase in world migration flows (Bellizzi et al. 2023). However, it is clear that countries, especially in the global south, will need to accommodate large internal displacement.

Third, integration of immigrants can be very successful, but this does not happen automatically. Receiving communities should prepare for the integration of climate migrants, building on what we have learned from the integration of economic migrants, refugees, and asylees (Waters and Gerstein Pineau 2016).

A Typology of Climate Migrants

There are four migration-related responses to extreme changes in climate. Disasters such as fires, floods and storms can cause large, rapid and chaotic *disaster migration*. Slow onset climate change like droughts, floods, rising temperatures, crop failures, sea level rise and destruction of ecosystems cause *strategic migration* and *managed retreat*. *Strategic migration* is a choice made by individuals. It can be economically motivated or because of a perception that staying in place will be impossible (Castro 2023). *Managed retreat* is the

organized movement of communities away from hazards. It will become inevitable in some places that become uninhabitable, such as low-lying island nations (National Academy of Sciences 2024). Finally, another there are trapped populations, people who cannot or will not move, but whose adaptation in place will increasingly fail (Black and Collyer 2014).

As the realization grows that people are moving and will move in the future because of the climate, policy debates have focused on how to define climate migrants and whether they should be a new legal category. Legally, a refugee is a person forced to flee because of a well-founded fear of persecution due to race, religion, nationality, membership in a particular social group, or political opinion. This definition does not include people moving because of climate-induced events or changes, many of whom claim asylum because it is often the only path available for migration. Consequently, identifying climate migrants at the individual level is very difficult. Critics of the idea of climate migrants question whether the category will be essentializing and worry that drawing attention to this population will fuel a backlash, further eroding support for welcoming immigrants.

There is also a policy debate about what the developed world owes to the developing world. The developed countries who contributed the CO2 emissions driving climate change are not bearing the brunt of climate change damage. The countries in the global south who have contributed the least to the problem are facing the worst consequences. Their citizens are the ones most likely to be forced to migrate in the future. An intriguing proposal addressing this inequity is that visas can be used as a form of reparation (Gonzalez 2022). Permanent visas could be issued to countries facing all three types of migration – disaster, strategic and managed retreat.[1] Strategically allocating visas to countries badly affected by climate change as a way of responding to climate disasters and seeding thoughtful climate migration is a plausible path forward for developed countries to consider.

There are several benefits to increasing the number of visas available to countries experiencing the negative effects of climate change, without necessarily requiring that migrants prove they are "climate migrants". These visas will be taken up by strategic migrants seeking a solution to deteriorating conditions. These migrants will then, following common practice, send

[1] The United States already uses Temporary Protected Status (TPS) as a way to help people fleeing disasters – but it is merely a temporary fix that does not grant a path to citizenship and only benefits disaster migrants after they have made their way to the U.S.

home economic remittances that can be used to adapt in place by those who cannot or do not choose to move, increasing the resources of the trapped populations. Disaster migrants will seek out established migrant communities, using network ties to integrate and join the work force. Low fertility and an aging population in almost all developed countries means their need for labor will be very strong in the coming decades. Allowing more migrants under a planned process will ease labor shortages and optimize integration.

A city that has built on previous migration to create mutually beneficial opportunities for disaster migrants is Buffalo, New York. Buffalo is a declining city that has been losing population for decades following the collapse of manufacturing jobs, going from a peak population in 1950 of 580,000 to a current population of 260,000. As a result, Buffalo has enough land, housing, sewer and water infrastructure to support hundreds of thousands of additional people. Buffalo saw a chance to increase its population when Hurricane Maria hit Puerto Rico, a U.S. territory, in 2017, causing 5,000 deaths and leading 130,000 people, 5% of the island's population, to leave. Most migrants went to Florida but family and network connections to Buffalo's Puerto Rican community also attracted migrants. Buffalo advertised on Puerto Rican radio to welcome people considering relocating. The city hired teachers from Puerto Rico to help with the influx of Spanish speaking students. Community organizations found households to host families from Puerto Rico who needed a place to stay and put together fresh start kits with kitchenware, blankets, winter clothes, and baby items. While some of the 5,000 people who consequently came to Buffalo went back when they could, many permanently relocated. In the 2020 Census Buffalo showed its first population increase in 70 years (National Academy of Sciences 2024). Across Europe and North America there are regions and cities that have been losing population. Some of these areas have been revitalized by the settlement of refugees, and disaster migrants could also be framed as a solution to their economic woes to be embraced, rather than as a problem to be resisted.

Managing the Integration of Climate Migrants

A recipe for declining social trust and anti-immigration politics would include rapid immigration, the kind of migration that most characterizes disaster migration. Conditions undermining integration would include segregation and limited interaction between immigrants and natives, rising income inequality, fears about economic insecurity and declining social

mobility, and leaders who exploit these fears and use immigrants as a scapegoat. To add to this recipe, one might also include the existential fear of climate change and predictions of the arrival of masses of climate migrants.

Immigrant integration can, however, be remarkably successful (Waters and Pineau 2016). The recipe for success is equal contact between natives and immigrants in institutions in everyday life, a slower growth of immigration, and settlement in areas with institutions that facilitate integration and have a history of incorporating immigrants (Kotzur, Tropp and Wagner 2018). Also, it is important to have leadership that frames immigrants as a benefit. Ramos et al. (2019) finds that within four to eight years the effect of intergroup contact mediates and vastly reduces the relationship between higher diversity and lower social trust.

In planning for the future, governments should plan for the different types of migration, increasing opportunities for strategic migration by preparing destination locations and accepting more migrants. To facilitate successful integration, societies should focus not just on who goes where, but how natives and immigrants will have opportunities to interact and create bonds.

In considering disaster migration, plans should incorporate social justice into the response, not just recreating existing inequality or worsening it. Best practices will abandon an individualistic approach to resettlement and prioritize the need of people to be with their communities and family members in any relocation (Waters 2016). The integration of disaster migrants into their new communities, whether internally or internationally displaced, should also involve focusing on the needs of receiving communities. Too often refugees have been settled in areas where the poor who already lived there did not receive aid, and this caused conflict with the refugees who were seen to be getting preferential treatment. Current residents will be much more likely to welcome migrants if they are also getting needed assistance and having their social problems addressed.

Western Europe and the United States are facing a demographic crisis and labor shortages. Like Buffalo, many cities and rural areas need migrants to rejuvenate their economies. To facilitate the successful match between climate migrants who need a safer place to live and communities who need migrants to bolster their populations, we need to strengthen institutions that help integrate migrants, and strengthen government capacity for facilitating integration. In anticipation of the growth of migrants coming to these areas, we need to develop plans for both slow and fast climate migration.

Social scientists can contribute to this planning, sharing how increasing the numbers of strategic migrants through visa programs will help more

people adapt in place by increasing remittances, ultimately relieving population pressure. These migrants will also seed further migration, but the social networks that connect sending and receiving communities will assist the integration of later migrants, including those who move rapidly because of disasters. Our institutions can be advised to be organized to foster positive contact and sustained social interactions between natives and immigrants. We also need political leadership that frames immigration in a positive way and rises to the inevitable challenge that increased human mobility will pose in the coming decades.

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Climate Change and Children: Contexts, Impacts, and Supporting Resilience

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Abstract

Climate change poses a significant threat to children worldwide, with nearly half at "extremely high risk" (UNICEF, 2021, p. 4). This paper explores the specific impacts of climate change on children, categorizing vulnerable groups into those living in areas directly affected by eco-devastation, those displaced by eco-migration, and those experiencing eco-anxiety. The paper analyzes how these vulnerabilities affect children's development and well-being. Recommendations are offered to enhance eco-resilience among these young populations, emphasizing targeted strategies in climate mitigation planning and funding to address the specific risks children face.

Climate Change and Children: Contexts, Impacts, and Supporting Resilience

The "inconvenient truth" (Guggenheim, 2006) of climate change is a significant concern, especially for our world's children and youth (UNICEF, 2021). UNICEF's Children's Climate Risk Index revealed that nearly half of the world's children – an estimated one billion – were "at 'extremely high risk' of the impacts of climate change" (UNICEF, 2021, p. 4). While most children face direct eco-devastation, some are displaced, and others experience eco-anxiety (Clayton et al., 2017). We are facing a "children's rights crisis" (UNICEF, 2021). Despite children's unique vulnerabilities to climate change, their plight is often under-considered in mitigation planning and funding (UNICEF, 2023b). This paper examines how climate change impacts children and youth in three key contexts: 1) those living in regions directly impacted by *eco-devastation*, 2) those displaced by *eco-migration*, and 3) those experiencing *eco-anxiety*.

1. Eco-Devastations: Children Living with Immediate Impacts of Climate Change

Eco-devastations can be categorized as rapid-onset shocks (e.g., hurricanes, floods) and slow-onset events (e.g., drought, water scarcity) (Cattaneo, 2019; Kazan & Orgill-Meyer, 2020). Rapid-onset shocks are the most

immediately disruptive, causing death, illness, and displacement. Over the last six years, an estimated 43 million children have been displaced by such events (UNICEF, 2023a). The most prevalent slow-onset form of eco-devastation is drought and water scarcity. UNICEF estimates that 739 million children live with high or extremely high levels of water scarcity, with nearly a third of children worldwide exposed to "extreme" water scarcity (UNICEF, 2023b). These risks are unevenly distributed, with 64% of children in the Middle East and North Africa and 55% in South Asia lacking access to potable water, compared to 11% in Western Europe. Water scarcity is linked to food shortages, malnutrition, and waterborne diseases (like cholera and dysentery), to which infants and toddlers are particularly vulnerable (Hanna & Oliva, 2016; UNICEF, 2023b). Climate change and eco-devastations are most immediately dangerous for children in the Global South, where health is already compromised (Hanna & Oliva, 2016; UNICEF, 2023b). Northern Africa faces higher rates of water scarcity and air pollution, while tropical areas face increased risks of flooding and vector-borne diseases. The Middle East experiences excessive heat, drought, desertification, and dust storms, while East Asia and the Pacific face rising sea levels, ocean acidification, cyclones, floods, landslides, and droughts (UNICEF, 2023b).

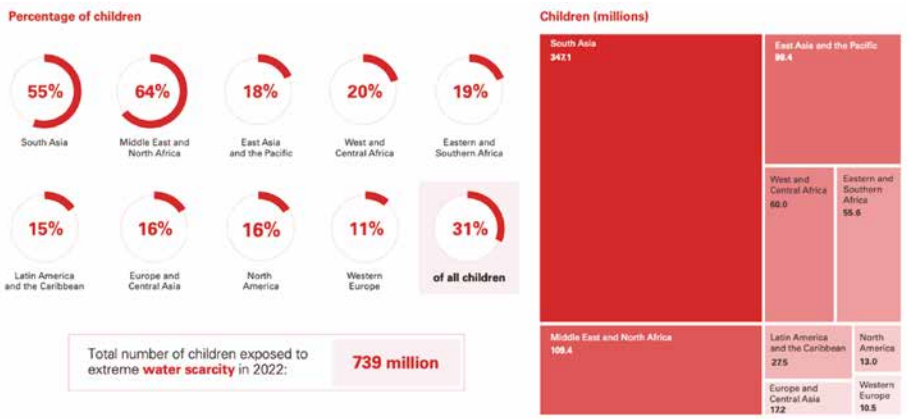

Figure 1. Water Scarcity Index. Credit: UNICEF (2023b).

1.1 Impacts of Eco-devastations on Children

Children are particularly vulnerable to the effects of climate change due to their developing bodies and minds (Hanna & Oliva, 2016; UNICEF, 2023b). These risks are particularly damaging when experienced prenatally[1] and during early childhood due to heightened neurobiological plasticity (Cuartas et al., 2024). Eco-devastations can create havoc or multiply pre-existing vulnerabilities for already fragilely resourced children stemming from a lack of resources to adapt to and manage the impacts of climate change with lasting impacts (Cuartas et al., 2024; Hanna & Oliva, 2016). The vast majority live in "zones of entrapment," unable to migrate away from the source of disruptions (McMichael, 2020; UNICEF, 2023a, b).

1.1.1 Physical Health Implications

It is estimated that "children will experience 80% of physical health impacts of climate change" (Sanson et al., 2022, p. 2). Children are most vulnerable to the health impacts of climate change due to their developmental stage, high exposure, and the regions they live in (Sanson et al., 2022). Rapid-onset shocks can lead to injuries, illnesses, fatalities, loss of loved ones, and disrupted access to necessities (Sanson et al., 2022). Slow-onset eco-devastations, such as extreme heat and water scarcity, can cause heat-related illnesses, malnutrition, stunted growth, and waterborne diseases (Hanna & Oliva, 2016; UNICEF, 2023b).

1.1.2 Mental Health Implications

Much less is known about the mental health implications of living with eco-devastations as attention is focused on triaging immediate health needs (Sanson et al., 2022). Research on the mental health implications of eco-devastation is primarily based on rapid-onset events, with less known about the effects of slow-onset events (Burrows et al., 2024). Available research suggests that eco-devastation is linked to anxiety, depression, and post-traumatic stress disorder (PTSD) for children and youth (Burrows et al., 2024; Sanson et al., 2022; Shultz et al., 2019).

Living in environments with limited access to water can cause chronic stress and anxiety for children, youth, and their families. Uncertainty about

[1] While the field of prenatal climate related catastrophic exposures is an emerging one, evidence suggests that significant epigenetic changes may influence child development and health outcomes later in life (Feil & Fraga, 2012; Perera, & Herbstman, 2011).

when and where the next water supply will be available can lead to psychological distress. Parents may become psychologically compromised, which affects their ability to attend to their children's well-being in optimal ways (Cuartas et al., 2024; Hanna & Olivia, 2016). Some encouraging research suggests, however, that for some, post-traumatic growth can result (Clayton et al., 2017).

1.1.3 Increased Exposure to Violence & Exploitation

Climate change-related violence may increase due to water scarcity, declining agricultural productivity, and loss of natural resources, exacerbating existing tensions and generating new instability (Homer, 1999; Selby et al., 2017). Children, especially those from marginalized communities, may be at increased risk of exploitation, including child labor trafficking and child transactional sexual exploitation, as families may struggle to meet their basic needs (Hanna & Olivia, 2016).

1.1.4 Educational Impacts

Educational access, experiences, and outcomes are at risk for children living in eco-devastated regions. Schools in these areas often lack adequate water and sanitation facilities, posing health risks for students and contributing to absenteeism due to illness (Shohel, 2022). Moreover, water scarcity disproportionately affects girls, who are frequently responsible for water collection in many cultures (Devonald et al., 2020). These additional responsibilities exacerbate gender disparities in education, as girls are more likely to be exposed to waterborne diseases and have less time for schoolwork compared to boys (Devonald et al., 2020).

2. Eco-Migrations: Children Displaced by Climate Change

The evidence presented by UNICEF (2021, 2023a, b) suggests that most "climate-changed" children remain in place despite their adversities, particularly those impacted by slow-onset drought and water scarcity (UNICEF, 2023a). Only those with more resources, mainly living among the world's poorest nations, can migrate (Kaczan & Orgill-Meyer, 2020). When families from poorer regions move, it is most likely within national borders and from rural to urban areas (McMichael, 2023). Nonetheless, climate change has become a "driver of human displacement" (UNICEF, 2023a, p. 19). Between 2016 and 2021, an estimated 134.1 million people were classified as eco-migrants, including 43.1 million children (UNICEF, 2023a) [see Figure 2]. The majority were displaced by storms (21.2 million) or floods (19.7

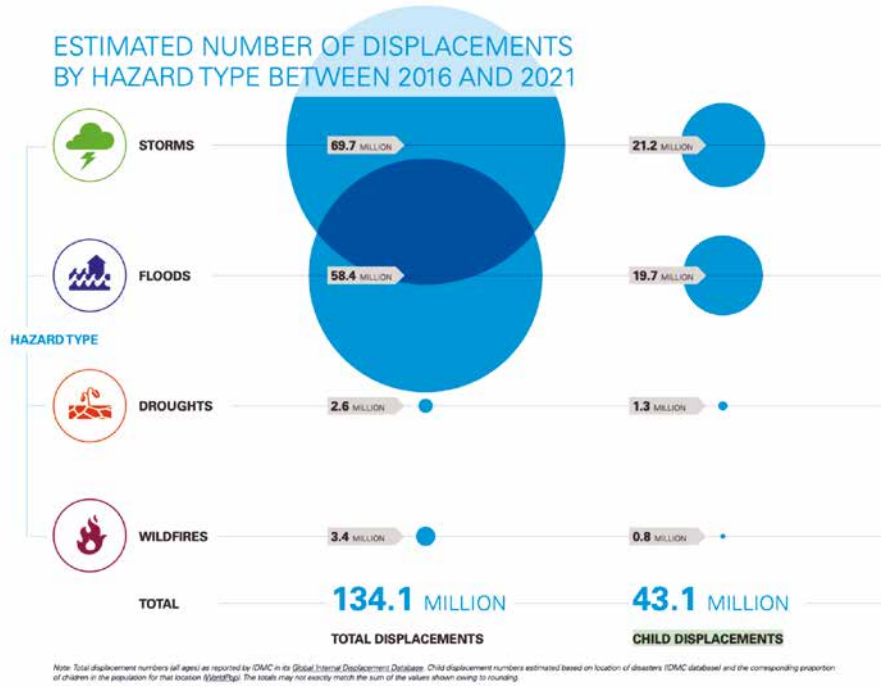

Figure 2. Children Displaced in a Changing Climate. Credit: UNICEF (2023a).

million), primarily from the Philippines, India, China, Bangladesh, Somalia, Indonesia, and Ethiopia. Droughts and wildfires also precipitated migration for children, with those displaced by wildfires largely originating from the United States, Canada, and Israel (UNICEF, 2023a).

Eco-migration often results from compound climate change-related hazards (UNICEF, 2023a) and may be multiply determined due to the adverse effects on livelihoods, health, violence, and unrest (McLeman & Smit, 2006). Climate-induced displacement can occur internally or across international borders, with the latter posing additional legal, cultural, and linguistic barriers (Warner, 2010).

While eco-migrants could be considered "ecological refugees" (Myers, 1994), international law does not recognize them as refugees under the 1951 Refugee Convention, which was implemented before climate change was foreseen (McAdam, 2012; Nishimura, 2015). Displaced children may face statelessness, liminal documentation issues, and challenges in accessing

healthcare, education, and other services (Southwick & Lynch, 2009). Unaccompanied minors face additional difficulties navigating asylum procedures (Bhabha, 2014). The legal status and protections afforded to displaced children vary by country, creating uncertainty and insecurity (Ferris, 2012).

2.1 Impacts of Eco-Migration on Children

Displaced children are a particularly vulnerable population, facing multifaceted challenges that can have profound impacts on their physical health, mental health, and educational opportunities.

2.1.1 Physical Health Impacts

Children displaced by climate change face numerous physical health challenges. Physical injuries may result from violence, accidents, or hazardous conditions experienced before, during, and after displacement (Sirin & Rogers-Sirin, 2015). In refugee camps, displaced children are exposed to high rates of infectious diseases due to overcrowding, poor sanitation, and limited access to clean water, with diarrhea, respiratory infections, and malaria being common (Gupta et al., 2014). Incomplete vaccination coverage increases the risk of outbreaks of vaccine-preventable diseases. Malnutrition and nutritional deficiencies are significant issues among refugee children due to insufficient food supplies, lack of dietary diversity, and interruptions in food distribution (Black et al., 2013). Undernutrition can lead to stunting, wasting, and micronutrient deficiencies, impacting children's growth and development (Sphere Project, 2011).

2.1.2 Mental Health Impacts

The mental health impacts on displaced children are profound and multifaceted. Forced migration involves loss at multiple levels, including material possessions, lifestyle, social status, community, and a sense of familiarity and safety (Shultz et al., 2019). Experiencing or witnessing traumatic events, such as natural disasters and the loss of homes or loved ones, can lead to post-traumatic stress disorder (PTSD), anxiety, and depression (Fergusson & Lynskey, 1996). Displacement-related uncertainty and the loss of community and social networks can further exacerbate stress, anxiety, and disrupt children's sense of belonging and security (Pfefferbaum & North, 2008).

Developmental psychologists emphasize the crucial role of parents and caregivers in moderating the effects of extreme stress (Cuartas et al., 2024; Wachs, 2009). However, eco-migrant children often experience separation

from or loss of close family members during displacement. Moreover, traumatized parents facing their own mental health challenges may struggle to provide optimally sensitive caregiving (Cuartas et al., 2024; Eltanamly et al., 2023; Hope et al., 2019). Conversely, a supportive caretaking environment can significantly contribute to the resilience of displaced children (Jafari et al., 2022).

Refugee children often experience traumatic events, such as violence, loss of loved ones, or direct threats to their safety. The prevalence of PTSD, depression, and anxiety disorders is high among refugee children, impacting their overall well-being and ability to engage in daily activities and education (Fazel et al., 2012; Betancourt et al., 2015). Psychological adjustment to new circumstances, including stress related to living in migrant camps, can affect their sense of security, identity, and belonging. However, research also highlights the remarkable resilience of refugee children and the importance of supportive relationships and community networks in fostering their mental health and well-being (Kia-Keating & Ellis, 2007; Jafari et al., 2022; Sim et al., 2018).

2.1.3 Educational Impacts

Displacement disrupts educational pathways, leading to delayed enrollment, increased dropout rates, and learning gaps. Displaced children face barriers to education, including interruptions in schooling, lack of documentation, language differences, and financial constraints.

Becoming a refugee often means abruptly abandoning schooling due to conflict, persecution, or environmental disaster in home countries. The transient nature of displacement can lead to frequent school changes, interrupting educational continuity and contributing to lower academic achievement (Dryden-Peterson, 2015). Interrupted schooling affects both current learning and long-term educational trajectories and opportunities (Dryden-Peterson, 2015).

Access to education in host countries is challenging for refugee children. Legal barriers, lack of documentation, overcrowded camps, and insufficient educational provisions in refugee settlements hinder school enrollment. Host countries may lack the infrastructure or resources to accommodate displaced learners (UNHCR, 2016). The quality of education for refugee children is often compromised, with programs lacking adequately trained teachers, resources, and curricular relevance (Sinclair, 2001). Language barriers make it difficult for displaced students to understand lessons and par-

ticipate in class, leading to academic struggles, lower self-esteem, and increased dropout rates (McBrien, 2005).

Displaced children often carry psychological burdens of trauma and loss, impeding their capacity to focus on learning. While psychological support is paramount, such services are often limited or non-existent in refugee education settings. Social integration challenges, including discrimination and bullying, can further alienate refugee children from the learning environment and host society (Fazel et al., 2012). However, educational contexts that support peer relationships (Jafari et al., 2022) and promote belongingness (Dryden-Peterson, 2022) foster positive adaptation.

3. Eco-Anxiety: Children & Youth Preoccupied with Climate Change

Children and youth not directly disrupted by climate change may still experience eco-anxiety, a term encompassing climate anxiety, eco-trauma, ecological grief, and eco-dread (Burke et al., 2018; Clayton et al., 2017; Ojala, 2015; Sanson et al., 2022). Youth are more likely than their elders to worry about climate change's impact on their future (Bell et al., 2021).

Eco-anxiety, defined as "a chronic fear of environmental doom" (Clayton et al., 2017, p. 68), can manifest as anxiety, grief, guilt, anger, helplessness, and numbness (Clayton et al., 2017; Goldman, 2022; Hickman et al., 2022). Some researchers suggest eco-anxiety is an adaptive response to realistic concerns (Clayton et al., 2017; Hickman et al., 2022) and that channeling these concerns into sustainable living and activism are healthy coping strategies (Clayton et al., 2017; Goldman, 2022).

Notably, most research on eco-anxiety has been conducted in high-income nations in the Global North (Lee et al., 2020; Sanson et al., 2022). This body of work suggested that eco-anxiety was primarily an issue in the Global North, with children and youth learning about climate change through media, school, and social networks, perceiving it as a distant issue (Sanson et al., 2022). In contrast, the limited evidence from low- and middle-income countries indicated that children in these regions understand climate change through direct, often traumatic experiences, responding with despair and hopelessness (Sanson et al., 2022).

However, a recent global survey of 16-25-year-olds challenged this notion, revealing widespread eco-anxiety across countries in both the Global North and South (Hickman et al., 2021). The majority of respondents were worried about climate change and reported sadness, anxiety, anger, powerlessness, helplessness, and guilt, with over 45% saying these feelings

negatively affected their daily functioning. Strikingly, these trends were most extreme in countries highly impacted by rapid-onset eco-devastation, such as the Philippines, India, and Brazil. This suggests that children and youth directly affected by climate disruptions are even more likely to report eco-anxiety concerns, contrary to the previous focus on eco-anxiety as a Global North phenomenon.

4. Recommendations to Support Climate Resilience for Children and Youth

Children and youth across the globe are deeply affected by climate change, with implications for their physical health, psychological well-being, educational experiences, and potential to flourish. We must recognize these profound impacts and prioritize children and youth in policies and practices that foster climate resilience (UNICEF, 2023b) and never allow them to simply be an afterthought in our resilience planning.

Following the MAST framework of the Planetary Protocol for Climate Change Resilience and UNICEF's child's rights-oriented recommendations at COP-28 is essential. Strategies must be tailored to address the varying experiences of children in different regions, including those living with eco-devastations, those displaced by climate change, and those experiencing eco-anxiety.

For those living with eco-devastations, adapting and expanding essential health and social services is crucial. This requires significant increases in climate financing, private sector involvement, and programs to prepare for and respond to sudden-onset climate events (UNICEF, 2023b; Suárez-Orozco & Senarriaga-Esteve, 2024).

For children and families displaced by climate change, we must recognize climate migration as a reality and support policies that provide protection, healthcare, mental health services, and education for displaced children and their families (UNICEF, 2023a; Biermann & Boas, 2008).

Addressing eco-anxiety requires focusing on the mental health and future orientation of children and youth in both the Global North and South (Sanson et al., 2022). Empowering young people through community-led initiatives, youth-led protests, and mobilization can foster resilience and a sense of agency (Sanson et al., 2022; Hart et al., 2014).

Lastly, integrating climate science, environmental studies, and sustainability education into school curricula worldwide is crucial for equipping the next generation with the knowledge and skills needed to navigate and adapt to the challenges posed by climate change (Suárez-Orozco & Senarriaga-Esteve, 2024).

5. In Conclusion

It is imperative to recognize that climate change has a profound impact on our world's children and youth. Therefore, it is crucial that our responses are swift, comprehensive, and child centric. Efforts to bolster climate resilience must include targeted support for the physical and mental health of children, ensure their educational empowerment, and actively engage young people in climate action, fostering their agency and resilience. As stakeholders in their future, and ours, both children's voices and needs must guide our policies and actions, ensuring a livable and equitable planet for all.

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Santuario Frontera: A Sanctuary for Climate Migrants at the US-Mexico Border

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We are witnessing an audacious resurgence of dehumanizing tropes across the world that portray migrant populations as less-than-human. A nativist mentality that once characterized the political fringe has gone mainstream, legitimizing an open racism and intensifying hostility toward migrants that evokes histories of radical collective violence against minority groups – where Jews become "parasites", Tutsis "cockroaches", Mexicans "criminals", and so on. Our world is veering dangerously away from the norms of basic human respect and dignity enshrined in the 1948 Universal Declaration of Human Rights. Too many countries are closing their doors to our planet's most vulnerable people, building walls and surveillance technologies capable of repelling "infestation" and protecting national resources from an endless flow of "vermin" who compromise the purity of "national blood."[2]

I live and work at the international border between San Diego, California and Tijuana, B.C., Mexico, a key destination for Central American, Haitian and other migrant groups seeking protection from poverty, violence, and the accelerating impacts of climate change in their home countries. National borders in migration zones across the world typically aim to regulate the movement of people across them, and ours is exemplary in this sense. The continental border between the United States and Mexico manifests a long history of annexation and partition, grounded in nineteenth-century legacies of colonialism, dehumanization, violence, and the destruction of natural systems. But even thickly militarized borders like

[1] For more than a decade I have been privileged to partner with architectural designer Teddy Cruz to realize the cross-border projects presented in this paper. Teddy is Professor of Urbanism and Public Culture in the Department of Visual Arts at the University of California, San Diego. I want to convey my gratitude for his design brilliance and his tenacious commitment to the communities we work with.

[2] Ben Zimmer, "What Trump Talks About When He Talks About Infestations: The frightening political history of the word 'infest.'" *Politico Magazine*, July 29, 2019.

ours are ultimately porous things. Borders cannot contain many flows – air, water, waste, health, and the rich social, commercial and cultural exchanges and circulations that define everyday life in places like this.

In the Center on Global Justice at the University of California, San Diego, we investigate the ecosocial dynamics that define this border region, and shape the transgressive, hybrid identities of people who inhabit it. Our work reimagines the border zone as a tissue of social and spatial ecologies that provide an alternative vantage on how national identity and "citizenship" actually perform in this region. We see the border as a mesh of flows, exchanges and interdependencies, not merely an artificial jurisdictional line that divides two cities, two states, and two countries.

Our work at the San Diego-Tijuana border is local, but we see this region as a microcosm of all the injustices and indignities faced by vulnerable people across the world: political violence, climate disruption, accelerating migration, deepening inequality, escalating nationalism and border-building everywhere. Our campus sits just a few miles away from the child detention centers that will forever stain this period of American history. San Diego-Tijuana is a lightning rod for American nativism. In recent years, tens of thousands of Mexican, Central American and Haitian migrants waited at the wall for asylum that never came, too often reviled by publics on both sides of the wall. Many sat in US detention centers as tools of deterrence, exposed to a global pandemic and separated forcibly from their children. It has been devastating in recent years to witness the emotional impact on children, their fear and the inevitable psychic internalization of being socially and morally marginalized.

Ambiguous US asylum policy, and rumors of increased border porosity, typically draw people north. For the moment migration numbers are down, a response to policy changes on both sides of the border;[3] but climate change will inevitably accelerate these flows in the years to come. Northward migration in this part of the world is typically understood as a function of violence and poverty, and of course this is true. But climate change is a "threat multiplier." It makes poverty and food insecurity worse, aggravates violence, and ultimately compounds the reasons why people take the risk, leave their homes and walk north.[4]

[3] "Migrant encounters at U.S.-Mexico border have fallen sharply in 2024," John Gramlich, Pew Research Center, October 1, 2024.

[4] "Climate of Coercion: Environmental and other drivers of Cross-Border Displacement in Central America and Mexico," U.S. Committee for Refugees and Immigrants, International Refugee Assistance Project, and Human Security Initiative, March 2023.

Geopolitical preliminaries

Three geopolitical remarks before introducing our work:

First, international agencies do not see climate migrants as refugees. They are defined as economic migrants who are drawn toward a better life. What this means is that they are not entitled to asylum or international refugee protection under the Geneva convention. By mid-century, climate change is projected to displace millions, as many as one billion people.[5] Our commitment to planetary climate resilience must include serious and central attention to seismic demographic shifts already taking place across our planet. We need to rethink the category of "refugee," as well as retool and reaffirm our commitments to interstate cooperation around asylum protection for those forced to migrate within and across national boundaries.

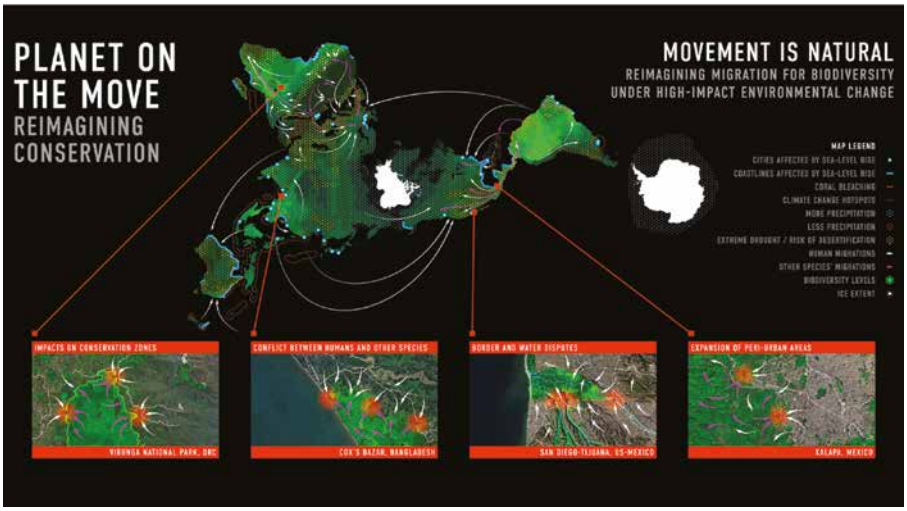

Figure 1. Planet on the Move, Estudio Teddy Cruz + Fonna Forman, 2021. An infographic developed for the International Union for the Conservation of Nature to illustrate global hot zones where climate change is intensifying the clash between migration and ecosystem protection. The need for cooperative planning is urgent.[6]

[5] Fonna Forman and Veerabhadran Ramanathan, "Climate Change, Mass Migration and Sustainability: A Probabilistic Case for Urgent Action," *Humanitarianism and Mass Migration*, ed. Marcelo Suárez-Orozco, pp. 43-59. Oakland, CA: University of California Press, 2018.

[6] *Planet on the Move: The Implications of Migration and Environmental Change on Conservation and Conflict*, Commission on Environmental, Economic and Social Policy (CEESP), International Union for Conservation of Nature (IUCN), 2021.

Second, we need to rethink our language. Well-intentioned people often refer to waves of northward migration as "caravans" or "convoys" where the human struggle is grasped in its magnitude from above. When depicted aerially within a mass of others, the migrant loses her own story. Her reasons become invisible; her rights become easier to violate, easier to homogenize and distort into ugly political tropes about "infestation." We need to rethink our language.

Third, as climate-forced migration accelerates, there is deepening contention between the migration rights community and the conservation community – between those who advocate for migrants' rights to movement and safe resettlement, and those who prioritize protection of ecosystems, wildlife habitats and biodiversity. This clash often manifests profoundly. Our border region at San Diego-Tijuana is one of these places – an epicenter of both accelerating climate-forced migration and a hotspot for dramatic biodiversity loss.

Spaces of dignity and sanctuary at the US-Mexico border

Finding common ground – very literally, common ground – for nature and people, is our priority in the UCSD Center on Global Justice. We are a team of social scientists, urban designers, architects and engineers, environmental and public health researchers and artists, based at the University of California, San Diego. To carry out our work, we've developed a network of sanctuary spaces on both sides of the border called the *UCSD Community Stations* where we partner with border communities to build spaces of dignity and sanctuary for nature and people at the periphery of our cities, including the largest migrant sanctuary in the US-Mexico border region, which I will share in this paper.[7]

Inspired by the famous *Library Parks* project of Medellín, Colombia in the early 2000s, which we've studied and written much about,[8] we work closely

[7] For more on the UCSD Community Stations, and the ethical commitments that ground this work, see Fonna Forman and Teddy Cruz, *Socializing Architecture: Top-Down / Bottom-Up*. Cambridge: MIT Press, 2023.

[8] For discussion, see Fonna Forman and Teddy Cruz, "Global Justice at the Municipal Scale: The Case of Medellín, Colombia," pp 189-215 in *Institutional Cosmopolitanism*, ed. Luis Cabrera (New York: Oxford University Press, 2018); and Fonna Forman and Teddy Cruz, "Latin America and a New Political Leadership: Experimental Acts of Co-Existence," pp 71-90 in *Public Servants: Art and the Crisis of the Common Good*, eds. Johanna Burton, Shannon Jackson, and Dominic Wilsdon (Boston: MIT Press, 2016).

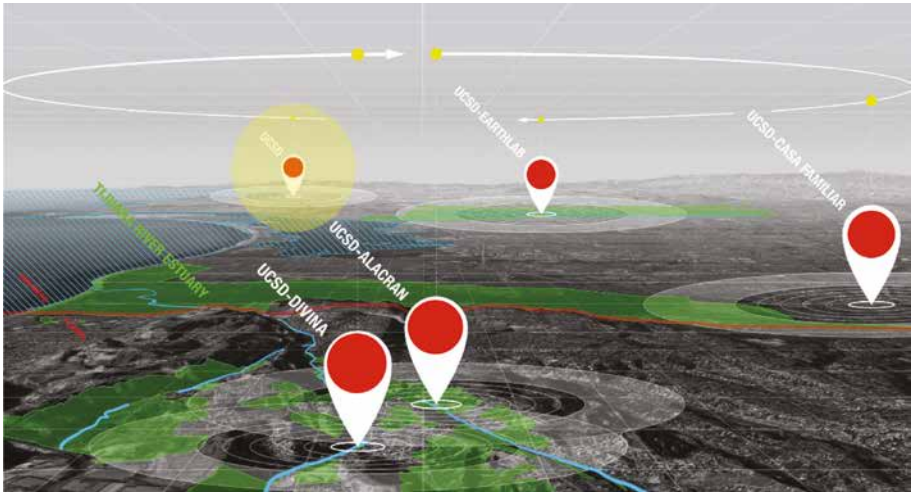

Figure 2. UCSD Community Stations, Estudio Teddy Cruz + Fonna Forman, 2017. A network of field stations on both sides of the San Diego-Tijuana border where UC San Diego researchers partner with community-based agencies to build resilience in communities at the frontlines of climate disruption, including social housing, public space and green infrastructure.

with community partners to transform urban remainders into social housing and civic spaces that are richly programmed for dialogue, collaborative research, urban pedagogy, participatory design and cultural production.

We have four stations, two on each side of the wall. Each is designed, funded, built and programmed collaboratively between our campus and a grassroots non-profit agency, and is focused on unique community-defined ecosocial priorities. Funded by the Mellon Foundation, by the Parc Foundation and David Deutsch, and by Robert Rubin and Stéphane Samuel, among others, the UCSD Community Stations are committed to a model of partnership and horizontal "co-development" and "co-production." We are keenly attuned to power dynamics when universities arrive in communities, and are critical of both extractive research methods and humanitarian problem-solving missions. Academic culture is filled with vertical assumptions that *we* know more, that *we* are trained to solve the world's problems (if only *they* would listen to us). We are committed to horizontal practices of mutual learning and co-production, engaging communities as partners with knowledges and agency. Everyone contributes, everyone learns, and we do things together in the border region, that no one could possibly do alone.

Here I will briefly share one of our four stations, the UCSD-Alacrán Community Station, located at the edges of Tijuana, B.C., Mexico.

Visualize the scene: When migrants arrive in Tijuana many land in the informal canyon settlements at the western periphery of the city. We work in the Los Laureles Canyon, immediately adjacent to the border wall and home now to 100,000 people. Sitting just 30 minutes from our San Diego campus, Laureles demonstrates the dramatic proximity of wealth and extreme poverty in this border region. Laureles is impacted by drastic erosion, flooding and landslides exacerbated by the dramatic precipitation fluctuations of climate change, and the informal building practices of arriving migrants. Laureles, sitting at a higher elevation than the US, is encrusted with open dumpsites and lacks water and waste management, so much of the trash, and tons of sediment, is siphoned northward through sewage drains carved into the borderwall by US Homeland Security. It all ends up on the US side in a precious and protected federal estuary, the Tijuana River National Estuarine Research Reserve. It is a hot mess, and illustrates profound conflicts between political and ecological systems, and a stunning lack of collaboration between the United States and Mexico to tackle shared challenges.

Enter the University of California, San Diego. We have assembled a binational coalition of nonprofits and universities, state and municipal agencies, to identify and protect unsquatted parcels in the settlement with nature-based green infrastructure. *The Cross-Border Commons,* as we call it, is a binational conservancy that links the informal settlement in Mexico with the US Estuary, forming a continuous ecosocial envelope, a "sponge,"[9] that transgresses the wall and protects the environmental systems shared by both sides.

Our UCSD-Alacrán Community Station is located in one of these conservation islands, in the most precarious and polluted sub-basin of the Laureles canyon. It is a partnership with Embajadores de Jesús, a Christian organization led by activist pastor Gustavo Banda, that built a refugee camp in the canyon for hundreds, and over time thousands, of Central American and Haitian migrants navigating prolonged asylum processes in the US and Mexico. What began as a warehouse single structure evolved incrementally into a collection of informal housing units of varying sizes and configurations, threaded into impossible canyon topography.

[9] Kongjian Yu, "Sponge Planet," presented at the Joint Summit, *From Climate Crisis to Climate Resilience*, Pontifical Academies, Casina Pio IV, Vatican City, 15-17 May 2024.

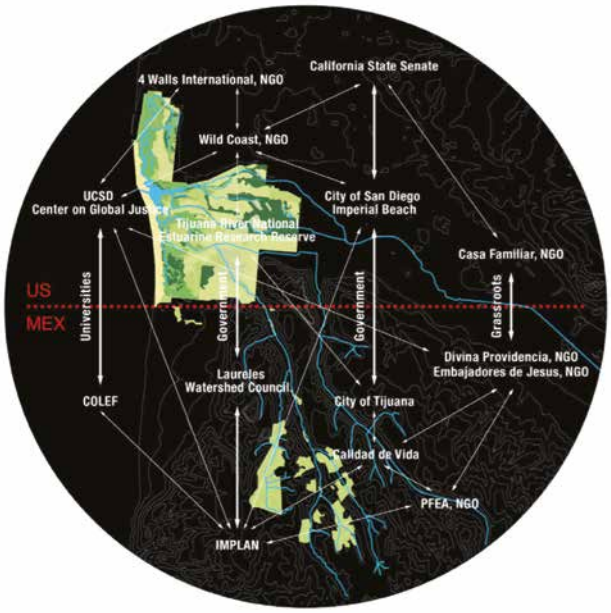

Figure 3. Cross-Border Commons, Estudio Teddy Cruz + Fonna Forman, 2020. A cross-sector coalition convened to steward a binational land conservancy that protect ecosocial systems on both sides of the wall.

When we met in 2018, Embajadores was receiving no formal institutional support or public subsidy, but they were rich in social capital. A cohesive core of migrant men and women were already dedicated to the life and future of the sanctuary, and through their sweat equity over time had asserted a sense of collective ownership of the spaces. Soon after meeting, we resolved to join forces to increase shelter capacity. Our work together began with envisioning future scenarios, which focused on increasing housing capacity, and more fundamentally, how the sanctuary could evolve into a more holistic and solidified home for migrant families who wished to stay.

In our Tijuana work we often approach and negotiate with local factories to subsidize building materials. Multinational factories in Tijuana, or maquiladoras, typically situate themselves strategically near the zones where migrants land, to benefit from easy access to cheap labor. So we knock on the door and propose an ethical loop where the factory might consider investing in the informal housing of their workers. Some are receptive, and they agree to work with us, to test ways we can utilize their materials to

Figure 4. Here, a team of migrant residents skilled in welding and construction install the blue and orange Mecalux metal frames as roofing systems on Santuario Frontera. Photo: UC San Diego Center on Global Justice.

support local housing practices. For the housing expansion we envisioned in Alacrán, we were fortunate to find a kind and receptive CEO at Mecalux, a Spanish maquiladora that produces large metal shelving systems that are exported across the world to shelve inventory in big-box stores. We worked closely with Mecalux engineers to design a prototype that retrofitted their prefabricated parts into structural scaffolds to support migrant housing.

Santuario Frontera broke ground in 2022. The site now houses 2000 people, and has become the largest migrant sanctuary in the US-Mexico border region. Once completed the site will accommodate an additional 2500 people, though a combination of dormitory spaces and family units for women and children. The site includes spaces for vocational training, fabrication and small-scale economic development, including a resident-owned construction cooperative that is building out this site, and will remain intact for future jobs to circle income back into the community. In addition, we have been committed to healing the site's topography to reduce erosion, hydro-filtration channels, gabions, terracing, native planting, pervious paving and water collection systems to demonstrate that migrant housing need not compromise, but can actually help restore local habitat. The project was

Figure 5. Santuario Frontera, Estudio Teddy Cruz + Fonna Forman, Tijuana BC, Mexico, 2023. A community performance with Little Amal, the 14-foot puppet of a Syrian refugee girl walking across the world.

profiled in the *New York Times* for its unconventional development model,[10] and in Bloomberg for our focus on longer-term habitation, social inclusion, community well-being, ecological restoration and generating jobs.[11]

With so much momentum, we are now transforming the site into a full-on sanctuary neighborhood, with social services, a hydroponics farm, an industrial kitchen, and this summer a health clinic with a consortium of regional medical schools. The state of Baja California has subsidized an elementary and middle school on site, a huge victory. There is no more effective method for integrating children into the life of a community.

Moreover, the municipality of Tijuana has just paved the road into the site, helping to regularize essential transport needs in this flood zone, even collaborating with us to minimize concrete and reduce ambient heat, by combining the grey infrastructure with hydrofiltration systems and native planting to manage erosion and runoff. These blue-green strategies provide

[10] "A Sanctuary Takes Shape, Framed Around Migrants," Alastair Gordon, *New York Times*, September 2, 2021.

[11] "Also Migrating From Latin America: A Wave of Urban Innovation," Linda Baker, *Bloomberg*, April 30, 2024.

an alternative to conventional concrete channelization strategies in slums across the world, and connect alternative water management approaches with habitat restoration, urban revegetation and adaptive green-infrastructures, to mitigate the impacts of flood and heat on this precarious site.

When migrants first arrive, they have immediate needs of food and water, medicine and shelter – urgent needs of the body. Responding to these needs is the proper, charitable response of an ethical society. But charity is not the appropriate model for building an inclusive society. Migrants need to be integrated into the civic, social and economic life of the city. Staying needs to be an option, needs to be a right. In an era of escalating climate migration, we need to evolve from hospitality thinking to inclusion thinking.

While Santuario Frontera is obviously the product of unique and fortunate convergence of committed partnerships in a particular place, we see the project as a translatable model of local collaboration between a public university, a faith-based organization, and a multinational factory. Not every research university has capacities to mobilize physical infrastructure and urban interventions (though many surely do); but we believe every research university has the social capital and leverage to help assemble regional coalitions to support climate migrants and cultivate a local civic sensibility of inclusive resilience.

Local collaboration across walls

I close with a note about collaborating locally across an international border as the migration crisis inevitably accelerates. Despite the wall and the ugly political rhetoric designed to divide us, San Diego-Tijuana is a binational ecology of flows and circulation, and our future here is intertwined. Air, water, waste, health, culture, money, hope, love, justice – these things don't stop at walls. Borders zones are unrelentingly porous places.

Ultimately, we are engaged in a cultural project here: to change broader public perceptions and beliefs about interdependence across this border. We want to cultivate a sense of belonging that is oriented not by the nation-state or the documents in one's pocket, but by the shared interests and aspirations among people who inhabit a violently disrupted civic space. So we curate "unwalling experiments" that dissolve the wall – using visual tools and radical cartographies to re-imagine ecosocial interdependence and cooperation beyond walls of all kinds.

Several years ago, we curated a cross-border cultural action through one of the sewage drains that the US had carved into the wall, between Laure-

les Canyon and the Tijuana River Estuary. We negotiated a permit with Homeland Security to transform the drain into an official port of entry southbound for twenty-four hours. They agreed, disarmed by our self-description as "just artists," as long as Mexican immigration officials were waiting on the other side to stamp our passports. Our convoy was comprised of 300 local activists, representatives from both municipalities, and border activists from around the world. As we moved together southbound under the wall, we witnessed slum wastewater and plastics rushing northward toward the Estuary beneath our feet. This strange crossing visualized the profound conflicts and interdependencies of our border region. The great take-away was that protecting the vulnerable US Estuary demands shared investment in the informal Mexican settlement. Climate resilience strategies in border zones cannot stop at walls, even though urban planning maps and budgets on both sides of the wall typically do.

In this cultural experiment we "went down" to un-wall the territory; but sometimes cultivating a cross-border civic sensibility demands "ascending up". Imagine a migrant child standing on a narrow sliver of land hundreds of feet above the borderwall, facing due west – with the blue Pacific Ocean in front of her, Mexico to her left, the US to her right. Below to her immediate left she sees the dense informal settlement where she now lives; and its proximity to a country she and her family are not permitted to enter. Below to her immediate right, almost directly beneath her feet, she sees the borderwall which, from this vantage, looks like a flimsy and ridiculous strip inserted onto a vast and powerful natural system. Lifting her eyes, she sees the green expanse of the Tijuana River Estuary with its vulnerable wetland habitats encrusted with waste. And further beyond still, downtown San Diego rises vertically into the sky. This is a real spot in Tijuana, a promontory called Mirador. From this vantage all the characters of this contested zone come to life. We've witnessed this moment of recognition again and again over the years. There are few places on earth where the collision of informality, militarization, environmental vulnerability, and the proximity of wealth and poverty, can be so vividly experienced.

Nevertheless, the conflicts we experience locally *between nation and nature* are reproduced again and again along the entire trajectory of the continental border between the US and Mexico, illustrating powerfully what dumb nineteenth-century sovereignty looks like when its "hits the ground" in a complex bioregion. Our *MEXUS* map re-imagines this continental border zone without line. MEXUS dissolves the border into a bioregion whose

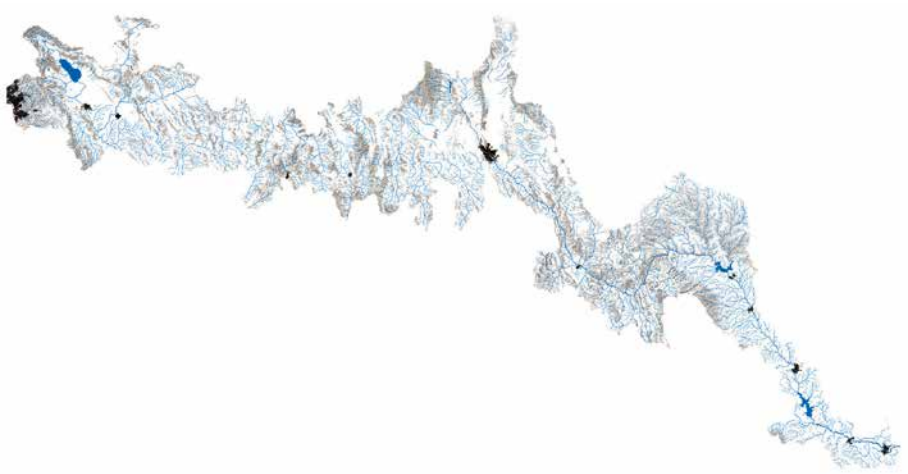

Figure 6. MEXUS: Geographies of Interdependence, Estudio Teddy Cruz + Fonna Forman, 2017. Reimagining the jurisdictional line between the United States and Mexico as a continental system of binational watersheds.

shape is defined by the eight binational watershed systems bisected by the wall. *MEXUS* also exposes other systems and flows across this bioregional territory: tribal nations, protected lands, croplands, urban crossings, many more informal ones, 15 million people, and more. Ultimately MEXUS counters America's wall-building fantasies with more expansive imaginaries of belonging and cooperation beyond the nation-state.

Stretching to the global scale, I conclude with a visualization project we call *The Political Equator* which traces an imaginary line from San Diego-Tijuana across the planet forming a corridor of global conflict between the 30th and 38th parallels north. Along this trajectory lie some of the world's most contested and violent thresholds. The US-Mexico border at San Diego/Tijuana, the busiest land crossing in the western hemisphere; the Strait of Gibraltar and the Mediterranean, the main routes from North Africa into "Fortress Europe"; the Israeli-Palestinian border, a cauldron of burning injustice that has exploded once again in the most horrific way; India/Kashmir, a site of persistent territorial conflict since British partition; the border between North and South Korea, representing decades of intractable Cold War conflict; and China's accelerating militarization of the South China Sea.

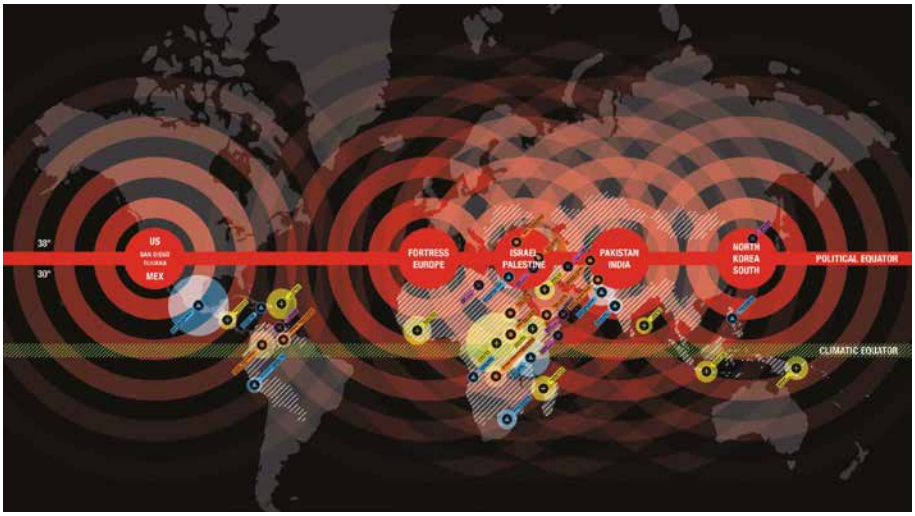

Figure 7. The Political Equator, Estudio Teddy Cruz + Fonna Forman, 2017. A corridor of global conflict between the 30th and 38th parallels north.

Visualizing the *Political Equator* in red alongside the climatic equator below in green was an astonishing discovery for us, because the ribbon in-between them, give or take a few degrees, contains our planet's most populous slums, its sites of greatest natural resource extraction and export; and its zones of greatest political instability, climate vulnerability and human displacement.

In the end, the collision of nationalism and border building, climate catastrophe and the dramatic movement of peoples is the global injustice trifecta of our time. But as I said at the beginning, these dynamics always hit the ground somewhere… and are experienced by people locally, in everyday places. From a resilience perspective, there is great hope in this. It may take years for migration projections to be validated, for broader cooperation to be solidified. But we don't have to wait. We can respond locally right now, from the bottom-up, when climate migrants arrive at our borders, and in our cities.

YOUTUBE PRESENTATION

Impact of Climate Change on Women and Children

Dr. Soumya Swaminathan
Chairperson, M.S. Swaminathan Research Foundation, Chennai

https://youtu.be/EohBy_r8Aj8?si=RH339wdnmle83zZW

SESSION X – SOCIAL TIPPING POINTS: ETHICS AND EQUITY

The Demands of Justice in the Context of Climate Change

Vittorio Hösle
PASS Academician, Notre Dame University

I.

The *causes* and the direct and indirect *consequences* of man-induced climate change, which is only one, but one of the most threatening of the various ecological dangers facing us, must be treated by the empirical sciences, and in fact by a still quite rare cooperation of the natural and social sciences. These sciences cannot treat the issue in separation, for the natural processes that lead to climate change are the topic of the natural sciences. But since many of these natural processes are triggered by human behavior, we need the social sciences in order to predict or at least explain such behavior and perhaps devise realistic possibilities of changing it if it leads to undesirable consequences. To give one example from the various anthropogenic factors influencing our climate: While the term "greenhouse" was applied only in 1901 by the Swedish meteorologist Nils Gustaf Ekholm to the phenomenon of greenhouses gases in a planet's atmosphere preventing it from losing heat to space,[1] the basic physical and chemical ideas go back to studies written by Joseph Fourier, Claude Pouillet, Eunice Newton Foot, and John Tyndall from the 1820s to the 1850s. In 1896 the Swedish physical chemist and later Nobel laureate Svante Arrhenius already calculated that a doubling of atmospheric carbon dioxide (CO_2) would lead to a rise of the global temperature by 5-6° Celsius.[2] This was an astonishing scientific achievement, even if Arrhenius still ignored several relevant variables. Arrhenius, however, was not worried about the prospect. For he underrated the speed of man-induced increase, and he thought that the greenhouse effect would be more beneficial than detrimental to humanity: It would avert the danger

[1] "On the Variations of the Climate of the Geological and Historical Past and their Causes", *Quarterly Journal of the Royal Meteorological Society* 27 (117), 1-62.

[2] Arrhenius' essay appeared in 1896 in German in Sweden and shortly afterwards in English translation: "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground," *Philosophical Magazine and Journal of Science* (fifth series), vol. 41, April 1896, 237-276. See http://www.rsc.org/images/Arrhenius1896_tcm18-173546.pdf

of a new ice-age and bring better climate to the Northern parts of the earth, where he himself lived. "The enormous combustion of coal by our industrial establishments suffices to increase the percentage of carbon dioxide in the air to a perceptible degree… As in every other case, there is good mixed with the evil. By the influence of the increasing percentage of carbonic acid in the atmosphere, we may hope to enjoy ages with more equable and better climates, especially as regards the colder regions of the earth, ages when the earth will bring forth much more abundant crops than at present, for the benefit of rapidly propagating mankind".[3]

What strikes most modern readers in Arrhenius's remarks is the combination of extraordinary acumen in physics and chemistry, lack of ecological and economic knowledge, and ethical naiveté. He does not consider, for example, that the rapid propagation of humankind as well as the growth of their needs would dramatically increase the combustion of coal, and while it might have been rational then to assume that the man-induced greenhouse effect could benefit Scandinavia, there was no reason to believe that the rise of temperatures in equatorial areas could be beneficial for agriculture there. Arrhenius's evaluation is clearly "Scandinavia-centric".

The quote from Arrhenius shows that the main reason for the actual situation, which is not unlikely to transform our planet into a partially uninhabitable place within the end of this century,[4] was not lack of knowledge. Many of the dangers confronting us have been known for decades to scientists and could certainly have been explored more in depth and communicated to a broader public much earlier if there had been a political will. Why was there none? The answer that brutal economic interests[5] hid the truth is certainly not wrong but it is unilateral – unlike in the case of the tobacco industry, the forces supporting the combustion of fossil resources were an integral part of the project of modernization that since the industrial revolution of the 18th century has radically transformed our value system, our social institutions, and in this process nature, too. The desire to subject nature completely to human needs has been traced to the divine empowerment of Genesis 1,28 but this is a remote ancestor that for

[3] *The Evolution of the Universe* (Swedish original 1906), Harper & Brothers: New York/London 1908, 61-63.

[4] See David Wallace-Wells, *The Uninhabitable Earth. A Story of the Future*, Tim Duggan Books: New York 2019.

[5] See Naomi Oreskes/Erik M. Conway, *Merchants of Doubt*, Bloomsbury: London 2010.

almost two millennia did not trigger any of the consequences ascribed to it. For even in monotheism, although perhaps to a lesser degree than in the pantheistic polytheism of the pagan world, nature, being God's creation, partakes in a holiness the awe for which has proved to be one of the most powerful inhibitors of human conduct.[6] We needed the replacement of this awe by a restless desire for new consumerist goods – a desire whipped up by modern technologies of advertising and manipulation – in order to get where we are.[7]

It is, first, the disappearance of this awe, second, Descartes's development of a new conception of humans being no longer part of nature but somehow opposed to it, and, third, the noble desire to ease human suffering, extend the human life-span, relieve the burden of hard physical work, and allow more people to enjoy commodities originally restricted to a small elite that have produced the world in which we live. Francis Bacon's *New Atlantis* already anticipates the scientific and the technological revolutions, which together with the unleashing of trade and industrial capitalism led to a self-reenforcing mechanism, further strengthened by the rise of the world market, democracy, and the welfare state. The success of a politician depends in such a system largely on economic growth, and the use of cheap energy was the easiest way to achieve such goal for the nation and re-election for oneself. For a long time, investments in fossil energies were understood as a generous renouncement of immediate consumption in order to render life smoother for future generations. Kant still considered the true problem of intergenerational justice the question on which grounds the present generations should make sacrifices for the benefit of future ones.[8]

But even after the deleterious consequences of certain investments could no longer be denied by informed and honest people, the decision to limit one's use of energy is inhibited, on the individual level, by at least three psychological factors. First, the undesirable consequences are not directly visible; and the effort of imagination requisite to fancy them is often beyond the intellectual and volitive powers of people. Second, even when this effort succeeds, the victims, such as people starving to death or forced to dangerous migrations because of extending deserts in Africa or drowning on smaller Pacific islands because of the rise of sea-water are perceived to be

[6] A great expression of this is Pope Francis' encyclical *Laudato si'*.

[7] See Ken Sayre's *Unearthed. The Economic Roots of Our Ecological Crisis*, University of Notre Dame Press: Notre Dame 2010

[8] *Idea for a Universal History from a Cosmopolitan Point of View*, Third Thesis.

far away in space and often also in time, and this did not enhance the motivation to use constraint. (The good news is that this has begun to change in the last decade in countries like Australia and the USA, for harm hits now closer to home.) Third, it is never my single individual contribution that triggers those consequences but collective behavior; and if I am the only one who renounces a certain good, while others continue to enjoy it, I will be worse off, while no real benefit will accrue to humanity at large, since others will step in for me. This is the well-known tragedy of the commons.[9]

Beyond this psychological level, the three most prestigious social institutions of the modern world, sovereignty of states, market economy, and democracy, have proven, if not hostile, at least not conducive to the solution of the problem of limiting climate change. As just said, often the destructive consequences of one's behavior do not hit oneself but people far away; and if these people are beyond the borders of a political unit, there is no easy mechanism to enforce a change, neither in the domestic political process nor in international law.[10] But how about a country's own citizens? As long as they are not yet born or at least not adults, it would be naive to assume that the market or the democratic process guarantee their rights. A true market (which must be defended by law against the formation of monopolies and oligopolies) is, on the whole, the most efficient mechanism to achieve an equilibrium of supply and demand *for those who have purchasing power* – but future generations do not have such power, and they do not have voting rights. *Nobody represents them*. It is therefore not at all surprising that we have not succeeded in institutionalizing justice between generations and between nations to the same degree that has been achieved with regard to justice between classes. Finally, it has to be mentioned that even among those who will in all likelihood be hit by the disastrous consequences of climate change denial is not rare. Human inertia plays an important role, since the social appreciation of certain activities is particularly hard to change – people do not like to acknowledge that what they and their parents cherished in the past, such as SUVs or expensive travels, was morally wrong. Furthermore, the complexity of the science involved and the

[9] See Garett Hardin, "The Tragedy of the Commons," *Science* 162 (3859), 1243-1248, who focused on unregulated population growth.

[10] It suffices to point to paragraph 52 of Draft Decision -/CP. 21 of the 2015 Paris Agreement within the UNFCCC: "Article 8 of the Agreement does not involve or provide a basis for any liability or compensation".

decline of the trust in authorities of all kinds, including that of scientists, give denial of the facts an easy excuse.[11]

II.

But while all this explains the enormous difficulties that we have in implementing intergenerational justice (which, of course is not limited to climate justice but represents a much broader concept), it does not change the fact that a behavior that creates considerable, probably enormous harm to people far away in space and/or time is gravely unjust, even if it satisfies immediate interests of the agents. It is impossible to reduce justice to an equilibrium between selfish interests. True enough, people may agree about Pareto improvements based on purely selfish interests if they are not yet in a Pareto-optimal situation; but it would be morally absurd to claim that only such moves are morally required. For the most horrific injustices may well be Pareto-optimal. The basic principle of any acceptable moral theory is the recognition of the demands of justice as something irreducible to one's own interests. *Justice demands the equal treatment of people and the recognition of the universality of norms, be they entitlements or prohibitions*. Deviations from this principle are inevitable in a differentiated society; but they must be shown to be in the common interest. On the basis of such a universalist ethics, it is clear that harming the life, health, property, and freedom of people spatially and temporally distant for the satisfaction of fleeting desires is immoral – even if one has to grant that the status of future generations entails complex ontological questions that do not concern contemporary, only spatially distant people. The focus on demands of justice toward other persons does not exclude that there is *intrinsic value in non-human entities, particularly organisms and ecosystems,* a value that is not reducible to their instrumental value for human purposes. (A value does not lose its intrinsic nature if one holds the position that the recognition of such values enriches also the life of humans).[12] But it is impossible to deny that in the case of conflict between a human and an animal life, the first, while not the only value, trumps the

[11] See my essay "Causes and Consequences of the Destruction of the Belief in the Attainability of Truth: Philosophical Reflections with a Historical Example," *Filozofia* 79 (2024), 113-132.

[12] For comprehensive ethical discussions, see Holmes Rolston, III, *Environmental Ethics*, Temple University Press: Philadelphia, PA 1988 and Robin Attfield, *Environmental Ethics*, John Wiley: Hoboken, 2014.

latter, since only humans can be moral agents. And in political discussions it is probably wise to focus on justice between humans for the simple reason that a general agreement on this issue is more easily achieved – but not for the reason that in the Western tradition the recognition of such an intrinsic value is less developed than in the Asian religions.

While the idea of justice is irreducible to selfish interests, human nature is so deeply flawed that it is morally imperative to render moral behavior on the whole compatible with individual interests. While morality will always ask for some form of self-sacrifice, we have to create economic, legal, and political systems in which the moral person does not become the victim and the immoral one the successful usufructuary. There must be disincentives to immoral acts, and while such disincentives are not limited to punishment, coercion is crucial to protect the basic norms. Just law is the system of norms rightly enforced by public authority. The trust in the social reality of fundamental moral norms is necessary to keep even decent people law-abiding; for few want to be the lonely fool who respects rules at a high personal price when others are deviating from them. *The tragedy of the commons cannot be overcome without a reliable mechanism of negative sanctions against those who break the laws*. Thus, the transformation of our morality into an attitude that accepts responsibility for the remote consequences of our behavior must be accompanied by far-reaching legal reforms. While in such a new system there will be a better balance between rational egoism and universal welfare, the process of changing the system in this direction will inevitably hurt many interests and thus provoke stubborn resistance. Historical experience shows that such processes of transformation are more likely to be successful if they are based both on moral passion and emergent interests connected to the change. Abolitionism was inspired by sincere outrage at the horror of slavery – but it would be disingenuous to deny that the expected increase of cheap labor was a powerful motive for Northern industrialists too. Analogously, wise politicians must point both to the great injustice connected to climate change, which will hit most those who have least contributed to it, and garner the support of those green capitalists investing in sustainable energies.

But what are the main institutional changes that moral policies have to bring about?[13] I want to quickly mention changes in our concepts of prop-

[13] For a systematic overview of a doctrine of natural law that takes account of the ecological problem, see my book: *Morals and Politics*, Notre Dame: University of Notre Dame Press, 2004 (German original 1997).

erty, liability, taxes, and constitutional and international arrangements. The central idea from the point of view of a universalist ethics can only be that both the use of resources and the emission of pollutants must be capped to a level that allows future generations to enjoy the same rights that the current generation is reaping the benefits of. While differentiations in property are just and inevitable as an incentive for work, it is hard to accept the idea that natural capital can become absolute property of a person or a generation – for unwrought natural capital is not made by human labor, the source of legitimate private property, but antecedes it. In the case of renewable resources, such as wood or fisheries, *there can be no right*, either of an individual or of a whole generation*, to use the capital stock up* – they can only harvest the "interests". In the case of non-renewable resources, the argument does not work; for it would prevent any generation from using them, while a reasonable limitation is directed towards rendering such use possible for as many generations as possible. One will have to posit that the use of such resources must be compensated for by investments in alternative resources, which must increase the scarcer the first resource gets. Concerning the pollution rights, the cap of the acceptable global amount should be divided by the number of persons existing, each being entitled to the same "environmental space". In order to avoid creating an incentive to further demographic growth, the UN should grant to the different countries the amount corresponding to the number of their inhabitants for a few decades so that countries may not be induced to policies fostering population growth. Rights to pollution should be tradeable in order to increase efficiency of allocation.

In order to facilitate the transition to a *closed-loop economy*, it is reasonable to conceive buying an environmentally problematic product as a mere buying of the *use* of the product. Thus, when it does not work anymore, the producers should be obliged to take it back since they are most familiar with the ingredients and best knows how to reutilize them. Whoever causes pollution, must be liable for it and pay appropriate compensation also in international courts – of course in the hope that this legal threat will lead to the prevention of future pollution. Concerning the problem that most ecological disasters are caused by a complex web of agents, the answer can only be that institutions who contribute to ecological damage have to pay into a compensation fund according to the quota to which their activities have contributed to such damage. There will be doubtless difficulties in determining such partial contributions; but even a rough demarcation would

be widely better than letting institutions off the hook that share responsibility. And while for a large institution a very high civil penalty is often a greater deterrent than criminal punishments, we need also an expansion of criminal law in order to protect the environment.

All this shows that what we need is not so much a radical transformation of our legal system as an intelligent further development of its toolkit. This holds also for the economy, an area that is only at a superficial level opposed to ecology – for both share a concern with scarcity and are subject to the imperative of efficient use of scarce resources. While the theoretical and empirical arguments for the superior allocation efficiency achieved by markets when compared with command economies are strong, it always depends on the legal framework whether the desirable outcomes of markets are achieved or whether the externalization of costs proliferates, as in all cases of environmental destruction. One has to distinguish sharply between two theories of the market: The one teaches that fair and free competition within a certain framework has to be accepted because it benefits society at large; the other claims that economic agents have an absolute freedom to engage in activities they think will maximize their profit whatever the costs for others. Such agents quickly understand that they can multiply their profits if they can influence legislation to change the rules of the game, for example by allowing them to externalize even more costs on others, like people far away or future generations. It does not help here to appeal to the Coase theorem and claim that bargaining leads to higher efficiency than compensatory Pigouvian taxation. For not only does the theorem ignore the question of just distribution, it presupposes that there are no transaction costs, which is almost never the case – and in the case of future generations there is not even a bargaining partner to begin with. Rightly understood, *ecotaxes* are no imposition from a state that does violence to individuals – such taxes not only diminish the use of scarce or harmful resources but somehow represent the demand or compensation claims of future generations, which would inevitably drive the prices up if they already existed.

On the constitutional level, I think that we need a new organ with high scientific expertise that *represents further generations* – either as a part of the legislative or, in countries with a constitutional court, as part of the judicial power when it comes to the decision whether certain laws violate basic rights of future citizens, which should be guaranteed by every constitution. And internationally we will have to move toward an Environmental Council that complements the work of the Security Council in determining the

basic environmental goals of humanity at large. All these are ambitious projects, and it will take decades to realize them. But if we do not modify our institutions in such direction, it is not unlikely that the Baconian project will prove not a blessing but the prelude to the greatest catastrophe in human history.

Transformation Policies for Climate Change – Why Mitigation and Adaptation Policies Are Not Sufficient

Stefano Zamagni
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1. Introduction

Growth is the funding myth of capitalist market society, without which the entire system would collapse: we must believe in the gospel of growth, in its myth. Growth is therefore the pillar of the modern economicist religion: an ideology is debatable, a faith is not. The term growth – not to be confused with development – as we conceive it today, is a metaphor of a natural process applied to social phenomena, as if what is true of one must necessarily be true of the others. The naturalistic metaphor is deformed for the authors' use: any natural organism is born, grows until it reaches a climax, and then inevitably begins to decline until it irrevocably ends its life. This last part, however, is forgotten in the transposition of the metaphor from nature to society. Growth, thus conceived, never ends. Rather than the Anthropocene, we should therefore speak of the Novocene, since not all *anthropoi* have contributed equally to the degradation of the planet. It is the rich world that bears the main responsibility. This myth has also led to what Amitay Gosh has called 'the great blindness', the inability to foresee a future. This was evident at the beginning of the pandemic: it only took two weeks of shutdown to bring the entire world economy to its knees and demonstrate its fragility.

What is to be done? It is late, perhaps, but not quite. 'Our thinking small does not serve the world,' said Nelson Mandela. We need to be able to think big, like the builders of the great cathedrals. None of them ever saw the end of the work they had planned, yet they did. They thought of a future even without them: it was the cathedral that was important, that lasted. And if today we can enjoy such beauty, it is because someone was able to look beyond and think not only of themselves, but of those who came after. Inspired by those masters today means setting in motion studies, practices, struggles against environmental degradation, against the loss of biodiversity, against the social and economic entropy of growth models that create chronic ine-

qualities and unjust privileges. It is a path that requires urgency and patience at the same time, research in the field, cultural and political action, clear and shared objectives, first and foremost on common goods. A sort of 'Factory of the World', understood as a common good, must be born.

We must then rediscover and reintroduce at the centre of our discourse that word now expunged from every political lexicon which is fraternal solidarity by extending it to all the components of the planet. Concretely, this implies that in addition to the necessary mitigation policies and adaptation policies, we should start thinking about real transformation policies. Mitigation policies aim at the progressive elimination of anthropogenic factors that produce the earth's temperature increase, thereby reducing climate risks (i.e. bending the warming curve down with the adoption of nature-based solutions). On the other hand, adaptation policies aim to protect health, human society and the natural environment from the impacts of climate pressures on them. In other words, such policies tend to reduce exposure and vulnerability to unavoidable climate risks by enhancing adaptive capacity. All this remains valid and therefore necessary, but not sufficient. The time has come to take into serious consideration transformation policies, whose ultimate target is to modify life styles; to enact mass education in ecological citizenship; to actively involve civil society organisations; to enhance a major engagement of science, both natural sciences and socio-economic sciences; updating and modifying the institutional architecture of our market economics. The conclusions of the IPCC Report (*Climate Change*, 2022, CUP, Cambridge, 2022) warrant the urgency to implement transformation policies, as the following pages will document and elaborate.

2. Explaining the substantial failure of COP Conferences

The many COP Conferences fell somewhat short of what it was to be expected for a plurality of reasons. One of the most relevant of these was the lack of trust that has burdened global climate negotiations since COP1 (Berlin, 1995). Developing countries regard climate change as a crisis whose main responsibility falls on developed countries, which failed to honour their promise – dating from COP15 in 2009 – to mobilise $100 BLs per year for fair burden shoring in favour of the weakest countries. This fund could be financed by adopting the Global Carbon Incentive proposed by Raghuram Rajan (*Project Syndicate*, 31 May, 2021), which envisages a contribution to be imposed on countries that emit more than the world average (more than 5 euros per capita) and to finance countries with below-average

emissions. The poorest countries could then be helped to ensure a green transition that is not only effective, but also fair.

A second reason of the partial failure of COPs is the disconnection between climate models and macroeconomic models. Up to now, fiscal policies have been based on the assumption that the costs of climate damages would appear in an uncertain future, and should undergo a cost-benefit type of analysis, whereas the costs of transformation are now. This brings to underestimate the damages of extreme events and also the long-run benefits of climate policies. It would be expected that COPs would have advanced a radical revision of the principles and models utilised up to now to direct the choices of policy-makers. We urgently a 'green golden rule', where by public investments for the transition do not contribute to the creation of so-called 'bad' public debt.

Third. Economists generally agree that the way to reduce greenhouse-gas GHG emissions is to tax them. But such taxes almost certainly will cause disruptive economic changes in the short run, which is why discussions of imposing them tend to run quickly into free-rider or fairness problems. For example, industrialised countries are concerned that while they work hard to reduce emissions, developing countries will keep pumping them out with abandon. But at the same time, developing countries point out that there is profound inequity in asking a country that emitted a little amount of carbon dioxide per capita to bear the same burden of advanced countries. The least costly way to reduce global emissions would be to give every country similar incentives. But each country will want to reduce emissions in its own way – some through taxation, others through regulation. The question, then, is how to balance national-level priorities with global needs so that we can save the one world we have.

Fourth. Designing policy for climate change requires analyses which integrate the interrelationship between the economy and the environment. However, much of the standard economic modelling – including the celebrated Integrated Assessment Models – does not embody key aspects of the problem at hand. As J. Stiglitz and N. Stern ("The social cost of carbon, risk, distribution, market failures: an alternative approach", NBER, Feb. 2021) have indicated, there are fundamental flaws in the methodologies commonly used to assess climate policy, showing systematic biases, with costs of climate action overestimated and benefits underestimated. The consequences are that using Integrated Assessment Models, with their choice of calibration, has lodged policy makers to conclude that societal optimisation entails accepting

an increase in temperature of almost 4°C, while the upper limit was set at 2°C already at the Paris Conference (2015). The many COP Conference should have underlined such a serious inconsistency and should have announced the constitution of a Global Working Group charged with the task of advancing an alternative methodology to directs the choice of policy-makers.

It is a fact that the most important economic models of climate change produce climate dynamics inconsistent with the current crop of models in climate science. First, most economic models exhibit far too long a delay between an impulse of CO_2 emissions and warming. Second, few economic models incorporate positive feedbacks in the carbon cycle, whereby carbon sinks remove less CO_2 from the atmosphere, the more CO_2 they have already removed cumulatively, and the higher is temperature. These inconsistencies affect economic prescriptions to abate CO_2 emissions. Controlling for how the economy is represented, different climate models result in significantly different optimal CO_2 emissions. A long delay between emissions and warming leads to optimal carbon prices that are too low and too much sensitivity of optimal carbon prices to the discount rate. Omitting positive carbon cycle feedbacks also leads to optimal carbon prices that are too low. So it is important for policy purposes to bring economic models in line with the state of the art in climate science. (See F. van der Ploeg, "Are economists getting climate dynamics right and does it matter?", CESifo, 8122, Feb. 2020).

To conclude. Economic models of climate change are out of line with the state of the art in climate science. We therefore recommend the climate modules in economic models be replaced. Models of the carbon cycle need to incorporate positive feedback effects, as suggested by R. Millar et al., "A modified impulse-response representation of the global near-surface air temperature and atmospheric concentration response to carbon dioxide emissions", *Atmospheric Chemistry and Physics,* 2017, 11. Models of temperature dynamics need to either be replaced or recalibrated so that they can reproduce the fast temperature response of Earth System models to CO2 emissions, as the model of O. Geoffrey et al. ("Transient climate response in a two-layer energy-balance model", *Journal of Climate,* 2013, 26) does.

3. Transformation policies

Climate change poses major risks to natural, human, and economic systems. To limit its impact, reaching carbon neutrality by 2050 has become one of the world's most urgent priorities (Intergovernmental Panel on Cli-

mate Change (IPCC), 2022). Previous climate change assessments, including the first ECB top-down, economywide climate stress test, have shown the importance of a timely transition in order to reduce the impact of physical risks in the long term. At the same time, the 27th Conference of the Parties (COP27) in November 2022 closed with a general feeling that an orderly transition that limits the temperature increase to a maximum of 1.5°C by the end of the century is no longer feasible.

Given that the transition to a carbon neutral economy is necessary and inevitable, the paper by M. Fuchs et al. ('The road to Paris: stress testing the transition towards a net-zero economy', European Central Bank, ECB, 328, 2023), assesses the impact of three potential transition pathways on the real economy and the financial system within a short-to-medium term horizon (2023 to 2030). Under a first scenario, the *accelerated transition*, the current energy crisis would trigger a green transition starting immediately, thereby allowing our economies to reach emissions reductions by 2030 that were compatible with the +1.5°C maximum climate target by the end of the century. Under a second scenario, the *late-push transition*, recent adverse macroeconomic developments would lead to a green transition starting in 2025. It would be sufficiently intense to achieve similar emissions reductions by 2030, thanks to strong and decisive action, albeit also with higher costs than under the first scenario. Under a third scenario, the *delayed transition*, the transition would again start with a delay of three years and would be smoother, therefore being less costly. However, emissions would be on a path only compatible with a temperature increase of around +2.5°C by the end of the century. FED, ECB and OECD have recently advanced a number of models whose purpose is to assess the pros and cons associated to the three scenarios above. As argued by J. Sachs, SDGs are an investment agenda: it is critical that UN member states support a comprehensive reform of the global financial architecture. (J. Sachs et al., *Sustainable Development Report 2023*, Dublin, Dublin University Press, 2023).

The results of these exercises show that acting immediately and decisively (the accelerated transition scenario) would provide significant benefits for firms, households, and the financial system, not only by maintaining the economy on the optimal net-zero emissions path (and therefore limiting the impact of climate change), but also by rapidly reducing their energy expenses and lessening the financial risk. If the transition is further delayed, the only way to reduce emissions compatibly with net-zero targets would be to act more intensively at a later stage, with an abrupt and strong transi-

tion that would lead to a weaker economy and higher annual expected losses for the financial system over the horizon set for this exercise, and probably further down the road (the late-push transition scenario). The results also show that an orderly and smooth transition, starting with a three-year delay (the delayed transition scenario), would lead, by 2030, to risk levels comparable to those implied by an immediate and accelerated transition. However, emission reductions would clearly undershoot the policy goal of a maximum rise in temperature of 1.5°C, accelerating the impact of physical risks in the long term. (See S. Urata et al., *Sustainable Development Disciplines for Humanity: Breaking Down the 5Ps: People, Planet, Prosperity, Peace and Partnerships*, Springer Nature, 2023).

A specific point deserves a special attention. While the ecological transition is universally perceived as a need that can no longer be postponed, the Global South is driven back into the arms of fossil fuels in the name of debt. This is what the British organisation Debt Justice denounces in its report 'The debt fossil fuel trap' (London, 2023). From 2010 to 2021, the public debt of the countries of the Global South has doubled its weight on GDP, rising from 35% to 60% of their domestic product. A debt increased not only to domestic creditors, but also to foreign creditors. From 2010 to 2021 the share of public debt to foreign creditors increased by ten percentage points from 19% to 29% of the gross domestic product. The conclusion is that from 2011 to 2023 the sums disbursed by the Global South in payment of foreign debt increased by 150%, reaching unprecedented peaks. The United Nations estimates that 3.3 billion people live in countries that spend more on debt interest than on health and education. And since many of these sums have to be paid in dollars or euros because they are owed to foreign creditors, the problem for each country is not only to increase its tax revenues, but also to increase its export earnings. Some countries, by now with a good industrial apparatus, can try to push manufactured exports, but the less industrialised ones have no choice but to increase exports of natural resources including coal, gas and oil.

Roughly half of the 76 least developed countries have fossil fuels in their subsoil and are planning to extract more of them to meet their financial commitments. Moreover, among the creditors in the South there are also states and companies that, in order to protect themselves against the risk of non-payment, have provided for the possibility of being paid directly in kind through the delivery of oil or the transfer of ownership of wells held by debtor governments.

Despite multiple declarations by governments and institutions in the North that they no longer want to finance fossil fuel extraction, many continue to provide loans to open new production sites in the South. According to Debt Justice, between 2020 and 2022, the multilateral banking system, of which the World Bank is the leader, granted a total of USD 10 billion in loans for fossil fuel extraction. History will tell whether it was a bargain for the Global South to go into debt to increase fossil fuel production. But right now we can say that it is a bad deal from an environmental point of view because the increased carbon dioxide emissions that will result will worsen an already bad picture.

Without the rediscovery of genuine, unspoken solidarity, the situation will get worse and worse. For everyone. The conclusion is that in order to free the Global South from its deadly embrace with fossil fuels, and at the same time enable it to meet the challenges imposed by climate change, it is necessary to cancel its debt and support it with outright sums. This may sound like good heartedness. In reality, it is only justice joint to wisdom.

4. In defence of a World Environment Organisation.

After COP28, it is clearer than ever the top-down pledges and policies are not enough. What we need in an institutional transformation from the ground up. Indeed, the lack of adequate international environmental governance (IEG) is a result of a fundamental injustice in the current state of global governance: tremendous power and resources have been concentrated in international finance and trade without a corresponding legal and institutional authority for the environment, social concerns and human rights. The increasing power and influence of major international finance and trade institutions such as the World Bank and World Trade Organization (WTO) that took place over the course of the 1990s contrasts sharply with a weakening of the, already-lesser, UN environment and development programmes (UNEP, UNDP).

The existence of powerful international trade and financial regimes without comparable legal and institutional structures for social and environmental standards allows the World Trade Organisation (WTO) to act as the *de facto* arbiter on environmental issues. However, the WTO is an institution that not only lacks a core competency on environmental issues and policy, but views the environment as a commodity to be exploited rather than a resource requiring management and conservation. The result is that environmental social and human rights issues, treaties and commitments are

trumped by finance and trade interests. Rather, it should be the case that these considerations get prioritised ahead of finance and trade. (W. Pace, V. Clarke, 'The case for a World Environment Organisation', *The Federalist Debate*, 1, 2003), The governance of a Common Good cannot but be a common governance, in the sense of Elinor Ostrom.

Exactly for this reason, I believe one response for international environmental governance is to create a World Environment Organisation (WEO) and to strengthen and upgrade the UN's social and development organisations so that these institutions can act as a counterbalance to the powerful finance and trade institutions. A WEO would be a designated and empowered advocate for the environment that could serve to ensure effective policy and decision-making and provide an adequate response to environmental management. That is precisely the aim of what has been called mission-oriented innovation policy. Of course, a World Environment Organisation alone will not solve the problems of international environmental governance and global governance. There also needs to be fundamental reform of the WTO and of the IMF. However, establishing a WEO would be one step towards a more balanced, effective and accountable system of global governance.

5. A final remark

A changing planetary reality poses immense challengers and risks. Yet, a shift towards a just future for all on a thriving planet is possible, provided we get rid of the most powerful obstacle on the way to a new climate regime, i.e. the inability to imagine a different economic system or even just a new balance between market and society, and between humanity and the environment. Considering change impossible is the best way to perpetuate the existing. The difficulty in setting up an effective response to climate change is linked to the difficulty of imagining another economic order in which the economy constitutes a function of society – and not vice versa – in which humans are aware of the effects caused by the counteraction of non-humans and in which the fight against consumerism should not be interpreted through the lens of poverty.

I do not wish to hide the difficulties lurking in the practical implementation of a project targeted at nothing less than a "paradigm shift" in economic theory and a new model of economic development. As in all human endeavours, it would be naif to imagine that certain changes do not create conflict. The differences of vision and the interests at stake are enormous. It is no accident that a kind of widespread anguish about the future is run-

ning throughout society today. Some people and certain pressure groups are exploiting this anguish as a political tool, deriving from it, depending upon the circumstances, either a market-centered Machiavellianism or a State-centered Machiavellism. It is precisely against this neo-Machiavellian culture and its underlying ethical relativism that Christians and non-Christians are called to put up a fight.

YOUTUBE PRESENTATIONS

Climate Change: The Franciscan Doctrine

Hon. Roberto Andrés Gallardo

President COPAJU & Instituto Bartolomé de las Casas

https://youtu.be/vs8f-fL76Ck?si=qBc2zwXOvoT6WhR1

Legal Significance of the Ethical and Scientific Foundations of *Laudato Si'*, Fratelli Tutti and *Laudate Deum*

Justice Antonio Herman Benjamin

Chief Justice-Elect of the National High Court of Brazil (STJ)

https://youtu.be/-ELE7dhjd-Q?si=Wv6U7Dp0U6BBi74m

The Kayapó People's Fight for the Amazonian Forest

Chief Raoni Metuktire

https://youtu.be/wqMV011boq8?si=6saEiPw7fah2P04I

SESSION XI – FINANCING RESILIENCY

Investing in Sustainable Water Solutions: A Holistic Approach to Addressing Global Challenges

Craig Cogut
Founder, Chairman, & CEO, Pegasus Capital Advisors

Water, an indispensable resource, sustains life and our food systems, and drives economic prosperity worldwide. Yet, its availability, quality, and equitable distribution face significant threats, resulting in water scarcity and contamination that directly impact food security and access to clean drinking water. A holistic approach – focused on water management, food security, and public health – is needed to address the multifaceted nature of the water crisis.

Ensuring water availability for all requires a 'systems thinking' approach, working with different stakeholders to ensure that not only the proper solutions and funding are available, but that the policies, education, and global priorities are aligned and established to accelerate the right interventions at the right time, operating off shared knowledge and capability, especially for those most at risk and underserved. This requires the public and private sector to work closely to expedite this change.

Food security and water conservation are closely linked, since almost every aspect of food production is intimately tied to water. However, we need to develop climate-resilient crops and supply chains with climate change exacerbating water scarcity, erratic rainfall patterns, and increasing soil degradation. By harnessing agricultural techniques like regenerative farming and developing cold storage solutions, we can support food security and mitigate the impacts of water stress on vulnerable communities. In regions like India, where women play a pivotal role in agriculture, empowering them with access to resilient crops and sustainable practices can be a powerful tool in averting food shortages, alleviating hunger, and preventing famines.

At Pegasus Capital, our investment strategy demonstrates our commitment to addressing solutions to complex global challenges systematically. From advanced water treatment technologies to innovative water generation systems and regenerative agriculture, our portfolio spans a wide range of solutions to address both water quantity and quality.

Millions of people worldwide, particularly in rural and marginalized communities, are deprived of access to safe and reliable drinking water, perpetuating social inequities and hindering economic development. Innovative technologies that leverage the ocean can serve as a viable solution. Atmospheric water generators are a promising solution that can immediately generate drinkable water using moisture in the air. This air-to-water technology can serve communities in need with clean water that is free of chemicals and other hazards while also adding minerals for improvements in nutritional value and taste.

Sustainable desalination projects may offer another option to alleviate water scarcity, particularly in regions facing freshwater shortages. By harnessing seawater and converting it into potable water through desalination technologies, we can diversify water sources and reduce reliance on finite freshwater resources.

With growing populations and increasing demands across agricultural, industrial, and domestic sectors, wasteful practices and inefficient water management contribute to resource depletion. Efficient water utilization is a critical aspect that demands attention. The agricultural sector needs support to reduce its water footprint through precise and efficient irrigation (e.g. drip irrigation), reduce runoff and contamination, and cultivate drought-resistant crops and improve crop and soil management through regenerative agriculture. This also increases water retention and infiltration in the soil, which also benefits farmers.

As part of our impact funds, we invest in agroforestry projects to restore degraded pastures, making them economically viable by growing organic produce. We also focus on agricultural efforts that unlock nutrient-dense and drought-resistant crops, incentivizing low-water footprint use that has the potential to support a region's food security. An example are crops like fonio and pongamia, proven to restore regions heavily impacted by climate change while generating economic development.

While water quantity is a pressing concern, water quality is equally crucial. Water contamination poses significant health risks and environmental hazards, threatening human well-being, public health, and ecosystem integrity. Industrial discharge, agricultural runoff, and inadequate wastewater treatment systems are just a few examples of contributors to such pollution. By investing in advanced water treatment technologies, water resources can be safeguarded for future generations.

Moreover, climate change exacerbates existing water challenges and may lead to erratic rainfall patterns, droughts, floods, and storms that dis-

rupt water infrastructure and community resilience. Building climate-resilient water systems and implementing disaster preparedness measures to address urban runoff and flooding are imperative to mitigate the impacts of extreme weather events and ensure the reliability of water resources in the face of climate uncertainty.

Proper water allocation is crucial for food, air conditioning, and agriculture to build resilient food and water systems to sustain communities. This requires strategic decisions that prioritize limited resources and leverage renewable energy to ensure these fundamental needs are met. We will need to proceed with the understanding that choices, hard choices, will need to be made on how and where resources such as water and renewables are allocated.

Pegasus Capital is committed to working with partners to advance innovation in the sector and collaborates with AltaSea – a unique public-private ocean institute at the Port of Los Angeles – to explore innovative technologies that leverage the ocean as a viable solution to contribute to water security and environmental sustainability. This includes ocean-based renewable energy such as wave energy, seaweed-based biotechnology, regenerative aquaculture, and blue tech and underwater robotics.

Investing in these technologies addresses the urgent need for water resource management and presents significant opportunities for sustainable development with an economic model. Ultimately, addressing the global water crisis requires concerted efforts from stakeholders across sectors. By prioritizing sustainable water solutions for all through collaboration and innovation, we can pave the way for a future where clean water is accessible to all, ensuring food security, public health, and economic prosperity for generations to come.

About Pegasus Capital Advisors, L.P.

Pegasus Capital Advisors, L.P. is a leading global private markets impact investment manager. As the first U.S. private equity fund manager accredited by the Green Climate Fund, Pegasus Capital is dedicated to fostering sustainable and inclusive growth while providing attractive returns for investors. Founded in 1996 by Craig Cogut, Pegasus Capital has invested over $2 billion across 7 private equity funds focused on sustainability, health, and wellness. Explore more at www.pcalp.com

Talent Finance for Green Jobs: How a New Generation of Innovative Investments in Workforce Training Can Address Climate Goals and Expand Economic Mobility

Tracy Palandjian
Social Finance

Xavier de Souza Briggs
Brookings Institution

Introduction

In the U.S., an estimated $30.2 trillion in transportation, water, and real estate assets could be reconfigured and repurposed to power a sustainable green economy – a daunting but necessary transition if we are to reach national climate goals, including the Biden Administration's aim of a 50% or greater reduction in economy-wide net greenhouse gas pollution by 2030.[1]

However, America's existing workforce development apparatus is fragmented, underfunded, siloed, and not designed to meet the demand for workers to fill the jobs that will power this transition – or ensure that these new jobs are good jobs.

A recent and unprecedented investment commitment from the federal government has given the U.S. the capital to not only renew our infrastructure but also launch a national workforce agenda focused on overcoming silos and expanding opportunity in climate-critical sectors. Smartly structured capital can help realign incentives and encourage collaboration across sectors to achieve outcomes by shifting the focus to *outcomes,* rather than fragmented outputs – creating new paths to invest in upskilling current workers to transition into in-demand, quality jobs for the green economy, and in apprenticeship programs for the next generation. The required scale

[1] The White House. *President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies* (The White House, 2021, April 22). https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/

is significant: recent Brookings Institution research estimates that the U.S. economy will need 32 million new workers over the next decade in infrastructure occupations alone.[2]

The definition of a "green" job[3] remains somewhat elastic, and not every green job is a good job; without new steps to ensure job quality nationwide, there are indicators that some occupations will be "deskilled," and wages kept low, in the green transition. Clearly, we must do better.[4]

Many of the most in-demand jobs being created by major national investments have a clear green component *and* are relatively well-paid, especially when compared to other jobs accessible to workers without a college degree.[5] Welding jobs are a telling example, requiring specialized skills and offering an average annual wage of $52,640.[6] As more of our infrastructure requires buildout or retrofitting for climate adaptation or mitigation, many similar occupations are poised for growth: electricians, line installers, pipe fitters, and more. Such jobs require training beyond a high school diploma – often called "middle skills" – but not a bachelor's degree. In this paper, we focus on this broad category of jobs, many in the skilled trades, rather than other kinds of good, green jobs – such as in science and engineering occupations – that require a bachelor's or more advanced degrees.

Given troubling long-run trends that point to stagnant economic mobility[7] in the U.S. – particularly among workers who do not have a college degree[8] – there is a growing imperative to invest in new pathways to the prosperity that comes with stable, quality, and well-paid work.

[2] Kane, Joseph. *The Incredible Shrinking Infrastructure Workforce – and What to Do About It* (Brookings Institution 2023, May).

[3] Jobs for the Future *Growing Quality Green Jobs*. n.d. Info.jff.org. https://info.jff.org/growing-quality-green-jobs

[4] Silkin, Lewis. *Deskilling: What Is It? – Future of Work Hub* (Future of Work Hub, 2021, April 28). https://www.futureofworkhub.info/explainers/2021/4/28/deskilling-what-are-the-historical-societal-and-legal-implications

[5] Bureau of Labor Statistics. *Green growth: Employment projections in environmentally focused occupations: Career Outlook: U.S. Bureau of Labor Statistics* (Bureau of Labor Statistics, 2021, April 28). www.bls.gov https://www.bls.gov/careeroutlook/2022/data-on-display/green-growth.htm

[6] Bureau of Labor Statistics, *Welders, Cutters, Solderers, and Brazers* (Bureau of Labor Statistics, May 2023). Bls.gov. https://www.bls.gov/oes/current/oes514121.htm

[7] Smith, E., Shiro A., Pulliam C., and Reeves, R. *Stuck on the Ladder: Wealth Mobility Is Low and Decreases with Age* (Brookings, June 29, 2022). https://www.brookings.edu/articles/stuck-on-the-ladder-wealth-mobility-is-low-and-decreases-with-age/

[8] Cooper, D., Scott, R. *Almost Two-Thirds of People in the Labor Force Do Not Have a Col-*

Transforming the American workforce system requires multiple solutions and additional funding, but who invests and under what terms matters enormously. Funding not only *fuels activity* but also *structures relationships among actors*, especially when they co-invest – rethinking who pays, who benefits, and who takes on risk.

The approach we will outline, of public-private "talent finance" partnerships, can and should be part of how we train and deploy a green workforce, given our ambitions and status quo gaps and inequities. This approach can scale up in ways that promote more equitable, accountable, and effective delivery of results for workers, employers, training providers, and supportive service providers alike.

A Critical Problem: Misaligned Incentives

Much of the estimated $1.25 trillion appropriated through the 2021 Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act is for climate-related work in the built environment, such as developing a large number of renewable energy and energy storage facilities and making transportation and water infrastructure more resilient.[9] A recent Brookings analysis identified $75 billion across 54 programs[10] funded by the two acts that either target green workforce development directly or are flexible enough to include it. The authorization of such significant public funding does not mean it will all be spent on workforce training. But this historic availability of public capital exposes a growing problem with the status quo: the U.S. currently does not have enough workers in these roles, nor does it have enough accessible pathways for workers to pursue these jobs.

For decades, the U.S. has underinvested in a more balanced and market-responsive mix of postsecondary programs – including applied skills training, sometimes called career and technical education (CTE).[11] Unlike

lege Degree n.d. (Economic Policy Institute, 2017, March 30). https://www.epi.org/publication/almost-two-thirds-of-people-in-the-labor-force-do-not-have-a-college-degree

[9] Here, we refer both to newly built infrastructure assets constructed to more demanding standards and to repaired or retrofits that enhance resilience to climate-related and other shocks.

[10] Tomer, A., Singer, A., & Kane, J.W. *Unlocking new federal infrastructure funding to drive green workforce* development (Brookings, 2023 October 12). https://www.brookings.edu/articles/unlocking-new-federal-infrastructure-funding-to-drive-green-workforce-development/

[11] Porcari, J.D., Kane, J.W., Korberg, R., & De Souza Briggs, X. *We haven't yet decided that climate and infrastructure jobs are for everyone, or even that we'll have enough workers* (Brook-

the widely available earn-while-you-learn applied skills opportunities in other advanced economies, only 519,000 Americans are enrolled in a registered apprenticeship program at any given time.[12] To put this in perspective, the U.S. spends about 50 times more on college degrees than applied skills training,[13] and has the lowest per capita job training expenditures[14] of any industrialized nation.

Where the U.S. offers high quality applied skills training, there are typically barriers to entry that disproportionately affect historically disadvantaged and underserved groups, especially women and people of color. For example, many of the highly selective apprenticeship programs for skilled trades associated with the clean energy transition have entrance exams, require pre-existing industry knowledge, do not assist prospective trainees with living expenses during pre-apprenticeship preparation, and do not offer supportive services during the program.[15]

The $3 billion federal Workforce Innovation and Opportunity Act (WIOA) illustrates these challenges: despite being the main source of goals, operating rules, and funding for the U.S. public workforce system, its training programs reach just a fraction of 1 percent of the U.S. worker population each year, and 75% of said programs reported incomplete data to evaluators.[16]

Meanwhile, organized labor plays a key role that is relevant to middle-skill green jobs: building trades unions collectively invest about $2 billion per year in training. But in many parts of the country, union density

ings, 2023 September 1). https://www.brookings.edu/articles/we-havent-yet-decided-that-climate-and-infrastructure-jobs-are-for-everyone-or-even-that-well-have-enough-workers/

[12] Apprenticeship, O.O. Apprentice Population Dashboard (Apprenticeship.gov, 2024, April 19). https://www.apprenticeship.gov/data-and-statistics/apprentice-population-dashboard

[13] Lerman, Robert I. *Scaling Apprenticeship to Increase Human Capital* (The Aspen Institute, 2019, February 4). https://www.aspeninstitute.org/longform/expanding-economic-opportunity-for-more-americans/scaling-apprenticeship-to-increase-human-capital/

[14] Holzer, H.J. *Should the federal government spend more on workforce development*? (Brookings, 2023, May 23). https://www.brookings.edu/articles/should-the-federal-government-spend-more-on-workforce-development/

[15] Lerman, R., Loprest, P., & Kuehn, D. *Training for Jobs of the Future* (Urban Institute, 2019). https://www.urban.org/sites/default/files/publication/101123/training_for_jobs_of_the_future_1.pdf

[16] Team, P.O.W. *Navigating Public Job Training* (The Project on Workforce, 2024, April 9). https://www.pw.hks.harvard.edu/post/publicjobtraining

and participation are low, and the traditional funding model for union-led training was not designed to anticipate and scale to meet dramatic growth in demand – a classic, timing-of-money financing problem now in stark relief as we figure out how to grow our green workforce.[17] We need complements and supplements to these traditional sources and arrangements.

Finally, systems that aim for effectiveness and equity should be smart, promoting continuous learning based on meaningful evidence. But our system's current assumptions and incentives provide far less information than we should have about effectively placing workers[18] in quality jobs with economic mobility.[19] Successfully scaling apprenticeships, CTE programs, and other types of "middle skill" pathways in the U.S. requires addressing long-entrenched norms and expectations, especially the comparatively high fragmentation of the U.S. system – and the scarcity of interdependent relationships among employers, employees, and jobseekers – than in many other industrialized nations.

Capital projects in the built environment represent perhaps the biggest opportunity for middle-skill green jobs, but the U.S. does not offer supportive, accessible, and affordable training at anywhere near the scale needed. There are many reasons for this supply and demand misalignment.

First, *accountability* – holding employers and training providers responsible for achieving meaningful results – is often elusive because workforce development funding is rarely provided by employers or linked to the most important and strategic worker outcomes, even though our public workforce system requires extensive performance measurement and onerous formal reporting.

Second – and relatedly – there are few *incentives* for employers to engage and co-invest to help meet their industry's skill needs, an absence made more conspicuous by the lack of adequate targeted public sector funding.

[17] Franklin Apprenticeships. *The Role of Trade Unions in the U.S. Apprenticeship Arena: An interview with Dr. John Gaal, Director of Training and Workforce Development, STL-KC Carpenters Regional Council* (Franklin Apprenticeships, n.d.). https://www.franklinapprenticeships.com/role-trade-unions-us-apprenticeship-arena/

[18] Contreras, C.D., Seyal, I., & Escobari, M. *Moving up: Promoting workers' upward mobility using network analysis* (Brookings, 2021, June 14). https://www.brookings.edu/articles/moving-up-promoting-workers-upward-mobility-in-a-time-of-change/

[19] Forston, K., Rotz, D., & Burkander, P. *Providing Public Workforce Services to Job Seekers: 30-Month Impact Findings on the WIA Adult and Dislocated Worker Programs* (Mathematica, 2017, May 30). https://mathematica.org/publications/providing-public-workforce-services-to-job-seekers-30-month-impact-findings-on-the-wia-adult

As a result, training providers struggle to evolve their programs to meet current or future labor market demands, and the heavy reliance on public funding makes effective programs vulnerable to the ups and downs of annual budget cycles.

Third, and more specific to infrastructure, the institutions responsible for planning and producing capital projects – such as infrastructure agencies or privately-owned utility companies – have rarely been expected to invest in the workforce needed for that production. Capital planning for projects proceeds with the assumption that the right skilled workforce will materialize[20] to complete them – without a comparable investment in making sure that such a workforce exists. This is another crucial disconnect between those charged with pursuing a broadly supported national goal and those charged with preparing the workers essential to achieving that goal.

In other words, the actors in the U.S. workforce development ecosystem do not have the sort of coordination and interdependencies that exist in other advanced economies: employers passively rely on the talent produced by education and training programs, for which workers are generally expected to pay on their own with minimal government assistance.

Too many workers therefore shoulder the risks of paying for a training program and taking time away from a current job to complete it. Though there is little systematic data available[21] on how learner-workers cover costs of training and living expenses for noncredit programs, available data on liquid assets for low to middle-income Americans,[22] together with analyses of subgroups of students and trainees, suggests it is highly likely that they use credit cards and high-interest loans to fill the funding gap. One estimate found that making federal loans available for CTE would cost as much as $500 million annually.[23]

[20] Porcari et al. (2023).

[21] Castleman, B., Xu, D., Bird, K., Cooper, M., & Solanki, S. *Noncredit workforce training programs are very popular. We know next to nothing about them* (Brookings, 2023, May 23). https://www.brookings.edu/articles/noncredit-workforce-training-programs-are-very-popular-we-know-next-to-nothing-about-them/

[22] Consumer Financial Protection Bureau. *Emergency Savings and Financial Security: Insights from the Making Ends Meet Survey and Consumer Credit Panel* (Consumer Financial Protection Bureau, 2022, March 23). https://www.consumerfinance.gov/data-research/research-reports/emergency-savings-financial-security-insights-from-making-ends-meet-survey-and-consumer-credit-panel/

[23] Thomas, J., Gonzalez, N., Wiegand, A., Paxton N., & Hebbar, L. *The Effects of Expanding Pell Grant Eligibility for Short Occupational Training Programs: Results from the Ex-*

More than cost, however, it is factors largely outside of the worker's control – such as a lack of access to affordable childcare, transportation, or credit to cover tuition – that appear to be the biggest impediments to program enrollment or completion.[24] Women and people of color are disproportionately impacted by these barriers, exacerbating the economic mobility challenge for historically marginalized groups. A recent study found that quality jobs in energy efficiency in particular "are the most challenging for women and people of color to access."[25]

A more successful workforce development system would share responsibility and accountability across all stakeholders, building relationships among actors by meeting the needs of employers, workers, and government alike. Having "skin in the game" from multiple stakeholders, whose investments (monetary and non-monetary) are organized around clear outcomes, would create a more robust, fiscally sustainable, resilient, and high performing system.

Leveraging existing public, private, and philanthropic dollars – and responding to the unique opportunity catalyzed by historic levels of federal investment in infrastructure to address the climate crisis – could help rebalance the equation among stakeholders and create on-ramps to opportunity for millions of workers.

A New Configuration: Talent Finance

Talent finance refers broadly to the use of public and private capital to address barriers to workforce development amid ballooning student loan debt, competing demands for limited public funding, and the impact of rapid technological innovation on the workforce.[26] Based on demonstrated

perimental Sites Initiative (NCEE 2021-001). (U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, 2021). Ies.ed.gov/ncee/pubs/2021001/pdf/2021001.pdf

[24] Hess, C., Mayayeva, Y., Reichlin Cruse, L., & Thakur, M. (2020, August 21). *Supportive Services in Job Training and Education: A Research Review* (IWPR – Institute for Women's Policy Research, 2020, August 21). https://iwpr.org/supportive-services-in-job-training-and-education-a-research-review/

[25] Axelrod, J., Bajak, A., Dallman, A., D'Elia, H., Ferrante, D., Scott, M. *Who Has Access to Good Clean-Energy Jobs?* (Urban Institute, 2024, May 1). https://www.urban.org/projects/clean-energy-job-access-race-gender

[26] U.S. Chamber of Commerce. *U.S. Chamber of Commerce Foundation Launches 'Talent Finance' Initiative to Develop New Models for Investment in the Workforce of the Future* (U.S. Chamber of Commerce, 2024, March 7). https://www.uschamber.com/workforce/

early results from innovative projects across the U.S., this model can also be a rich source of lessons and systems change, shifting incentives, rewiring institutional relationships and – with them – improving accountability. If adopted at scale, talent finance could play an important role in solving critical labor market shortages as well as expanding economic opportunities for millions of Americans.

Talent finance powers workforce training through partnerships among government, philanthropy, employers, training partners, and supportive service providers. Together, these stakeholders create outcomes-focused, self-sustaining programs that prepare workers for the specific jobs that employers need to fill, all while sharing risk on transparent terms.

Social Finance, a nonprofit organization founded and led by one of us, has helped implement talent finance in a range of places, industries, and occupations. Though each talent finance example is unique, there are four defining, shared elements (*see Figure 1*):

- Changing Payment Timing: In the U.S., employers and governments are unlikely to provide sufficient up-front financing of job training for prospective employees or incumbent workers. When such direct grants are not available, talent finance models use capital from other sources to pay for training in advance, which employees and/or employers repay through an affordable plan based on successful job placement and/or substantial earnings gains. Realigning the *timing* of costs and benefits reduces risks for employers and workers.
- Tying Payment to Outcomes: In many talent finance programs, employers commit to repayment on behalf of the trained workers they hire, so employers only pay for skills upgrades for workers who ultimately join and contribute to the success of their organization. These *outcomes-based* provisions offer robust protections for workers and address major drawbacks associated with traditional student loans.
- Holistic Support for the Learner-Worker: Talent finance models offer access to supportive services to address living expenses and other challenges. A 2021 Department of Labor study[27] found that nearly

education/us-chamber-of-commerce-foundation-launches-talent-finance-initiative-develop-new

[27] Ortagus, J.C., Skinner, B.T., & Tanner, M.J. *Investigating Why Academically Successful Community College Students Leave College Without a Degree* (AERA Open, 2021, December 16). https://doi.org/10.1177/23328584211065724

half (48%) of those who drop out of community college do so because of a lack of funds to cover living expenses. Talent finance models that include living stipends and flexible emergency grants build agency, as workers help determine the supports they need most.

– Align, Blend, and "Recycle" Capital from Co-Investors: Capital raised from both public and private sources is deployed via a variety of structures that tie repayments to outcomes. In the most robust models, these loan repayments are then recycled to serve additional workers over time.

Beyond funding new training programs, talent finance can help scale existing earn-while-you-learn opportunities by providing a funding mechanism for critical services to pre-apprenticeship program participants. Currently, such services are not adequately funded. Although many pre-apprentice-

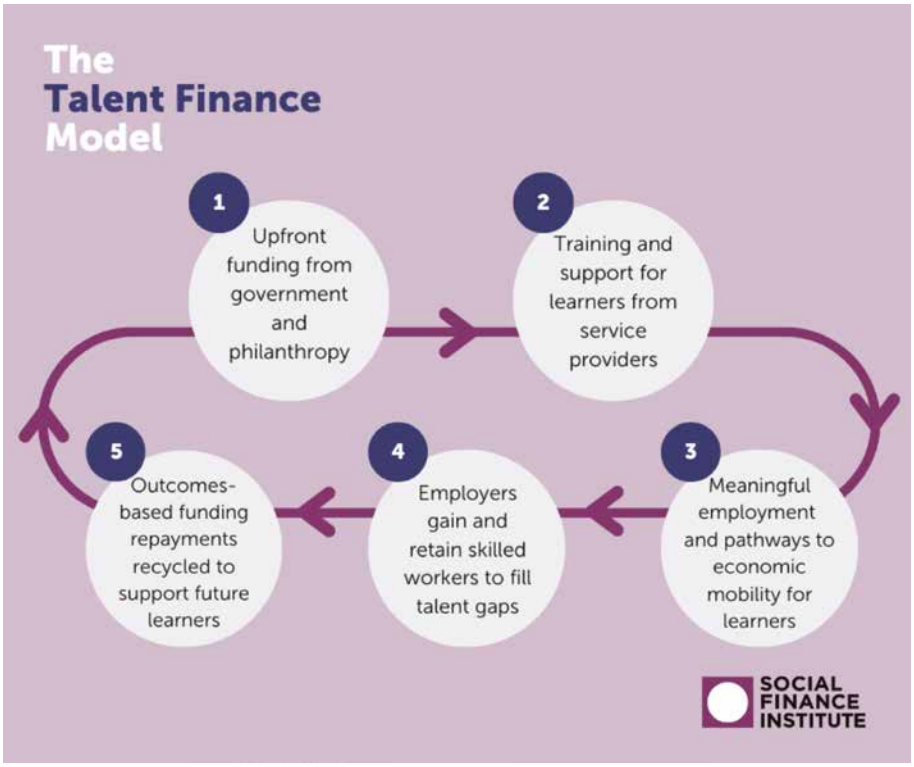

Figure 1.

ships cover the direct cost of participants' tuition, they generally do not provide wages or living stipends during training, nor do they pay for other important wraparound supports. Through talent finance, the ultimate employers of apprentices can help repay the funding advanced for supportive services that are vital to preparing workers to enter and succeed in the apprenticeship. Pre-apprenticeship programs can thereby create accessible apprenticeship entry points for under-represented populations, including low-income trainees, women, and people of color, by offering career exploration and skills development services while helping workers prepare to enter apprenticeships.

As of early 2024, there are active talent finance initiatives in the states of Colorado, Hawaii, Massachusetts, New Jersey, Ohio, South Carolina, Texas, and nationwide through the Google Career Certificates Fund. Efforts at scale are still nascent, but the examples below clearly demonstrate how this model can be effective.

Example: Leverage Private Sector/Employer Repayments: ADTC Career Impact Bond[28]

In 2020, Social Finance partnered with American Diesel Training Centers (ADTC), a diesel technician training program based in Ohio, to launch a nearly $9 million Career Impact Bond funded through two investments from Social Finance's UP Fund, a $50 million pool of catalytic capital from family offices, philanthropies, and other sources.

From 2020-2022, the ADTC Career Impact Bond served more than 1,100 people through a five-week hands-on training course at two ADTC locations in Ohio. The short timeline makes this program significantly more practical and accessible for both learner-workers and employers.

The UP Fund covered all upfront enrollment fees along with the costs of a medical, physical, and diesel mechanic toolset. Some participating corporate employers covered additional supports, like room and board. Participants also received career coaching, financial literacy training, and other services. Repayment by the learner-workers was contingent on finding a job paying above a minimum income level and only applied to the program fees, not the supportive services.

[28] Social Finance. *American Diesel Training Center Career Impact Bond*. https://socialfinance.org/work/adtc/

Top employers – including Penske Truck Leasing, Aim Transportation Solutions, and National Fleet Management – took over monthly payments for program graduates they hired. As a result, more than 50% of graduates had their training costs covered fully by employers and were able to exit the program with a better job and no repayment obligations. On average, program participants achieved a 60% median wage increase. At least one of the participating employers has now integrated the model into their overall workforce development strategy.

Example: Better Use of Public Funds: New Jersey Pay It Forward[29]

Social Finance partnered with the state government and eight large businesses in New Jersey to launch New Jersey Pay It Forward, a $24 million endeavor targeting in-demand industries like nursing, cybersecurity, welding, and HVAC (heating, ventilation, and air conditioning) technology. The program is designed to be additive: enhancing opportunity for disadvantaged workers without crowding out or substituting for other funding that already helps some workers to afford training.

New Jersey Pay It Forward provides zero-interest, no-fee loans for participants to enroll in high-quality job training, with a focus on people who may not have the credit history for a traditional loan. Participants also receive grants – which do not need to be repaid – for living stipends and supportive services as part of their enrollment, including access to emergency aid funds and mental health counseling. As of October 2023, more than 80% of participants were people of color, 65% did not have a four-year degree, and 45% identified as women.

The New Jersey program's outcomes-based design seeks to shift risk away from workers by only requiring repayment if they are hired for a job in which they earn more than a defined minimum salary based on household size (e.g., $50,730 for workers from a three-person household). Even then, monthly payments are capped at no more than 10% of their discretionary income[30] for up to five years, and workers never repay more than the cost of training itself because the loans carry zero interest. Also, the grants for living stipends and supportive services are not subject to repayment.

[29] Social Finance. *New Jersey Pay It Forward Program*. https://socialfinance.org/work/new-jersey/

[30] NJ Pay It Forward defines "discretionary income" as the worker's income after subtracting 150% of the Federal Poverty Level amount for their household size.

Graduation rates for enrolled participants are as high as 90% for the nursing program, where the average annual salary is $75,000.

Example: Talent Finance for Jobs of the Green Transition: Massachusetts Climate Careers Fund[31]

In most states, public officials have shown strong interest in mobilizing the talent needed for the green economy – but rarely at a level, and with an operable delivery model, that is commensurate with projected employer demand.[32] That is now changing. At the Vatican Climate Summit in May 2024, Massachusetts Governor Maura Healey announced a first-of-its-kind fund focused exclusively on finding and training the nearly 30,000 additional full-time equivalent workers needed to meet the state's 2030 greenhouse gas emissions reduction mandates.[33]

Social Finance and the Massachusetts Clean Energy Center, with coordination and support from Governor Healey's administration, designed the initial $10 million pilot to help participating learner-workers prepare for well-paid, in-demand careers in clean energy and climate technology by filling "last-dollar" financing gaps (e.g., unmet tuition costs) and addressing barriers to enrolling in and completing training. All funds recouped through participant loan repayments will be recycled back into the fund to finance future training, amplifying the impact of the capital seeding the fund.

Crucially, the Massachusetts model is enabled by a whole-of-government approach: a Cabinet-level climate action lead coordinates across a range of state agencies, including economic development, education, energy, and labor.

[31] Social Finance. *Massachusetts Climate Career Fund*. https://socialfinance.org/work/massachusetts-climate-careers-fund/

[32] To be sure, planners in all sectors are also grappling with the challenges of projecting when and in what specific occupations that demand will present. Many estimates, such as the decade-forward estimates cited above, are at the national level for large occupations, not specific to states or regional labor markets, let alone the near- to medium-term time horizons most useful to training providers and other critical actors. Another plus of the talent finance model is its flexibility to adapt, and "dial" investments, to respond to changing market conditions over time.

[33] Hoffer, Melissa. *Recommendations of the Climate Chief*. Pursuant to Section 3(b) of Executive Order No. 604. October 25, 2023. mass.gov/files/documents/2023/10/24/CLIMATE REPORT.pdf

Examples like New Jersey and Massachusetts show how governments can blend and braid federal funding with their own investments[34] to help reach their own workforce goals. As these jobs grow, it is essential to build on these models to achieve long-term sustainability, both in funding and/or financing and in maintaining shared accountability across all stakeholders.

Conclusion

With an historic influx of public investment, the U.S. can make shared stakes in outcomes part of the fabric of the workforce development system needed to green the economy and our built environment. The key is breaking down silos, prioritizing effectiveness, and putting stakeholders in durable and accountable relationships with each other, aligned around clear outcomes.

The U.S. has a big talent pipeline to build, and there are no panaceas or quick fixes. New and innovatively structured funding is necessary, but certainly not sufficient. Still, the results from talent finance models, some delivered with remarkable speed once the right elements were put in place, demonstrate that a more inclusive and sustainable future is possible.

A better workforce development system can strengthen the productive foundations of the American economy, expand economic mobility for millions of workers and their families, and mitigate the worst effects of a warming world. We now have the know-how, as well as a tangible and unprecedented opportunity, to move rapidly in that direction.

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[34] Tomer, A., & Kane, J.W. *Why green jobs plans matter and where US cities stand in implementing them* (Brookings, 2023, July 25). https://www.brookings.edu/articles/why-green-jobs-plans-matter-and-where-u-s-cities-stand-in-implementing-them/

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Building a More Just and Resilient World: The Role Philanthropy Can Play in Adaptation and Societal Transformation

Cathleen D. Stone and James M. Stone
James M. & Cathleen D. Stone Foundation

[Cathy] Thank you, Your Holiness, Eminences, Excellencies, and dignitaries. It has been an honor and a privilege to serve on the Advisory Committee for this important summit. And it is a pleasure to speak with you all today.

As many of you have been saying throughout this summit, my husband Jim and I firmly believe that we will not make progress in our work towards a climate resilient future without recognizing two undisputable facts: first, that climate change is inexorably linked to inequality, and second, that making progress on climate change requires working collaboratively across the lines that so often divide us – lines that separate disciplines, sectors, cultures, political parties, nations and more.

Our Foundation, the James M. and Cathleen D. Stone Foundation, is committed to building a more knowledgeable and inclusive society, with a special emphasis on environmental sustainability and the mitigation of wealth inequality.

During our talk today, Jim will share some brief thoughts about the connections between climate change and wealth inequality and then I will share some of the ways we believe philanthropy can be a catalyst for change.

First, Jim.

[Jim] It is certainly no surprise that the heft of the conversation about the dangers of climate change is focused on its direct physical threats: drought, flooding, human and animal habitat disruption, and the like. I will use my brief time today to try to examine yet another, less discussed, threat I urge you to take seriously: the vicious cycle arising between climate change and wealth inequality. As context, let me explain that Cathy and I agreed some years ago that, for maximum impact, our philanthropy should be tightly targeted, like a laser, not a flood lamp. We each picked a single issue around which to center the bulk of our giving. Cathy's choice was sustainability and bio-diversity. My choice was unequal wealth concentration. I spoke in this same Pontifical forum two years ago about the various harms – moral,

economic, and political – that arise from excessive wealth inequalities and about the accelerating trend toward increased inequality evident around the world today.

I haven't time today for a recounting of all the damage that the tightening grip on financial means by a small fraction of the population can reap. Let me only say that extreme wealth concentration runs roughshod over our better instincts for justice, compassion, and decency; it can render democracy an essentially empty fiction; and it can stultify economies. Rather than document these assertions once again, I will use my few minutes to argue the case that climate change is amplifying the already ugly trend toward wealth sequestration at the top and, further, that exaggerated concentration of wealth in turn hampers our ability to restrain climate change.

The first of these twin assertions is straightforward. The injuries of climate change fall unequally among economic strata within societies and all the more unequally among nations. It should be apparent that arid soil, intensifying winds, unhealthy extremes of heat, contraction of grazing lands, and invasive diseases are affecting tropical nations more than those in more temperate zones. Countries in the Global South, already poorer those in the North, have contributed the least to the sources of climate change yet they are suffering the most, and they are the least equipped to pay for required preparation and adaptation. Even with today's enhanced consciousness, the global most privileged 1% are still responsible for more emissions than the entire bottom half of the world's population. Justice surely requires that the wealthier nations that have brought us to this point aid those poorer nations to adapt – without asking them to sacrifice their own paths to economic betterment.

Within national boundaries the greatest pain of climate change also falls plainly upon those least able to bear it. Scholarship now suggests that harmful emission-related inequalities within nations are even greater than those between nations. Poor neighborhoods easily become unprotected neighborhoods. The wealthy have vastly disproportionate access to air conditioning relief when temperatures become unhealthy, to foods that become scarce or expensive, to second homes, and to employment in comfortable offices. And we must take great care not to impose solutions for warming trends that tilt the costs even more toward the least financially secure. As an example, I am happy to see that solutions such as carbon taxes, although quite promising in many respects, are now being subjected to examination for their distributive economic effects. Adaptive responses may need to be coupled with redistributive policies if they are to pass political and ethical muster.

Looking at this in the reverse direction, the reasons that wealth inequalities accelerate climate change are only slightly more subtle. As wealth becomes more concentrated, and the most fortunate few insulate themselves from the adverse effects of climate, their empathy for everyone else may well diminish. Lack of common experience always tends to reduce willingness to endure even modest sacrifice. Climate isolationism appears to be on the rise even now. Inequalities of means also shift political power to elites, oligarchs, and neo-aristocrats. The loss by degree of pluralistic influence over societal policies is a near-certain negative for climate justice. Unfortunately, though, we are witnessing a worldwide acceleration in the flow of wealth toward to the top, accompanied by a decline in the willingness to accept progressive taxes for the financing of common goals, and a near complete rejection of estate taxes in the world's leading economies. These trends can only diminish the cooperative efforts necessary to secure resiliency.

None of the central issues raised at this conference, including the corollary issue I have touched on, is not easy to solve – which brings me back to Cathy's and my approach to philanthropy. Wise and practical answers to the hardest questions surrounding environment and optimal wealth distribution remain elusive. While philanthropists cannot afford to pay for the physical protections our planet needs, we can certainly help finance the academic work required to show us the best approaches. So Cathy and I have aimed our giving at universities where the world's top scholars are seeking the wisest paths to a healthier climate and sounder distributional economics. In addition to the projects Cathy has addressed, we have created eleven university centers dedicated to the study of wealth concentration – six centers within the United States and five in other countries – and there will be more. We have charged these Stone Centers with training a generation of scholars to tackle the essential questions around merging prosperity, resiliency and distributive justice. Few accomplishments would make us happier than to feel that our sponsorship encouraged the development of a roadmap for breaking the vicious cycle afflicting climate and wealth concentration. And at that let me stop and pass the microphone back to Cathy.

[Cathy] Thank you, Jim. When we decided, years ago, that we would establish a philanthropic foundation, we could not have predicted how closely connected our two primary areas of interest would be. Preparing our world for the impacts of climate change – while simultaneously working to reduce inequality and halt emissions – is indeed one of the most pressing

challenges of our time. Today, I want to emphasize that we will not make progress if we continue to work within the silos that so often divide us. That is why I am so pleased to see the audience here includes individuals representing governments, NGOs, religious institutions, corporations, philanthropies, universities, and more. Looking around, I also see diversity in our academic backgrounds – we are social scientists, natural scientists, legal experts, engineers, public health professionals, doctors and philosophers. This diversity of thought is extremely important as it is going to take creative minds from all backgrounds, working together, to address this crisis for our planet.

As Jim mentioned, there are no easy answers to the challenges we face. If we knew all the right policies to implement, we would happily devote our time and resources to advocacy. As a foundation, our objectives in the area of adaptation are clear – help prepare our world for the consequences of climate change in a manner that protects people, ecosystems, and habitats with the least disruption to neighborhoods, cultural resources, and livelihoods. But how can we do this when the seas and temperatures are rising far more quickly than we ever thought possible? And when we live in a world where the neighborhoods and nations least able to pay for adaptation are the ones that face the most risk? The cost of adapting our world will be far greater than anything we have witnessed in modern times, but the cost of not adapting our world will be nothing short of catastrophic.

So what can philanthropy do?

First, philanthropy can encourage risk taking. We need to be willing to try new approaches and invest in innovation. Some ideas won't work and some projects will fail, but we won't make progress if we don't embrace risk. We need to get comfortable with supporting early-stage projects that may not yet have proof of concept. Some exciting ideas I've learned about recently include augmenting barrier islands or even building new ones, establishing sponge cities, creating eco-reefs, and developing green seawalls that can absorb wave energy while also cleaning the water and enhancing habitat. These are just a few of the concepts that we need to continue testing in a variety of real-world settings to see how they perform.

Second, philanthropy can help develop policies that will enable more capital to be available for resiliency and adaptation. It is not enough to create the solutions, we also need to know how we will pay for them. The upfront costs of adaptation are enormous and we must make progress towards quantifying the savings and loss prevention over time.

We can learn from organizations like Boston-based Social Finance which is pioneering new ways to complement philanthropy and government spending by developing investment opportunities that deliver positive change in our society.

And we can learn from governments and NGOs that are experimenting with resiliency banks that issue green bonds, loans and grants to finance resiliency projects. The state of Massachusetts and the City of Boston are leading the way by elevating climate to the very highest levels of government. Under Governor Healey, Massachusetts established the nation's very first state climate chief as well as the country's first green bank dedicated to affordable housing. Under Boston's Mayor Wu, the city appointed its first ever Chief Climate Officer as well as an ambitious green new deal.

Third, philanthropy can incentivize partnerships. Foundations and donors can be nimble with their funding and can serve as the connective tissue that gets multiple sectors rowing in the same direction. Unlike governments, universities and large corporations, which often have complex bureaucracies to navigate, philanthropies have the ability to act quickly and can require partnership as a condition to funding.

Our Foundation embraced these values when it worked to co-develop the Stone Living Lab headquartered in Boston Massachusetts. The Lab is a partnership of the University of Massachusetts Boston; the NGO Boston Harbor Now, the City of Boston's Environment Department; the Massachusetts Department of Conservation and Recreation; the Massachusetts Office of Energy and Environmental Affairs; the National Park Service; and the Massachusetts Tribe at Ponkapoag.

The Living Lab was established to test and scale nature-based approaches to coastal resiliency in and around Boston Harbor while engaging in place-based climate education and community focused research in collaboration with local municipalities and NGOs.

As of today, the Lab has several projects, each of which has been co-developed with practitioners. One currently underway compares the performance of cobble berms, also known as dynamic revetments. For this project, the Massachusetts Office of Coastal Zone Management partnered with the Stone Living Lab to evaluate the effectiveness and ecological impacts of cobble berms as nature-based solutions for coastal resilience. By comparing performance across six different sites, the Lab is gaining a deeper understanding of how these nature-based approaches function as well as the co-benefits they provide habitats and communities.

Another project designed in partnership with the City of Boston monitors the real-time impact of storms on neighborhoods across the City. The City of Boston's "Coastal Resilience Solutions" plans include over 70 climate adaptation projects totaling approximately $3 billion to be implemented within the next 20 years to prepare the City for sea-level rise and coastal storms. The Lab's real-time flood observations project is designed to help city managers improve storm models, understand exactly where flooding occurs, and make informed decisions about future resiliency planning. Better models mean more accurate predictions regarding the streets and neighborhoods that are most at risk. Just this past January Boston experienced a significant storm event that caused flooding throughout the city. During the storm, the late morning high tide was the fourth highest water level ever recorded in Boston Harbor. Our overland flood stations recorded 3.4 feet of flooding in one of Boston's most under-resourced neighborhoods. City officials are already incorporating this data into their resiliency planning and we will expand these monitoring capabilities to other municipalities in the near future.

The last project I will tell you about is a collaboration with Living Seawalls, a new evidence-based solution developed by the Sydney Institute of Marine Sciences. We first learned about Living Seawalls when Boston served as the host city for the prestigious Earthshot Prize. Living Seawalls panels, when placed on hard seawalls in urban coastal waters, are examples of effective green infrastructure that have been proven to increase habitat and water quality. This spring, when we install over 200 panels at two different Boston locations, it will be the first time Living Seawalls are installed as part of a controlled experiment in North American waters.

The Stone Living Lab was borne out of a local challenge – the Boston area is predicted to experience some of the most severe sea level rise in the world. The water in our harbor is eight inches higher than it was in 1950 and is now rising by approximately one inch every eight years. As a response, we have demonstrated that philanthropy can serve as a catalyst to bring academia and the NGO sector into close collaboration with all levels of government.

As the Holy Father has written so eloquently, "our responses" to the climate crisis "have not been adequate while the world in which we live is collapsing and may be nearing the breaking point."

Philanthropy must take bold action. We don't have the luxury of time. But we also cannot fall victim to despair. We must redouble our efforts to

take risks, prioritize partnerships, and work with colleagues from diverse cultures, disciplines and nationalities as we spur innovation and address what is undoubtedly one of the greatest challenges of our lifetime – building a more just and resilient world.

Thank you.

YOUTUBE PRESENTATION

Climate and the Private Sector

Dr. Andrew Forrest
Fortescue, Australia

https://youtu.be/CsieVw2jxkc?si=oxOCB9oj1YnAplaf

SESSION XII – VOICES OF THE YOUTH

Listening to Children is Listening to Nature

Carla Rinaldi
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President of Fondazione Reggio Children – Centro Loris Malaguzzi

Young people from all over the world brought a child-centered vision to the Summit. Children are the first victims of climate change, but they are also the best listeners of Nature, the ones who can take adults by the hand and completely change their paradigm. Childhood is nature; it is in symbiosis with nature. Listening to childhood, recognizing its role in society, and strengthening quality education are essential steps to dealing with climate and all emergencies. Quality education is a response to all emergencies.

Ecohope or Ecoesperanza is a word that I carry in my heart after the joy of participating in the Summit "From Climate Change to Climate Resilience" convened by the Vatican through the Pontifical Academy of Sciences and the Pontifical Academy of Social Sciences. Together with the best academics, experts and witnesses of climate change around the world, I was alongside Catarina, Francisco, Lu, Daenisha, Carlos, Sashoi and Maria Helena, a beautiful group of very young people, from different countries, sensitive and competent in launching a direct appeal to us adults. An appeal that comes from the daily experience of each of them, in Boston or in Colombia or in the Amazon, but which also has roots in the participatory process linked to the Convention on the Rights of the Child, which led to the General Comment[1] addressed to governments in order to consider the devastating consequences of climate change on children's rights.

1. The importance of a child-centered vision

Listening to children and young people is the main mission adults can devote themselves to. This is my idea, my belief as a pedagogist, teacher, and president of Fondazione Reggio Children, a foundation that deals with educational emergencies, starting from an experience, the educational ap-

[1] OHCHR, General comment No. 26 (2023) on children's rights and the environment with a special focus on climate change" to the Convention on the Rights of Child. www.ohchr.org

proach developed in my town, Reggio Emilia, which tries to be child-centered. To be child-centered is in its identity.

For this reason, I've been thrilled that childhood and adolescence have been at the center of the prestigious Summit. They were protagonists in a critical session that demonstrated the importance of being child-centered. This means we want to look at children with new and different eyes. Adolescents put children at the center as a starting point for a new peaceful cultural regeneration, a sort of quiet revolution.

These adolescents looked at children directly in their eyes, which made them able to look at the world with the eyes of children. They demonstrated how strong their thoughts are and how powerful their message is. They made a revolution in themselves and changed their role as if they were not necessarily the ones that have to learn from adults but the ones that have to teach them. They suggested us a new balance of power, a provocative expectation. They showed us another perspective, to see ecological hope or revolution as a change in our personal ecology, where the change is the research for a new equilibrium.

A complete change of paradigm is what young people offer us. We have to learn to trust them. They trust us a lot; they are generous. The holistic, ecological approach they offer us touches us through empathy. This is why we must embody this kind of revolution inside ourselves.

2. Listening to children, young people by adults

For this to happen, we must develop a unique pedagogy, the pedagogy of listening, which is also a pedagogical practice.[2] It is a process that we are witnessing here. What does it really mean to listen? I also had the great opportunity to bring this issue to the attention of the Global Compact for Education.[3]

From our perspective, listening is not just hearing but being open to differences, giving value and importance to the Other, to Otherness. Listening, in the deepest sense, means being ready to change. It means accepting that the real encounter with the Other changes you.

[2] Rinaldi C.,2021, *In Dialogue with Reggio Emilia, Listening, Researching and Learning,* 2nd edition, Routledge, OX.

[3] Rinaldi C., 2022, *Early Childhood in Reggio Emilia and in the World*, in Suárez-Orozco M. and Suárez-Orozco C., *Education. A Global Compact for A Time of Crisis*. Columbia University Press, NY.

So, listening as a metaphor is even more critical today, when our society can no longer listen to the Other, but everyone follows the flow of their thoughts.[4]

Listening means emotions, empathy, interdependence, and reciprocity. In this way, we get to reach that dimension of reciprocity in which the adults revisit their role as co-constructors of knowledge and culture together with children to the point of being guided by them.[5]

The same listening attitude must be adopted towards nature and the world around us to move towards Climate Resilience. To better understand the learning process in the relationship with toddlers, young people, and peers, we adults have to revisit our role, becoming the ones listening and encouraging questions, according to the "expansion of questions" that Jerome Bruner[6] always recommended to us in his frequent visits to Reggio Emilia. Cherish the questions, says the poet, the same one who writes, "We must become children if we want to reach the sublime."[7]

The teacher learns to be a teacher with the children, by listening to them, by listening to their continuous, repetitive, and transformative questions. Children are the best and most natural researchers.

3. Children as the best listeners of nature

Children are the best listeners of nature, and this is why we should learn to listen to and learn from them. The multiple intelligences theorized by Howard Gardner, like The Hundred Languages that children can use, theorized by the pedagogist and philosopher Loris Malaguzzi,[8] are the thousands of ways to build relationships with living beings and elements. Children are nature and can become nature.

The encounter with the Child and the Youth is profound, an intercultural encounter. The cultures of childhood and adolescence are qualities of our lives, glimpses of the world that we adults have lost. Encountering them questions us on the fundamental issues of our existence, like our relationship with nature.

[4] Chul-Han B., 2016 *Die Austreibung des Anderen*, S. Fischer Verlag, Frankfurt a. Main, Germany.

[5] Dewey, J. (1916), *Democracy and education*, McMillan, New York.

[6] Bruner, J.S. (1996), *The culture of education,* Harvard University Press, Cambridge.

[7] Rilke, R.M. *Lettere a un giovane poeta*. Piccola Biblioteca Adelphi, 110, 1980.

[8] Gardner, H. (1983), *Frames of mind. The theory of multiple intelligences*, Basic Books, New York.

Children are our cultural mediators regarding nature because they know how to listen to it. We keep saying, "We and nature," while children are able "to be and to become nature." It is necessary to have the courage to listen to nature through the words of children and youth. As we said, it is not just about hearing but also about listening, acknowledging deeply, and acting accordingly.

2.1 Children in dialogue with peers and trees

While trying to better explain the meaning of listening also as a pedagogical attitude and that children are the best researchers, as they bring wonder and enthusiasm, I had the opportunity during the Summit to share some images and a video showing the power of childhood imagination. When we talk about the culture of childhood, we are really talking about a different culture acquired through the hundred languages that children have. Through this video documentation, "Imagine a forest", we can truly appreciate not only the research carried out by the protagonists, the children, but the great work of listening and processing by the teachers behind the scenes.

In "Imagine a forest," which celebrates trees and the natural world, with the voices and drawings of children from all the preschools and infant-toddler centers of the Municipality of Reggio Emilia together with Reggio Children,[9] you can admire this ability of very young people to be nature. Five-year-old children dialogue with each other and say that "trees have a memory to survive," "have brains," that "beauty is the voice of the trees", and that "trees speak the Treesese language". They say that the strength of trees is not muscles, but "fortitude". They know that trees need friends like "suns, clouds, stars and moons". Children know that "for a habitat you need food, water and air" and that if you don't have a habitat "you have to go and live somewhere else". Children discover the Livingence as a kind of era that unites "living beings, everything and everyone".

[9] "Imagine a forest" is made by children, teachers, atelieristas and pedagogists of the municipal infant-toddler centres and preschools of the city of Reggio Emilia. Concept and video editing: Sara De Poi. Motion graphics: Sara De Poi and Simone Pace. Soundtrack created by the boys and girls of the Ernesto Balducci municipal kindergarten. © Scuole e Nidi d'infanzia – Istituzione del Comune di Reggio Emilia and Reggio Children. www.reggiochildren.it

3.2 Together without hierarchy

Not the humans-nature relationship but the children-youth-nature relationship shall characterize our era. Childhood still has the ability to interpret nature with all senses, the good look of nature. Children know how to see the invisible, open themselves to the Other, and be transformed by this encounter. The child's relationship with nature is a question that concerns biology: the instinctual, protective relationship with the living. Also, the fact that the child activates all their senses allows them to be immersed in nature, in a reciprocity that is complete, a quality of the embrace that is the same symbiosis as the embrace of the mother who nourishes the child, in a reciprocal immersion of listening, of trust, of the ability to abandon oneself, and which includes all living beings. So, we must move from "humanity and nature" to "humanity is nature". Childhood is nature, on the basis of the relationships whose interdependence and lack of hierarchy you perceive.

3.3 The role of adults and a policy for childhood

This invites us adults to question ourselves seriously and concretely on what to do, how to do it, and the relationship between rights and responsibility. It is the right-duty of being adults to humbly take a step back, to have the courage to listen to nature through the words of children and youth, as we did during the Summit, accrediting an enhancement policy of childhood and adolescence, with all the importance and beauty of the fragility they bear. Beauty and fragility are combined in the uniqueness of every person and every creature, as the Holy Father Francis teaches us, in a vision of the "throwaway culture" that is profoundly ecological, as well as ethical, social, political and metaphysical.[10] Fragility is a quality in the face of what is powerful and devastating. Everything that most moves us in Creation is fragile: a child, an old person, a drop of dew, a ray of sunshine. Fragility is a quality to be valued and taken responsibility for. The partners that we, as adults, have in this challenge are childhood and adolescence, and childhood and adolescence are a resource.

Thinking about them with them, leaving childhood and youth their leading role, is the only way forward in the path we want to follow of Mitigation, Adaptation, and Social Transformation. Acting alongside them and building responses with them is the necessary change that also affects

[10] Francis, 2015, *Laudato si'*, Encyclical letter of the Holy Father Francis on Care for Our Common Home, nr 22.

us. The path set by the Summit is the right one: a culture of childhood, a child-centered approach, and a children's rights-based approach to the environment. Dropping this premise and promise, disappointing these future adults' request to change, would be the most severe crime that our society could commit.

Our challenge is to love childhood mightily. Therefore, investing in quality education is indispensable to helping society take on this responsibility.

4. Recognizing children in our societies

Nowadays, emergencies can no longer be considered anomalies but a permanent status. Quality education for all children remains a difficult target to reach and, in addition, childhood is the most affected by emergencies. Carola Suárez-Orozco's documented report on educational poverty and on the impact of climate change on young people brought this evidence to light at the Summit. This target of quality education for all children must be tirelessly supported, and fundamental questions and cultural issues need to be faced. Where is the acknowledgment of children and young people in our society? In my opinion, childhood still does not garner the necessary social and political prominence. Recognizing childhood as a quality of life, as a culture to be preserved throughout life, recognizing that young girls and boys are citizens endowed with great and unrepeatable potential, competent to learn with others, bearers of rights from birth and of the right to quality education, is a step that must be taken by our societies. Let us start from here. It is an ecological issue, a question of the ecology of the mind. Furthermore, we are deeply convinced that education is the answer that helps us deal with all emergencies, as we wrote in our chapter "Quality education, a global challenge".[11] It implies a vision of humanity starting from childhood. This is the job of quality education, which has a key role in the fight against educational poverty, contributing to building democratic societies and citizenship based on participation and solidarity.

4.1 Emergencies affecting childhood

Major emergencies that affect entire societies, and in particular childhood, are to be found in refugee camps: migrations and famines, wars, regimes, discrimination, climate disasters, the exploitation of labor and traf-

[11] Fondazione Reggio Children, 2022, *Quality Education, a global challenge*. www.frchildren.org

ficking in human beings, the globalization of indifference, in the retreat towards individualism and isolation. And, of course, there are other forms of poverty in our advanced societies: there is an educational poverty linked to economic hardship and the fragility of communities and families; lack of relationships, individual and psychological fragility, which emerged and exacerbated with the consequences of the pandemic, the digital divide and the lack of digital culture.

There is the poverty of beauty and care in public and private spaces, there is the poverty that concerns the disappearance of the relationship with nature and with the community of the living beings, and there is also the poverty and loneliness of children at the center of too many stimuli and too much attention.

4.2 Education as the most serious emergency

A choral action needs to be taken in favor of and alongside children, to defend their rights, to give them a voice, and to listen to their voice, which, as we have seen, shows us the way to the solution of our common problems. This dream is not condemned to remain a utopia but can be achieved collectively, with a common action and a cultural change.

Suppose it is true that the climate change emergency, which affects the lives of millions of people, leading to migration and poverty, depends on human behavior. In that case, the most serious planetary emergency is the educational one. "Education is one of the most effective ways to humanize the world and history", Pope Francis wrote in his message for the Global Compact for Education.

We have all seen how young people have been the first to passionately embrace the ecological cause. We are therefore called to collective action to make childhood and young people visible and protagonists by listening to and talking to them. Paraphrasing ourselves, we could say that we are making childhood visible. The invitation is to have the courage of the future to look for new paradigms, letting ourselves be taken by the hand by childhood, to welcome the present and the future without being overwhelmed by indifference and resignation.

5. Acknowledgments

In closing, I would like to express my deep gratitude to Professor Marcelo Suárez-Orozco, together with Professor Veerabhadran Ramanathan, for the immense work done and the magnificent framework given to the Cli-

mate Change Summit. A special thank you from me, both for the invitation to this high-level meeting and for connecting me with young people who are passionate about saving life on the planet. A group of young people, who, thanks to the Pontifical Academies, has been given the opportunity to speak to the great thinkers and decision-makers of our time, is a development that gives us hope, Ecohope, and trust.

Propelling Climate Literacy in Our Youth: The Example of California

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"We are the first generation to feel the consequences of a warming planet, and the last generation that can steer a different course."
Rosanna Xia

As described by environmental writer, Rosanna Xia, this time in human history is temporally perched in a hinge moment: between actions that will directly address the earth's climate changes or inaction that will lead ineluctably to disaster for the planet and the species. In her book *California Against the Sea: Visions for Our Vanishing Coastline* (2024), Xia uses California as an example of both the many threats to the planet and an approach to meeting these threats through collective knowledge and its filial complement, environmental justice. Along similar lines, Pope Francis (2020) uses Friedrich Hoelderlin's poem 'Hyperion' to inspire hope in the pursuit of that knowledge: "Where danger is, also grows the saving power." He goes on to say, "That's the genius in the human story. There's always a way to escape destruction. Where humankind has to act is precisely there, in the threat itself: that's where the door opens" (para. 17).

In this volume and the Vatican meeting that they organized (2024), leading climatologist, V. Ramanathan and university president Marcelo Suárez-Orozco champion an emphasis on Climate Resilience as the foundation for educating ourselves and our youth to use our knowledge and power to propel us into action. To achieve Climate Resilience, they advocate a multi-pronged, trans-disciplinary approach. One of those prongs involves a commitment to a type of education for the young that transforms the way that they think and we all live. The goal is to equip our society to understand the sources of our climate crisis, the lasting changes needed to address it, and the steps needed along the way to respond to the inevitable disasters accompanying the effects of the ongoing climate crisis.

This paper will use the example of California to illustrate both ongoing and future efforts to give our youth the tools they need in this mission, beginning with *climate literacy*. Just as literacy is the foundation for educating the individual, we conceptualize climate literacy as one of the principal building blocks for educating our society's resiliency in the face of the climate-based hazards to survival that have already begun.

Alberto Manguel, in his book *Fabulous Monsters: Dracula, Alice, Superman, and Other Literary Friends*, writes (2019), "What has become a cornerstone of faith for me, truer than true and more so as time goes by, are the words the Abbot says to the painter of illuminations, in Kipling's story 'The Eye of Allah': 'But for the pain of the soul there is, outside God's Grace, but one drug; and that is a (hu)man's craft, learning, or other helpful motions of mind'" (p. xxii). Building the mindsets of our youth through learning is a "cornerstone of faith" for those who choose collective action over inaction, over indifference, and over outright denial in this hinge moment. It is learning, therefore, that becomes the antidote to disaster. In the words of Pope Francis (2020), education is "one of the most effective ways of making our world and history more human…Education is above all a matter of love and responsibility handed down from one generation to another" (para. 7).

Frank Niepold, Senior Climate Education & Workforce Program Manager at the National Oceanic and Atmospheric Administration, has outlined all the ways in which key leaders are already building climate literacy. He identifies that our students are being educated not only in schools, but also in communities and through organizations such as museums, zoos, and parks, and through engagement in youth groups and faith communities. Climate literacy is further maintained through constant communication through entertainment organizations and media outlets, and through our access to important and timely information as provided by federal, state, and international agencies. Finally, a deepening of climate literacy can be sustained by the kinds of coordination that can be delivered by local government and community groups, as well as the kinds of training and workforce development that professional organizations and unions can provide (2024). As emphasized at the climate resiliency meetings at the Vatican and an ensuing meeting in Santa Barbara (2024), there is a great need for far better coordination of the many current efforts on climate change both within groups working on the same conceptual area (e.g., community preparedness or climate literacy) and across all climate-related areas so that silos can be prevented and knowledge can be better accessed and shared across groups.

California provides a unique opportunity to begin to link the various organizations and approaches to climate literacy, beginning with initiatives at the state level. For example, California uses Assembly Bills on Climate Literacy and Resiliency to initiate changes in its schools. Assembly Bill 3051 allows the state's taxpayers to donate to the California K-12 Climate Change Education Voluntary Tax Contribution Fund, which is used to "award grants to school districts, county offices of education, resource conservation districts, district and county office of education partnerships with higher education institutions, and community-based nongovernmental organizations focused on environmental and climate change education" (2024, §18752, No. 2A**).** More specific in its intent, Assembly Bill 285 (2024) requires a California course of study for grades 1-6 and grades 7-12 to emphasize the causes and effects of climate change and methods to mitigate and adapt to its effects. Assembly Bill 130 (2024) contains a provision appropriating funds to build free and open education resources on climate change and environmental justice for K–12 students through standards-based curriculum units and the integration of environmental principles and concepts.

Such initiatives directly and indirectly target the three pillars of an overall approach described by climate scientists like Ramanathan: Mitigation, Adaptation, and Societal Transformation (MAST) (2024). That said, the onus is upon how MAST initiatives are implemented in local communities and schools so that our youth become part of the solution. According to a press release from Ten Strands (2021), a non-profit organization aimed at raising environmental literacy in California, "Senator Ben Allen [D-District 26] led the way in championing the proposal to change the way California teachers and students understand climate change and environmental justice issues while developing critical thinking skills around global topics. Ten Strands… worked with Senator Allen to garner support for this budget request" (para. 3), recruiting over 165 nonprofits, county offices of education, school districts, teachers, regional parks, and organizations to endorse the appropriation. Organizations such as Ten Strands are involved in creating such curriculum units dedicated to a developmental approach to Climate Literacy in K to 12. A related group, the Environmental and Climate Change Literacy Projects (ECCLPs, pronounced "eclipse"), aims to "Educate, activate, and empower all California students by the time they graduate to be literate in climate and environmental justice issues, drivers of solutions, and to become environmental stewards of our planet." (EC-

CLPs, n.d.). The ECCLPs is a multisystem initiative organized by the UC and CSU systems in partnership with key community partners in PK-12 school districts.

The University of California operates 10 campuses and includes more than 280,000 students and more than 227,000 faculty and staff, with 2 million alumni living and working around the world, while the California State University operates 23 campuses and educates 485,550 students every year. The partnership with Ten Strands and ECCLPs aims to advance PK–12 climate change literacy and environmental justice by focusing on teacher preparation and professional learning, and annually to graduate 400,000+ California high school students to be literate in climate change and environmental justice issues and solutions. This is achieved not only through the aforementioned government initiatives and local communities, but specifically through programs that already promote literacy itself.

Our research team within the UCLA/CSU Collaboration for Neuroscience, Diversity, and Learning hopes to connect our research on literacy development to the work on Climate Literacy by groups like Ten Strands and ECCLPS. Our work underscores that literacy is our species' change agent: the means to changing our brain, the individual's life trajectory, and the future of our species. Too little understood in our current milieu, the human brain was never born to read. The act of learning to read has not only added an entirely new circuit to our brains, but also changed the very structure of that circuit's connections. It is the brain's plasticity that allows new circuits to be made by connecting older cognitive and linguistic structures (like vision and language) to new knowledge. Just as a young brain becomes literate through time, exposure, teaching, and effort, the same principles for its development are useful to incorporate in curricula that help our young become climate literate. By making climate literacy one of the basic foundations of our entire educational curriculum, we can take advantage of the brain's ability to go beyond its original capacities and develop whole new pathways, just as it must do to form what we call *deep reading*.

It is important to provide a description here of what deep reading involves, so that the intersection between cognitive neuroscience research on reading can propel work on climate literacy development. Briefly, deep reading represents the development and integration of some of our most sophisticated cognitive, affective, and linguistic processes with basic reading skills. These processes include the formation and continued growth in background knowledge; empathy and perspective-taking; inference and

deduction; critical thinking; and insight-driven reflection. These same deep reading processes are fundamental to both expert reading and to climate literacy. Together they are the foundation for the future growth and development of our citizenry of the 21st century. Neither can be taken for granted in the present.

In the United States, the National Assessment of Educational Progress (NAEP) frequently discusses as our country's grade card for its students. NAEP describes the relative performance of our students on areas like reading and math. Progress is depicted as *basic, below basic, and proficient* for those who are fully comprehending what they read. Very importantly, the most recent NAEP report indicates that only one-third of our fourth and eighth grade students reach the *proficiency* level, while a staggering majority of children of color never reach *basic* levels of reading, much less proficiency (NAEP, 2023). This has led to a recognition that the US has a "literacy crisis", which has led to increased attention to the development of literacy in the K-12 areas. We believe that this attention for greater funding for better methods for the teaching of literacy can be combined with climate literacy initiatives. Our existing work on the reading brain suggests that the same principles for teaching the deep reading processes underlying *proficiency* are equally important for attaining climate literacy. Just as UCLA Dean Tina Christie (2024) advocates the incorporation of climate literacy efforts within funding for community schools, we advocate that we piggy back efforts to create *reading proficiency alongside climate literacy initiatives*.

Such a combined set of emphases could undergird a future, developmental curriculum for climate literacy for PK to 12. More specifically, at every age there would be age-appropriate stories, curricular activities, and books with emphases on background knowledge empathy, inference, and critical thinking. There would be an entire strand in the reading and language arts periods in school that would be devoted to climate literacy-based concepts found in stories written especially for this goal. Every new story in this strand could introduce new information about the earth (i.e., Background Knowledge) or about how others think and feel (Perspective-taking), and a chance to try this on for themselves in their lives (Empathy and Reflection).

Very important for issues that too often polarize members of our society, stories allow us show how differences between us and "others" can be the very things that bring us together and allow us to imagine whole new worlds. Thus, the emphases in empathy and background knowledge can be developing the ability to read text ever more deeply, all the while learn-

ing new knowledge and developing new ideas about their own potential for "bending the curve" (Ramanathan et al., 2019) of climate warming. In addition to developing new emphases in curricula (e.g., programs like Ten Strands and ECCLPs) based on neuroscience research on deep reading, there can be an effort to add climate literacy emphases within existing reading intervention programs (e.g., our own RAVE-O program). Due to the work by the Vatican's Pontifical Academy of Science and Pontifical Academy of Social Science, we have begun to build new stories and activities based on climate resiliency for struggling readers. Thus, we are using our interventions for increasing deep reading to teach climate resiliency and a path to action by our youth.

Until this time, we have conceptualized literacy programs as a way to build a kind of a moral laboratory for what Martha Nussbaum called "compassionate imagination." We now wish to add to our programs stories with emphases on empathy, background knowledge, and reflection that can become a building block for environmental justice and climate literacy. This kind of youth engagement, allowing our youth to pass over into the consciousness of another, is an ability that is, according to Junot Diaz, the "closest we can get to telepathy." Such a capacity has never been more important for empowering us to understand the needs of others around a troubled planet, and indeed the needs of our entire species.

Another goal within our reading-brain-based curricula is the formation and development of critical analysis processes. These capacities have also never been more important for our society and especially for our more vulnerable young. Critical thinking processes are not only the basis for reaching proficient, deep reading, they are also the basis for protection from the rampant misinformation and disinformation that bombards our society. Armed with metacognitive strategies that teach our students to connect what they read to background knowledge, inferential and analytic thinking habits, we can help our youth learn to discern truth value and disregard misinformation and disinformation, particularly with regard to the maelstrom of misinformation about climate change.

At its best, deep reading goes further than the very important use of critical analytic and empathic processes when young readers encounter text. Although it is never a given, deep reading can help the young and older readers strive to develop their own thoughts about what they have read. In the process of such a goal, the readers can discover not only their own unique insights and associations, but also their own path to acting upon

such insights. Such a path can contribute to climate literacy by the realization that, in the words of St. Thomas Aquinas, "We must hang on to others the things gained in contemplation." When work on literacy and climate literacy is combined, this 'handing on' can become a catalyst to action and part of the antidote to the hinge moment that we find ourselves facing. As Fr. John S. Dunne (1985) said, "Wisdom… is not contemplation alone, not action alone, but contemplation in action" (p. 77).

There may be no other sector in our population better primed to take action on our climate issues than our youth and young adults, many of whom are already taking action. The example set not only by the fictional characters, but also by the real child actors playing them in the American TV series "Jane," focuses on our environment and its endangered species. Produced by the Jane Goodall Institute, this program and its young actors serve as a reminder of the untapped power of our young, especially in California. In her review of this television show in the LA Times High School *Insider*, high school junior Sherman Kim (2024) writes that "the environmental issues are becoming so dire that even the children must now take action" (para. 6). She memorably concludes: "the morality and clear view of the world that children possess could do wonders for the world" (para. 6).

Yet another CA high school student, Anaya Gupta, has designed a high school curriculum called "Bending the Curve" to propel climate literacy and to mobilize youth. Based on her grandfather Ramanathan's highly influential book of the same title, her curriculum teaches a foundation in climate change knowledge and a universal language about climate literacy that students can apply to their own forms of targeted action. It is extraordinary to see such a young person describe the need for modules that teach our young, her cohort, background knowledge about social justice, mental health, the government, and how to effectively communicate and talk about climate change.

In summary, one of the major prongs in our approach to teach climate literacy and resiliency must be based on education. Although our emphases in this chapter are predominantly directed to learning for our youth, we believe that climate literacy begins well before the child enters school and must continue through the life span if our society is to save itself. That said, an important force in education has to be on the ethical, empathic, thoughtful formation of our young citizens and the utilization of the inimitable energies and idealism of our young. Placing increasing focus on climate literacy in our youth and giving them the tools to take meaningful action

is essential for their future and ours. As high school student Sherman Kim wrote, the views of the young can do "wonders for the world".

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YOUTUBE PRESENTATION

Voices of the Youth

Catarina Lorenzo, Lu Lipmen, Carlos Bautista, Daenisha Howard Oliver, Sashoi Sanchez, Francisco Javier Vera

https://youtu.be/w_294GpGu1k?si=3KCnUVS4879MaYCZ

SESSION XIII – ROLE OF SCIENCES IN REDUCING CLIMATE RISKS & ENHANCING CLIMATE RESILIENCE

No Child Left Inside: Nature-Based Education as Holistic Approach to Climate Resilience and Sustainable Development

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"In the end we will conserve only what we love;
we will love only what we understand;
and we will understand only what we are taught."
Baba Dioum, 1968 IUCN General Assembly

Abstract

This paper explores Nature-Based Education (NBE) as a transformative approach to addressing the global climate crisis at the local level and fostering sustainable development. By integrating environmental learning with traditional academic subjects, NBE offers a holistic educational model that enhances cognitive and academic outcomes and promotes emotional and social development, community engagement, and climate resilience. This paper outlines some of the theoretical foundations of NBE, its practical implementations, and its potential impact on creating a generation of environmentally conscious and action-oriented global citizens.

Introduction

We stand at a critical juncture in our journey as a species and as stewards of our planet. The threats posed by climate change are pervasive, impacting every facet of our existence. And while children have not contributed to this crisis, it disproportionately affects them. A comprehensive report prepared in 2021 by the United Nations delineates the severity of the Earth's triple environmental emergency: climate change, biodiversity loss, and pollution (UN, 2021) and the impacts of this poly-crisis – resulting from the interconnected and escalating nature of multiple global crises such as food scarcity, lack of potable water, migrations, epidemics, droughts, floods, and

heat waves – are particularly acute for children, due to their unique developmental characteristics (UNICEF, 2016). It should be alarming to all to note that more than one in four deaths of children under the age of five is directly or indirectly related to environmental hazards (WHO, 2017).

In addition to the impacts of climate change, children are experiencing another interconnected crisis, which is less often discussed. The quality and quantity of children's access and connection to the natural world significantly declined. Ailton Krenak, a Brazilian Indigenous leader of the Krenak ethnicity, argues that the primary cause of the socio-environmental crises we face today is the disconnection of Western humans from the living organism we belong to – the Earth (Krenak, 2019).

The severity of the human impact on the planet mustn't be merely a forecast of doom but a catalyst for change. To this end, we argue that a progressive, transformative education agenda should be central to global resilience and societal transformation efforts. This agenda should equip individuals as agents of change, actively engaging them in developing and implementing solutions through new technologies, effective policies, or sustainable business models. Achieving this requires acknowledging the disconnect observed by Ailton Krenak and a profound transformation in how we engage children in learning that involves restoring children's fundamental space for exploration and experimentation – nature – granting them the right to a healthy environment and the experience of perceiving nature as a living being deserving of respect. Such an approach is essential for developing an understanding of and respect for interdependence, which is crucial for our survival (Louv, 2008).

Education as a Solution

Our complex global climate change emergency necessitates innovative solutions and collective action, with education being one of the most powerful tools at our disposal. The United Nations and other agencies are pivotal in shaping global responses to climate and biodiversity crises, which includes ways in which education could and should be a central piece of climate resilience and societal transformation. General Comment 26 of the UN Committee on the Rights of the Child underscores the importance of ensuring that all children have access to an education that prepares them to face environmental and climate challenges (UNCRC, 2021). Opportunities for education, as mandated in the UNFCCC Paris Agreement and the Convention on Biological Diversity Kunming-Montreal Global Biodiver-

sity Framework (KM-GBF), are mobilizing governments around the world to include climate education and biodiversity education in their national curricula, National Adaptation Plans (NAPs), and Nationally Determined Contributions (NDCs) as never before (UNFCCC, 2015; CBD, 2020).

Globally, educational systems must transform to ensure that every child engages with the climate crisis both inside and outside the classroom. Schools should become centers of climate resilience, fostering access to and connection with nature for children, youth, and their families. (Green Education Partnership – UNESCO) They should facilitate the development of knowledge and skills that empower young people as change agents for the green transition our societies need to survive. Nature-based education (Sobel, 2013) can ground this transformation by reimagining schools, curricula, spaces, and communities by providing a pathway to develop resilient, aware, and ecologically literate people who are prepared to take on our climate challenges now, not tomorrow, with knowledge, passion, compassion, and care.

Nature-Based Education: A Whole-Child Development Approach

As climate change and environmental degradation become increasingly prominent global concerns, education systems worldwide seek innovative approaches to foster environmental stewardship, resilience, and sustainability. One such promising approach is Nature-Based Education (NBE). Nature-based education is rooted in the belief that direct interaction with nature is essential for whole-child development by integrating environmental learning with academic subjects and social-emotional learning and emphasizing the interconnectedness of humans and nature in communities and globally.

Starting with early childhood, it should emphasize free play in nature, fostering skills like problem-solving and empathy (Wilson, 2012). As they progress through school, learners explore the environmental, social, and economic dimensions of climate change, linking scientific principles with concepts of justice, as nature provides a learning space for culture, diversity, languages, investigating natural phenomena, and problem-solving. This prepares learners to advocate for sustainability and climate resilience at higher levels of education (Sterling, 2010). For neurodiverse learners, NBE provides an inclusive and supportive learning environment that caters to diverse learning needs. The sensory-rich experiences offered by nature can be particularly beneficial for students with autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD), who often thrive in settings that allow for movement and sensory engagement. The calming ef-

fects of nature can help reduce anxiety and improve focus, making learning more accessible and enjoyable for neurodiverse students.

Integrating Indigenous knowledge into NBE provides all students a richer, more diverse educational experience. Indigenous communities possess a wealth of traditional ecological knowledge developed over millennia. This knowledge includes sustainable practices, spiritual perspective and a deep understanding of local ecosystems, which can enhance NBE curricula.

NBE benefits individual students and has the potential to enhance community resilience. Schools that adopt NBE practices often become hubs for environmental education and action, influencing the broader community. Projects that involve students, parents, and community members in environmental initiatives create a culture of sustainability and resilience. Urban schools face unique challenges in implementing NBE due to limited access to natural spaces. However, innovative solutions such as green roofs, urban forests, and natural playgrounds can bring nature into urban school settings.

Educated and environmentally conscious students are more likely to engage in policy advocacy and environmental stewardship. NBE encourages students to participate in climate action initiatives, equipping them with the skills and confidence to advocate for local, national, and global sustainable practices (Sterling, 2016). Programs that involve students in climate strikes and public speaking events amplify their voices, influencing policy decisions and promoting environmental justice.

This paper aims to provide an overview of Nature-Based Education, exploring some of its theoretical foundations, practical implementations, and potential impact on creating environmentally conscious and action-oriented individuals. We argue that NBE is an educational reform and an essential evolution toward a sustainable and resilient future.

Theoretical Foundations of Nature-Based Education

Nature-Based Education (NBE) is grounded in a rich array of educational theories and pedagogical approaches emphasizing the importance of experiential learning and connection to the natural world. These theoretical underpinnings provide a robust framework for understanding how direct experiences with nature can facilitate deep, meaningful learning and foster a sense of environmental stewardship. By synthesizing various educational philosophies, NBE creates a comprehensive approach to education that addresses not only academic goals but also the broader developmental needs of students in the context of our rapidly changing environment.

As originally described by John Dewey, *experiential learning theory* grounds NBE by providing a framework for understanding the learning process through direct experiences with nature. Experiential learning describes a cyclical process involving four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. This theory aligns closely with the principles of NBE, emphasizing the importance of direct, hands-on experiences in the learning process.

In the context of NBE, direct experiences with nature initiate the learning cycle. For example, a student might experience the life cycle of a butterfly in a school garden. This experience leads to reflective observation, where students consider what they have seen and how it relates to their knowledge and understanding of butterflies. The abstract conceptualization stage follows, where the student might connect their observations to broader concepts of life cycles and ecosystems. Finally, in the active experimentation stage, the student might design an experiment to test how environmental factors affect butterfly development. This cyclical process allows students to engage with environmental concepts in an intellectually stimulating and emotionally resonant way. The tactile, sensory-rich experiences nature provides help to strengthen neural connections and facilitate more profound understanding and retention of knowledge. Moreover, the experiential learning approach of NBE aligns well with students' diverse learning styles, ensuring that visual, auditory, and kinesthetic learners can all engage with the material in ways that best suit their individual preferences.

In addition to stand-alone lessons, experiential learning theory in NBE informs the overall structure of nature-based curricula. Educators design learning sequences that guide students through the experiential learning cycle, ensuring that reflection, conceptualization, and application opportunities follow concrete nature-based experiences. This approach helps students develop a deep understanding of environmental concepts and the critical thinking and problem-solving skills necessary to address complex ecological challenges.

As Sobel (2013) described, *place-based education* offers a complementary grounding for NBE. Place-based education emphasizes the importance of using the local community and environment as a starting point for teaching concepts across the curriculum. Notably, a key tenant of placed-based education supports the argument that learning is most effective when contextualized within the learner's immediate surroundings and lived experiences. This approach aligns closely with the goals of NBE.

In the context of NBE, place-based education encourages students to connect with their immediate natural surroundings, fostering a sense of place, belonging and environmental stewardship. This has several key benefits that contribute to the effectiveness of nature-based learning experiences. First, it makes learning more relevant and engaging by grounding abstract concepts in the familiar context of the local environment. For example, studying local watershed ecology can make principles of hydrology and ecosystem interdependence more tangible and meaningful to students. Second, it promotes a deeper understanding of local environmental issues and challenges. By studying their local ecosystems, students become more aware of the specific environmental concerns affecting their communities, which can inspire a sense of responsibility and a desire to take action. This local focus can serve as a gateway to understanding broader global environmental issues, as students learn to extrapolate from their local experiences to consider larger-scale ecological challenges.

Furthermore, NBE encourages community engagement and intergenerational learning. Students may interact with local experts, community members, and traditional knowledge holders during their learning experiences. This enriches their understanding of local environmental knowledge, strengthens community ties, and helps students see themselves as part of a more extensive ecological and social system.

The integration of place-based education principles in NBE also supports interdisciplinary learning. The local environment can serve as a unifying theme that integrates various subjects, from science and math to history and art. For instance, a study of a local river might involve scientific water quality testing, mathematical analysis of flow rates, historical research on human use of the river, and artistic representations of the river ecosystem. This interdisciplinary approach helps students develop a holistic understanding of environmental systems and their relationship to human society.

Systems thinking is another congruent framework for NBE, as it provides a framework for understanding complex, interconnected systems (Rohanna & Christie, 2023). This approach emphasizes recognizing patterns, relationships, and feedback loops in natural and human systems. In NBE, systems thinking is applied to help students understand the complex web of relationships in ecosystems, the global climate system, and human-nature interactions. Integrating systems thinking in NBE curricula helps students develop several crucial skills. They learn to identify the various components of environmental systems and trace their connections. Students al-

so develop the ability to recognize feedback loops and to understand how these loops can lead to either stability or change within a system. Moreover, systems thinking in NBE encourages students to consider multiple perspectives and to recognize the often-unintended consequences of human actions on ecological systems.

Nature-based education also draws on theories of social-emotional learning, recognizing that connection with nature can foster empathy, self-awareness, and social skills (Goleman, Bennett & Barlow, 2012). This element of NBE contributes to the whole child's development, preparing them both academically and emotionally to face environmental and other life challenges. The integration of social-emotional learning in NBE is based on a growing body of research demonstrating the positive effects of natural experiences on emotional well-being and social development.

A central aspect of social-emotional learning in NBE is the development of empathy, not just for other humans but all living things. Regular contact with nature has increased empathy and compassion as students develop a deeper understanding of and connection to the natural world (Goleman, Bennett & Barlow, 2012). This expanded circle of empathy can lead to more respectful environmental behaviors and a deeper commitment to conservation efforts.

Nature experiences in NBE also reduce stress and improve emotional regulation (Ríos-Rodríguez, Rosales, Hernández, & Lorenzo, 2024). Time spent in nature has been linked to reduced stress levels, improved mood, and enhanced ability to cope with life's challenges. These benefits are significant in the context of increasing rates of anxiety and depression among youth. By incorporating regular nature experiences into education, NBE provides students with valuable tools for managing stress and maintaining emotional well-being.

Additionally, NBE fosters the development of social skills through cooperative outdoor activities. Many nature-based learning experiences involve group work, whether it's conducting field research, maintaining a school garden, or participating in conservation projects. These activities provide opportunities for students to develop teamwork, communication, and leadership skills. These shared experiences in nature can also strengthen social bonds among students, creating a more positive and supportive learning environment (Ríos-Rodríguez, Rosales, Hernández, & Lorenzo, 2024).

Resilience development and self-reflection are other important outcomes of social-emotional learning in NBE. Overcoming challenges in natural settings, whether completing a difficult hike or solving an environmen-

tal problem, can build resilience and self-efficacy. These experiences help students develop the confidence and skills to face and overcome obstacles in their personal lives and in addressing larger environmental challenges. Nature experiences can also promote mindfulness and self-reflection, contributing to enhanced self-awareness. Activities such as nature journaling or solo time in natural settings encourage students to tune into their thoughts, feelings, and sensory experiences, fostering a deeper understanding of themselves and their place in the natural world.

In sum, the theoretical foundations of Nature-Based Education described here draw from well-known and understood educational and psychological theories. By integrating experiential learning, place-based education, systems thinking, and social-emotional learning, NBE creates a robust framework for educating the whole child. This approach enhances academic learning and fosters the development of environmentally conscious, emotionally intelligent, and socially responsible individuals equipped to face the complex challenges of the 21st century.

Some Key Components of Nature-Based Education

Nature-based education (NBE) is distinguished from traditional educational approaches by several key components. These components create a holistic learning environment that fosters deep connections with nature, enhances academic learning, and promotes environmental stewardship.

The emphasis on *outdoor learning environments* is central to NBE. This recognizes that nature itself is a powerful teacher, offering rich, multisensory experiences that cannot be replicated in a traditional classroom setting. Outdoor learning environments in NBE can range from school gardens, green and natural school grounds, and local parks to more extensive natural areas like forests, wetlands, or coastal regions. The benefits of outdoor learning environments are multifaceted. Research has shown that outdoor learning environments can improve cognitive function, creativity, and problem-solving skills (Kuo, Barnes, & Jordan, 2019). The natural world provides a wealth of stimuli that engage multiple senses and promote active learning. Outdoor learning naturally incorporates physical activity, contributing to improved fitness levels and overall health (McCurdy et al., 2010). Exposure to natural environments has been linked to reduced stress levels and improved mental well-being (Chawla, 2015). Importantly, outdoor environments provide real-world contexts for academic concepts, making learning more relevant and memorable. Direct experiences in na-

ture foster a deeper understanding of ecological processes and environmental issues (Cheng & Monroe, 2012).

Implementation of outdoor learning environments can take various forms. For example, school gardens serve as living laboratories for studying plant biology, food systems, and sustainable agriculture. Nature trails with established paths in natural areas can be used for guided exploration and independent study. Outdoor classrooms, designated spaces equipped with seating and teaching tools, allow traditional lessons to be conducted in a natural setting. Green schoolyards, created by transforming traditional asphalt playgrounds into diverse natural spaces, provide daily access to nature.

By definition and design, NBE employs an *interdisciplinary approach*, integrating environmental concepts across various subjects. This integration demonstrates the interconnectedness of natural systems with human knowledge domains and provides multiple entry points for students to engage with environmental learning. Key aspects of interdisciplinary curriculum integration in NBE include cross-curricular connections, where environmental themes are woven into traditional subjects, illustrating the relevance of nature to all areas of study.

Examples of interdisciplinary integration in NBE are diverse and creative. In mathematics, students might analyze data on local biodiversity, calculate carbon footprints, or model population dynamics. Language arts classes could involve writing nature poetry, crafting persuasive essays on environmental issues, or studying nature-themed literature. Social studies courses might explore the cultural significance of local landscapes, study the history of human-nature interactions, or examine environmental policy. Art classes might focus on creating artwork inspired by nature, designing sustainable architecture, or using natural materials in sculptures. Physical education could incorporate outdoor activities like hiking, kayaking, or orienteering that connect physical fitness with nature exploration.

NBE extends beyond the school grounds, involving students in *community-based and engaged* environmental projects. This fosters a sense of civic responsibility and empowers students to act on environmental issues in their local communities (Smith & Sobel, 2010). Community engagement in NBE can take many forms. Partnerships with local environmental organizations, such as conservation groups, wildlife rehabilitators, or botanical gardens, provide students with expert knowledge and real-world conservation efforts. Creating and implementing public awareness campaigns, such as educating the community about local environmental issues, develops

students' communication and advocacy skills. Engaging with older community members in well-designed intergenerational learning opportunities results in learning about local environmental history and traditional ecological knowledge. Community-engaged eco-entrepreneurship projects encourage students to develop and implement sustainable business ideas that address local environmental challenges. For instance, the EcoRise Youth Innovations program engages students in identifying sustainability challenges in their communities and developing innovative solutions, often in collaboration with local businesses and organizations.

Many NBE programs *incorporate traditional ecological knowledge from Indigenous communities*, recognizing the value of long-standing, sustainable practices and holistic worldviews (Barnhardt & Kawagley, 2005). This integration serves multiple purposes. It broadens perspectives by introducing students to diverse ways of knowing and understanding nature. It supports cultural preservation by aiding in preserving and transmitting Indigenous knowledge. Indigenous perspectives often emphasize the interconnectedness of humans and nature, which fosters respect and understanding for Indigenous cultures and their relationship with the land. Examples of Indigenous knowledge integration in NBE include learning traditional plant uses and harvesting techniques, studying Indigenous land management practices such as controlled burning, exploring creation stories and their ecological teachings, practicing traditional crafts using natural materials, and learning about seasonal cycles and traditional ecological calendars and learning about spirituality, with the perspective that the forest is not just a physical environment but a sacred, living space inhabited by spirits and forces that influence daily life, and also with children learning about the forest through rituals, stories, and by observing their elders.

Benefits of Nature-Based Education

Research has demonstrated numerous benefits of Nature-Based Education across various domains. For example, it is well-documented that education enhances academic performance across multiple subjects (Wilton, Gonzalez-Niño, McPartlan, Terner, Christoffersen, & Rothman, 2019). We mention only some of the benefits here to highlight the impact of NBE on learning and well-being.

The cognitive benefits of NBE are far-reaching. Outdoor environments are complex and ever-changing and provide rich context opportunities for developing critical thinking and problem-solving skills. Ernst and Monroe

(2004) showed that students in environment-based programs scored higher on critical thinking measures than their peers in traditional programs. This finding points to the potential of NBE to foster higher-order cognitive skills. These cognitive benefits improve overall academic performance and prepare students for the complex problem-solving required in addressing global environmental challenges. Additionally, and in support of the argument that NBE supports whole-child education, exposure to natural environments has been linked to improved attention capacity and concentration. For example, Kuo and Taylor (2004) found that children with ADHD showed reduced symptoms after spending time in green outdoor spaces, suggesting that nature-based experiences can help mitigate attention deficit issues.

Engagement with nature through NBE has been linked to improved physical health outcomes. The physical health benefits are numerous and significant. Outdoor learning naturally incorporates more physical activity into the school day. Studies have shown that children are more physically active in greener environments (Dyment & Bell, 2008). This increased physical activity can contribute to better overall fitness and help moderate the growing problem of childhood obesity while providing challenges that help develop gross and fine motor skills. Exposure to diverse microbiomes in natural environments can also strengthen the immune system, and natural light helps regulate circadian rhythms, potentially leading to improved sleep patterns. These physical health benefits contribute to students' overall well-being and create a foundation for lifelong health and active engagement with the natural world.

NBE has also been associated with improved mental health outcomes for students. Learning in nature and green spaces has been shown to reduce stress and anxiety levels. Engagement with nature has been linked to improved mood and self-esteem. Regular contact with nature contributes to overall psychological well-being. Capaldi et al. (2014) examined a significant positive relationship between nature connectedness and happiness. Barton and Pretty (2010) found that even short-term exposure to green exercise improved self-esteem and mood across all age groups. This suggests that NBE can almost immediately positively affect mental health, leading to overall life satisfaction and well-being.

Case Studies in Nature-Based Education

Several programs and initiatives around the world demonstrate the successful implementation of NBE principles. These case studies provide

valuable insights into the diverse approaches to NBE and their impacts on students, communities, and the environment. Here, we present those with which we are most familiar.

The Edible Schoolyard Project

Founded by Alice Waters in Berkeley, California, the Edible Schoolyard Project integrates gardening and cooking into the school curriculum. This program demonstrates how NBE can be applied in urban settings, connecting students with the food system and promoting healthy eating habits. Several key features characterize the Edible Schoolyard Project. It centers around a one-acre organic garden and kitchen classroom, providing hands-on learning experiences from seed to table. The program integrates gardening and cooking into core academic subjects, demonstrating the interconnectedness of food systems with various areas of study. There is a strong focus on environmental stewardship and social responsibility, encouraging students to consider the broader implications of food production and consumption. The project also emphasizes community engagement through shared meals and events, extending its impact beyond the school grounds.

Castillo et al. (2023) documented several positive outcomes from the Edible Schoolyard Project. Students demonstrated improved nutritional knowledge and healthy eating habits, suggesting that hands-on experiences with food production can influence dietary choices. The program enhanced students' understanding of ecological principles and sustainable agriculture, providing a practical context for these complex concepts. Increased student engagement and academic performance were observed, particularly in science subjects, indicating that the hands-on nature of the program can boost overall academic interest and achievement. Students developed essential life skills such as teamwork, problem-solving, and communication through their participation in gardening and cooking activities.

It has fostered stronger community connections and increased parental involvement in school activities, extending its impact beyond the students.

The success of the Edible Schoolyard Project has inspired similar programs across the United States and internationally. For example, the Stephanie Alexander Kitchen Garden Foundation in Australia has implemented kitchen garden programs in over 1,000 schools nationwide. This widespread replication demonstrates the adaptability and appeal of this NBE model.

Criativos da Escola Program

The project *The Amazon: A Natural Laboratory*,[1] part of the initiative implemented by The Alana Foundation, Criativos da Escola program, and part of the global Design for Change movement, illustrates how using local natural resources can transform education and enrich the curriculum. Faced with the lack of a science laboratory and overly theoretical classes, Escola Estadual Professora Maria Belém students in Barreirinha, Amazonas, Brazil, decided to use the Amazon Rainforest as a natural laboratory. Students participate in field trips where they learn about the region's biodiversity, exploring various species of plants, fungi, and snakes. This project makes learning more dynamic and engaging and connects students directly with nature, promoting a deeper and more sensory understanding of scientific content.

Traditional knowledge and intergenerational wisdom can and should be integrated into the curriculum, bringing a more territory-contextualized perspective to education. An exemplary project in this regard is the *Plantas Medicinais*,[2] developed by Colégio Estadual do Rio do Antônio, in Bahia, Brazil, also part of the initiative of The Alana Foundation's Criativos da Escola program. This project is focused on the use of medicinal plants in the municipality and arose from the initiative of a group of students, guided by a teacher, to explore the theme. Community-based survey data revealed to the students that medicinal plant knowledge passed down from generation to generation was being gradually forgotten. Through interviews with community elders, the students documented stories about how these plants were used by their grandparents and great-grandparents, illuminating rich traditional knowledge. To preserve and promote this knowledge, the students created a book that documents the medicinal plants, their functions, and contraindications, allowing these understandings to be understood, appreciated, and used by teachers and future generations. The project not only highlighted the importance of medicinal plants as a practical and accessible alternative to pharmaceutical remedies but also strengthened the relationships between generations, showing that nature is a trustworthy source of medicine. It also centers on traditional community knowledge, beliefs, and values, thus promoting respect, justice, and equity of experience, voice, faith, and positionality.

[1] https://www.youtube.com/watch?v=vlX98uvhIUw
[2] https://www.youtube.com/watch?v=_7-X8Z98AY4

Another example of NBE is Cruzando os Sertões da Mata Branca[3] (also a program of the Alana Foundation's Criativos da Escola). The students at Lucas Emmanuel Lima Pinheiro Vocational School in Iguatu, Ceará, developed this program that focuses on the unique Caatinga biome, which is exclusively Brazilian and critically endangered, with over 40% already devastated. Initially, students were surprised when their teachers instructed them to skip the textbooks, as they did not adequately cover the content of biomes. This signified to the students that there was a significant gap in their knowledge about the Caatinga. To address this, they created a garden of endemic species at their school and conducted field trips to explore the Caatinga firsthand. They also drafted a bill approved by the City Council, proposing public policies for preserving and conserving the Caatinga, demonstrating their ability to influence policy and promote environmental justice.

Chinis – Children Institute of Nature and Inclusion, a project aimed at nurturing children's emotional connection with nature through planting activities in schools, inspired by Tinis – Ania

The Chinis program, implemented by the Alana Foundation in both Los Angeles, California, and Novo Hamburgo, Brazil, offers a compelling example of how nature-based education can be adapted to diverse cultural and environmental contexts. This program integrates nature into the daily curriculum, serving as a model for global NBE approaches.

A key feature of the Chinis program is its emphasis on daily nature-based activities integrated into the curriculum, ensuring that students engage with nature as a regular part of their learning. This consistent exposure helps to normalize nature connections and reinforces the idea that the natural world is an integral part of education and daily life. The program involves a significant transformation of school grounds into natural learning spaces. This physical change in the school environment serves multiple purposes. It provides readily accessible natural areas for daily play and learning activities, increases biodiversity on school grounds, and serves as a visible demonstration of the school's commitment to environmental education. The process of creating these spaces is driven by students, giving them hands-on experience in ecosystem design and management.

The Chinis program also involves parents and community members in creating and maintaining green spaces. This community engagement ap-

[3] https://www.youtube.com/watch?v=rwB7WGHvtXI

proach extends the program's impact beyond the school, fostering a broader culture of environmental stewardship. It also provides opportunities for intergenerational learning and strengthens the connection between the school and the wider community. The program also prioritizes developing emotional bonds between children and nature. This emphasis on the affective dimension of nature connections aligns with research showing that emotional affinities with nature are powerful predictors of pro-environmental behaviors (Kals et al., 1999). The program aims to create a lasting foundation for environmental stewardship by fostering these emotional connections.

Another important aspect of the Chinis program is its emphasis on local biodiversity and ecosystems. By focusing on the natural environment specific to each location, the program helps students develop a strong sense of place and an understanding of their local ecology. This local focus makes the learning more relevant and tangible for students.

The Alana Foundation (2023) reported several positive outcomes from the Chinis program. Students showed increased engagement and enthusiasm for learning, suggesting that the nature-based approach enhances overall educational experiences. Improved academic performance was observed across multiple subjects, indicating that the benefits of NBE extend beyond environmental education to general academic achievement. The program also led to enhanced social-emotional development and stress reduction among students. This finding aligns with broader research on the mental health benefits of nature exposure (Chawla et al., 2014) and underscores the potential of NBE to support overall student well-being.

Importantly, the program fostered greater environmental awareness and pro-environmental behaviors among students and their families. This outcome suggests that the program's effects extend beyond the school, potentially influencing broader community attitudes and behaviors toward the environment.

Implementing the Chinis program in the United States and Brazil demonstrates adaptability across different cultural and environmental contexts. This cross-cultural success provides valuable insights into the global potential of NBE approaches. It offers a model for how such programs can be tailored to local needs and conditions while maintaining core principles.

Policy Implications

As the global community increasingly recognizes the urgency of addressing climate change and environmental degradation, Nature-Based Education is poised to play a crucial role in shaping education policies and

practices. We argue that countries should first consider integrating NBE principles into their national curricula, recognizing its potential to address multiple educational and environmental goals simultaneously. This integration represents a significant shift in educational policy and practice, with far-reaching implications for preparing climate-conscious populations.

Reforms should support comprehensive curriculum transformation that places environmental literacy and sustainability at the core of national education frameworks. This would involve reimagining curriculum standards across all subject areas to incorporate environmental themes and sustainability principles. For example, mathematics curricula could emphasize data analysis related to climate change, while literature courses could incorporate more texts exploring human-nature relationships. Policy implications of this curricular integration are significant. Alignment with the United Nations' Sustainable Development Goals, particularly SDG 4 (Quality Education) and SDG 13 (Climate Action), provides a framework for this integration (United Nations, 2015). National education policies would need to be revised to explicitly include environmental literacy and sustainability as core educational outcomes.

Finland's National Core Curriculum for Basic Education, implemented in 2016, provides a case study of how NBE principles can be integrated into national curricula. This curriculum integrates sustainability and eco-social understanding across all subjects and emphasizes phenomenon-based learning, which aligns closely with NBE principles (Finnish National Agency for Education, 2016). The Finnish example demonstrates that comprehensive integration of NBE principles into national curricula is possible and practical.

Pre-service and in-service teacher education programs should incorporate NBE methodologies, preparing educators to effectively implement nature-based learning in their classrooms. This shift in teacher preparation is crucial for the adoption and success of NBE approaches. This would involve not just adding separate courses on environmental education but infusing NBE approaches throughout the teacher preparation program. For example, courses on instructional methods could include strategies for outdoor learning, while child development courses could explore the impact of nature experiences on cognitive and social-emotional growth.

Developing specialized NBE certifications or degree programs focused on sustainability education is needed to support the successful classroom implementation of curricular reforms. These advanced programs could provide in-depth training for educators who wish to specialize in NBE

or take leadership roles in implementing these approaches in their schools or districts. Such programs should include intensive field experiences, advanced ecology and environmental science coursework, and curriculum development training for NBE.

Creating comprehensive, career-long professional learning pathways for in-service teachers to develop NBE expertise is crucial for supporting educators already in the field. These pathways could include workshops, online courses, mentorship programs, and action research projects that allow teachers to gradually build their skills in implementing NBE over time.

These changes to teacher education have significant policy implications. Teacher certification requirements at the national or state level must be updated to include NBE competencies. This would ensure that all new teachers enter the profession with at least basic knowledge and skills related to nature-based learning.

Cross-Sector Partnerships

Establishing formal structures for collaboration between education, environmental, and health agencies at national and local levels would be a crucial step in supporting NBE. This might involve creating inter-agency task forces or committees that promote and support NBE initiatives. Developing policies encouraging schools to partner with local environmental organizations, parks departments, and health agencies could facilitate these collaborations. These policies might include providing incentives for schools that engage in such partnerships or removing barriers to collaboration between schools and community organizations.

The U.S. Department of Education's Green Ribbon Schools program exemplifies how policy initiatives can promote cross-sector collaboration. This program recognizes schools, districts, and higher education institutions for reducing environmental impact, improving health and wellness, and providing effective environmental education. By highlighting the interconnections among environmental, health, and educational outcomes, this program demonstrates the potential for cross-sector collaboration in promoting NBE principles (U.S. Department of Education, 2023).

The First Children's Nature-Based Education Summit was held in Los Angeles, organized by the UCLA School of Education and Information Studies and the UCLA Lab School in partnership with the Alana Foundation and the International Union for Conservation of Nature – Commission on Education and Communication. The Summit showcased examples

of green and blue school infrastructure, including urban forests, natural playgrounds, green roofs (green), and systems for managing urban water resources (blue). These initiatives were used to change the paradigm for school infrastructure design, use, and management, ensuring that all students have access to the natural world in the places they visit daily. One important case mentioned is Green Schoolyards America's National Schoolyard Forest System®, a national initiative to increase "child-accessible tree canopy" on public school grounds across the United States to shade and protect PreK-12 students from extreme heat and rising temperatures due to climate change. The State of California was the first state to invest public resources to support school districts in implementing this NBE initiative.

The Role of Cities in Nature-Based Education

It is essential to address the role of cities in offering spaces and educational opportunities through NBE initiatives. In partnership with the Van Leer Foundation through the Urban95 initiative, Alana created natural play spaces in underprivileged neighborhoods in seven Brazilian municipalities. Since then, the municipalities have adopted this approach as public policy and extended its reach to new areas. Brazil's fourth-largest city, Fortaleza, is investing US$2.5 million to expand the natural playgrounds into 30 new areas. The municipality of Caruaru has built two natural parks near the municipal Centers for Early Childhood Education that connect schools to external public spaces and expand children's access to the city. The parks were built through a collaborative and participatory approach formed by children and the local community.

Another compelling illustration of cities fostering nature-based initiatives is a project in Brasília, Federal District. The neglect of the Guará Stream, situated only 400 meters from the school, became a central issue for students. Problems such as deforestation of riparian vegetation and sewage discharge were significant concerns. With support from a teacher, the students researched the issue, conducted interviews with local residents, and gathered historical information about the stream.

The students then organized a community cleanup of the Guará Stream, planted trees, and staged a play to raise awareness about the endangered Brasília pirarucu fish among students from other schools. Their efforts also included mobilizing the community for a public hearing with a committee of lawmakers, resulting in a legislative proposal for stream restoration. Additionally, the students partnered with community leaders to

form the Environmental Defense Committee (CONDEMA). This project highlights how cities, through their educational institutions, can champion nature-based solutions that address local environmental challenges and promote civic engagement, offering students meaningful and impactful learning experiences.

Policy Support for Nature-based Education

The policy implications of supporting green school infrastructure are significant. Policies that support climate resilience, such as green school infrastructure, natural playgrounds, and energy-efficient buildings, will facilitate the successful implementation of NBE. To support NBE, green building standards should be developed or adapted specifically for educational facilities. These standards would go beyond general green building practices to incorporate features that support nature-based learning, such as indoor-outdoor learning spaces, school gardens, and natural play areas. This would require funding mechanisms to support the transformation of existing school buildings and grounds into NBE-friendly environments by way of grants or low-interest loans for schools to undertake green retrofits or the inclusion of NBE-supportive features in school renovation and construction projects.

Integrating green infrastructure into urban planning and ensuring that school design is considered in broader urban greening initiatives is necessary. This could involve collaboration between school districts and city planning departments to create green corridors that connect schools with parks and other natural areas. Updating building codes to require or incentivize green features in new school construction and renovations might involve creating specific standards for school buildings beyond general green building codes to include features supporting nature-based learning. Another facilitative policy change is to modify land use regulations to allow more flexible use of school grounds for NBE purposes. This could involve changes to zoning laws or other regulations that currently restrict the creation of natural learning spaces on school property.

Research and Evaluation

Continued research is needed to assess the long-term impacts of NBE on academic achievement, environmental attitudes and behaviors, and overall well-being. This ongoing research and evaluation is crucial for refining NBE approaches and demonstrating their value to policymakers and edu-

cators. Ideally, longitudinal studies will be conducted to track the impacts of NBE from childhood through adulthood. These long-term studies could provide valuable insights into how early nature-based learning experiences influence environmental attitudes, behaviors, and career choices later in life. Such research could help make the case for early and sustained investment in NBE approaches.

Another critical research direction is comparative studies analyzing the effectiveness of different NBE approaches across various cultural and environmental contexts. These studies could help identify best practices and guide the adaptation of NBE approaches to diverse settings, from urban to rural environments and across different cultural contexts.

Research should include perspectives from and be grounded in education, psychology, environmental science, and public health is crucial for understanding the full range of NBE impacts. This interdisciplinary approach could provide a more comprehensive picture of how nature-based learning affects student development and well-being.

Robust research and evaluation studies should be used to inform climate-resilient policy. Dedicated funding for NBE research and evaluation through national science foundations and education departments, including specific funding streams for NBE-related research, would support other climate and environmental justice policies. This evidence-based policymaking approach would ensure that NBE initiatives are grounded in solid research and continually improved based on emerging findings. Developing standardized evaluation frameworks with common metrics and evaluation tools to assess NBE programs consistently across different contexts would facilitate comparisons between different approaches and help build a more cohesive body of evidence about NBE's impacts.

To conclude, the future of Nature-Based Education depends on concerted efforts across multiple sectors and levels of governance. By integrating NBE principles into national curricula, enhancing teacher education, fostering cross-sector partnerships, supporting ongoing research, and developing supportive infrastructure policies, we can create an educational system that not only prepares students academically but also equips them to address the pressing environmental challenges of our time. These policy directions represent a significant shift in how we approach education, recognizing the critical role that connection with nature plays in fostering sustainable, resilient, and thriving communities.

A Final Note

The May 2024 Summit *From Climate Crises to Climate Resilience*, organized by the Pontifical Academy of Sciences and the Pontifical Academy of Social Sciences (from which this volume was developed), included a panel of young people. The session "Voices of the Youth" highlighted and demonstrated the impact of NBE on developing and promoting youth's knowledge and understanding of climate issues and the skills and confidence necessary to advocate for resilient practices and policies. This is an exceptional example of the growing global movement of youth demanding climate action, demonstrating their essential views and recommendations on addressing the climate crisis. We thank the Pontifical Academies for honoring their voices and perspectives and for genuinely listening to our youth, who are inheriting our magnificent planet with complexities and challenges that prior generations helped to create and are now mostly unwilling to change to save its existence. Our youth are the change, and they are the future.

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Children drawing in Labschool.

Before.

After.

Water features. Large playground equipment.

Uneven terrain.

Herb beds and gardens.

Native trees (biodiversity) and outdoor classroom.

YOUTUBE PRESENTATIONS

Towards Agricultural Resilience: Bending the Carbon Curve

Benjamin Z. Houlton
The Ronald P. Lynch Dean, Cornell University

https://youtu.be/4qhYBj7Tiv0?si=P9RRD8CVSl2_A9io

Role of Sciences in Reducing Climate Risks & Enhancing Climate Resilience: A Virtuous Cycle of Knowledge & Action

Jane Lubchenco
PAS, Distinguished University Professor, Oregon State University

https://youtu.be/8y5gtjZMvbQ?si=1ygQF_RAmOdLhC_K

SESSION XIV – PUBLIC HEALTH

Climate Change and Population Health

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David E. Bloom
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Climate change may be the greatest public health threat of the 21st century (Romanello et al. 2023). Climate change is already plausibly to blame for increasing the frequency of deadly natural disasters, aggravating air pollution, and exacerbating the spread of infectious diseases. With a temperature increase projected to reach the 1.5°C limit in a few decades and 3°C by the end of the century (IPCC 2021), the negative health impacts of climate change will only intensify.[1] The key question then is how to promote and protect population health in the face of climate change.

In this chapter, we address two issues related to the interplay between climate change and population health. First, we focus on the potential "health co-benefits" of climate change mitigation and discuss why recognizing, comprehensively measuring, and accounting for these co-benefits can spur timelier and more effective climate action. In particular, we highlight how a proper assessment of health co-benefits can address two of the main economic and policy challenges of climate change mitigation: the intergenerational issue and the free-riding problem. Second, we argue that health is often undervalued in economic assessments of climate change, despite the growing evidence that, much like education, population health promotes economic growth and wellbeing (Bloom and Canning 2003). This implies that (i) we need to rethink what exactly is the full value of population health and how to quantify it better, and (ii) accounting for the potential broad social and economic benefits of improving population health strengthens the case for near-term climate action.

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[1] The 1.5°C threshold represents the level of warming above preindustrial temperatures that the signatories to the Paris Agreement have agreed to try to respect (IPCC 2018). The Paris Agreement was signed in 2015 by 196 parties at the 21st United Nations Climate Change Conference in Paris, France.

That climate change frequently impinges on population health is now well understood (WHO 2021). For example, climate change is expected to intensify the risk of extreme weather events such as droughts, wildfires, heat waves, tropical storms, and floods. A recent report from the World Economic Forum estimates that floods, heat waves, and droughts will cause 13.3 million deaths globally by 2050 (WEF 2024). In addition to widespread destruction and death, extreme weather events also lead to soil and water degradation, which increases the risk of foodborne and waterborne illnesses. Considering that an estimated 2 billion people currently lack access to safe drinking water (WHO 2022) and that unsafe food already causes 600 million cases of foodborne illnesses and 420,000 deaths per year (WHO 2015), the increased risk due to climate change will exacerbate an already daunting problem. Furthermore, climate change will likely impose a significant long-term mental health burden due to the cumulative effects of grief, displacement, and the loss of livelihoods (Obradovich et al. 2018).

Climate change is also expected to reduce agricultural, fishery, and aquaculture yields and disrupt the food supply, leading to volatility in food prices and thereby causing further illness and death. For example, the Intergovernmental Panel on Climate Change's special report on climate change and land projects up to a 29% cereal price increase by 2050 due to climate change, putting as many as 183 million more people at risk of hunger (Mbow et al. 2019).[2] The most recent Food and Agriculture Organization report estimates that between 691 and 783 million people (nearly 10% of the world population) already faced hunger in 2022 (FAO et al. 2023).

Rising temperatures and changes in precipitation patterns are expected to substantially increase the risk of infection by vector-borne diseases, such as malaria, dengue, Zika, and yellow fever, in many geographies (Thomson and Stanberry 2023). Globally, vector-borne diseases account for more than 17% of all infectious diseases and cause more than 700,000 deaths annually (WHO 2020).

Finally, climate change is increasing the burden on already strained healthcare systems and medical resources. The combination of climate change-induced secular increases and episodic surges in the demand for

[2] Across the Shared Socioeconomic Pathways 1, 2, and 3, the median price increase by 2050 is 7% (range 1-29%). This corresponds to a median increase in the number of people at risk of hunger by Shared Socioeconomic Pathway equal to 8, 24, and 80 million, respectively (range 1-183 million). The wide range in price increase and in additional people at risk of hunger depends on differing model assumptions.

healthcare will impede the ability of health systems to provide timely and quality care for many health issues and impose potentially crushing fiscal burdens (WEF 2024). Just to give a concrete example, when Hurricane Maria hit Puerto Rico in 2017, it inflicted severe damage on manufacturing plants that produce IV bags, sparking a shortage of those bags in the United States (Mazer-Amirshahi and Fox 2018).

Compounding these challenges, disadvantaged populations – due to geographic location, pre-existing health status, and access to health and economic resources – are likely to bear the brunt of the health impacts of climate change (Hallegatte et al. 2016). Such populations include people living in low-income countries and on small islands, children and older adults, ethnic minorities, poor communities, and migrants. Notably, and unfairly, these are also the populations that have contributed the least to the accumulation of greenhouse gas emissions (Chancel 2022).

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To explain countries' apparent lack of action (or insufficient action) against climate change, the classical economic framework highlights two aspects of climate change that impede intervention. First, climate change reflects a tragedy of the commons (Ostrom 1990). Because the climate change effects of greenhouse gas emissions have no borders, the cooperation of all countries is needed to solve the problem, but some countries may decide to wait for – and free ride on – the climate change mitigation efforts of other countries (Nordhaus 2015). Second, climate change is characterized as both an intergenerational justice problem and an intragenerational justice problem. As an intergenerational justice problem, the current generation bears the burden of change and cost while future generations reap the benefits (Broome 1994). Thus, a generational bifurcation exists between who pays the costs and who enjoys the benefits. Climate change is also an intragenerational justice problem, as the world's poor are expected to bear the brunt of a changing climate, which may further reduce the incentives of wealthy nations to tackle the climate change problem.

Stressing the health co-benefits of climate change mitigation can help stimulate the design and implementation of interventions that address the dual challenges of the free-riding problem and the justice problems. Indeed, the major sources of climate change coincide with some main drivers of current poor population health. As a consequence, slowing the pace

of climate change will deliver substantial health co-benefits, in addition to myriad non-health benefits such as the preservation of biodiversity and the preservation of physical capital and infrastructure.

Let us consider three specific examples. First, the sectors that contribute the most to greenhouse gas emissions, like transportation and energy, are – intuitively – the greatest sources of air pollution, increasing the risk of cardiovascular diseases, respiratory diseases, cancers, and dementias. To give an idea of the potential magnitude of the health co-benefit of retooling these sectors, recent estimates suggest that fossil fuel air pollution accounts for 5 million deaths per year (Lelieveld et al. 2023). That means that transitioning to greener energy sources by, for example, incentivizing the use of electric vehicles will not only mitigate future climate impacts but also improve air quality and save numerous lives over the next few decades.

Second, the Food and Agricultural Organization indicates that meat and dairy production contributes roughly 14.5% to global greenhouse gas emissions (FAO 2016).[3] The prevalence of red meat – and processed meat-based diets are also major risk factors for chronic noncommunicable diseases such as type 2 diabetes, coronary heart disease, and colorectal cancer (Kennedy et al. 2024). Thus, especially in higher-income countries, transitioning to plant-based diets can reduce both greenhouse gas emissions and the growing burden of noncommunicable diseases (Laine et al. 2021). Estimates suggest that the monetized value of health improvements from dietary changes could be comparable to, and possibly larger than, the environmental benefits of the avoided damages from climate change (Springmann et al. 2016).

Third, urban planning that focuses on car transportation encourages a sedentary lifestyle and increases the risk of noncommunicable diseases (Rutter et al. 2024). By contrast, urban planning that promotes safe walking, cycling, and the use of public transportation contributes to a healthier lifestyle while mitigating climate change (Sharifi et al. 2021).

Importantly, the health co-benefits of climate change mitigation will be substantially experienced (i) in the near and medium term (especially clean air); (ii) locally; and (iii) disproportionately by disadvantaged populations, as those suffering the most from poor health are also those who suffer the most from the health impacts of climate change. The last feature adds to

[3] The greenhouse gas emissions associated with animal-based foods are due principally to land management (e.g., cutting down trees to create grasslands), enteric fermentation (methane emissions during the digestive process of cows and sheep), manure management, and chemical fertilizers used on crops for cattle feed (Xu et al. 2021).

the moral imperative of addressing climate change. The first two features – the near-term and local nature of health co-benefits – imply that stressing the health co-benefits of climate change mitigation can encourage a more urgent policy response.

First, because health co-benefits are near-term, some benefits of climate action can be realized immediately, allowing both current and future generations to gain from responsible climate policy. Thus, the narrative that the current generation pays the costs and the future generations reap the benefits no longer applies. Everyone, now and in the future, benefits from aggressive climate action.

A few modeling studies have demonstrated this result. For example, Scovronick et al. (2019) develop an integrated climate-economy model with an air pollution component and report that failing to acknowledge near-term air quality health co-benefits results in an optimal climate action policy that has net costs for much of this century and that will not keep the temperature increase below the 1.5°C limit. When accounting for the health co-benefits, optimal climate policy is more stringent and will have immediate and continued monetized net benefits – upwards of trillions of dollars annually worldwide. Similarly, Markandya et al. (2018) find that air pollution health co-benefits far outweigh the policy cost of achieving the mitigation targets set in the Paris Agreement.

Second, because health co-benefits tend to be local in nature, they do not suffer from the tragedy of the commons and free-riding incentives. Only cities and states that implement some form of climate mitigation can reap these health co-benefits. This implies that health co-benefits may enhance the potential efficacy of gathering local support for climate policies. As an intuitive example, by incentivizing the use of green energy sources in place of fossil fuels, governments can improve air quality for their citizens – a local benefit – while simultaneously providing climate benefits for the whole world.

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Focusing on population health and in particular on the health co-benefits of climate change mitigation will naturally drive more urgent climate action. Moreover, the complementary message that investing in population health is good for the economy magnifies the case for climate change action.

Let us take the example of clean air once more. Clean air promotes health, but by improving population health, clean air also creates a sequela

of economic benefits. These take the form of improvements in concentration, learning abilities, and educational outcomes among children, which in turn lead to better labor market opportunities, higher wages, more human capital, and more robust economic growth. Clean air also increases labor force participation and labor productivity and reduces the healthcare costs of treating respiratory conditions, eye infections, and other chronic illnesses. These reductions will lead to lower fiscal pressure and more economic growth. The same story can be told for the other health co-benefits previously mentioned, like encouraging healthy lifestyles and reducing the burden of noncommunicable diseases. These changes also have sizable, quantifiable economic implications.

For decades population health has been substantially and widely undervalued by economists (Bloom et al. 2004; Ferranna et al. 2023). The undervaluation is rooted in economists' failure to reckon with the fact that health not only has intrinsic value but also has instrumental value. Intrinsic value refers to the fact that actual and prospective states of good health are enjoyed for their own sake. By contrast, instrumental value refers to the fact that good health enhances our capacity to gain other things of value, for example, by improving our ability to work productively and earn income; to attend school and augment our knowledge, skills, and productive potential; and to look after our children and grandchildren and contribute to their wellbeing. The bottom line here is that the benefits of climate change interventions will encompass gains in human health and the social and economic gains that follow from those health gains.

Accounting for the social and economic sources of benefits is conceptually appropriate and technically feasible. Doing so greatly magnifies the estimated returns to climate change interventions, thereby strengthening the case for such interventions. It also emphasizes the economic value of investing in population health and allows the calculation of rates of returns and benefit-cost ratios, which is the natural language of ministers of finance and planning and other policymakers who hold the power of the purse. Also worth noting are the recent innovations in economic evaluation methods that incorporate distributional equity concerns and allow for the calculation of distributionally sensitive rates of return and benefit-cost ratios, which are crucial ingredients in remediating the inequities of climate change impacts (Adler and Norheim 2022).

★ ★ ★

Climate change is already imposing substantial economic, social, health, and environmental costs on the world. Accounting for these costs is appropriate to the design of current climate change mitigation policies and rationalizes more aggressive interventions. For example, reducing greenhouse gas emissions will deliver sizable near-term, local health co-benefits. Such health co-benefits not only have intrinsic value but also instrumental value that is conferred to virtually every aspect of our lives. They can promote economic growth and wellbeing through their impact on labor force participation, productivity, education, and healthcare costs, and on nonmarket productive contributions such as childcare. Accounting for these economic and social implications provides a strong argument for policymakers to invest in population health and contribute to the climate change fight.

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Weather Extremes & Mental Health

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I begin these remarks with a reflection on my personal journey at the intersection of climate change and mental health. I have been personally motivated for climate action for most of my life, growing up in a family in India that always prioritized sustainability, zero waste and that everything broken can be fixed! In 2017-18, my six-year-old son joined climate action demonstration marches with me that stimulated even greater resolve to take action (Figure 1). One day, my son came home with a flyer for a penny-drive fundraiser to support those impacted by California's worst wildfire in history that hit Butte County. The 'Camp Fire' of 2018 still remains California's deadliest wildfire to-date with 50,000 evacuations and 150,000 acres of area burned and 85 human lives lost. Wildfires have only continued to increase in frequency and intensity since the 'Camp Fire' of 2018. What is most notable is that these fires primarily hit vulnerable communities that reside at the Wildland Urban Interface (WUI). These communities are often the ones that rank highest in poverty rates and additionally have low health outcome rankings, which means that climate change accelerated dis-

Figure 1. At a climate action march at UC San Diego.

asters such as the frequent wildfires are putting an added toll on our most impacted communities.

With collaborative community partnerships, we have investigated the chronic mental health impacts of climate change exacerbated California wildfires. Nearly one-year after the wildfire event, we found significant chronic impacts, observing 3X prevalence of post-traumatic stress disorder (PTSD), and 1.5-2X prevalence of depression and anxiety compared to prevalence rates in neighboring non-impacted regions [1]. We have also shown that individuals who are not directly impacted by the fires in terms of impacts on self/family/property, but just witness the fires occurring within their communities, i.e., indirectly exposed, also suffer a significant mental health toll (Figure 2). Such mental health impacts have been corroborated by other studies [2,3] and our results have also been cited by the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report [4] and by the US Fifth National Climate Assessment [5]. At this point, I'd like to emphasize that the dissemination of this knowledge to practicing clinicians is very important so that they may be aware of the mental health implications of climate change accelerated extremes, and be prepared to provide care to patients appropriately.

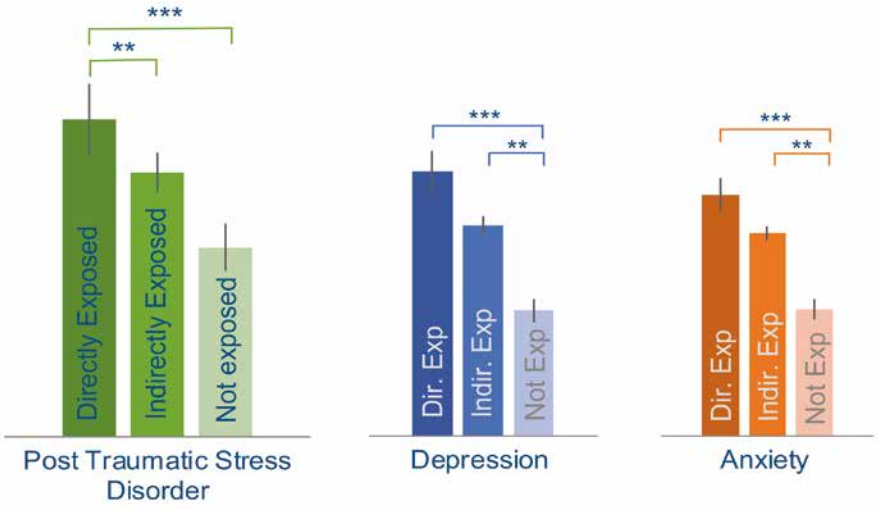

Figure 2. Lasting mental health impacts of climate disasters showing increased levels of PTSD, anxiety and depression in impacted communities. Data are from the aftermath of the Camp Fire in California.

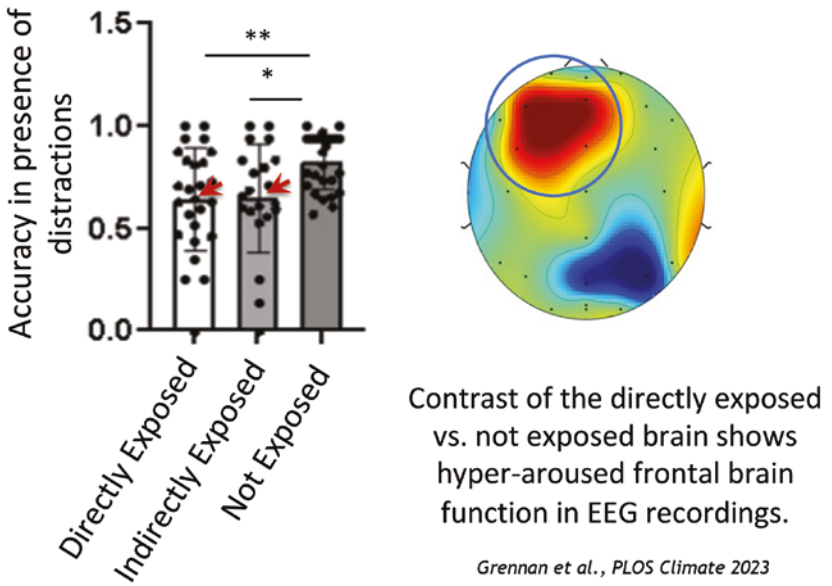

Figure 3. Impact of wildfire exposure on cognitive functioning. At left, individuals exposed to the wildfires show lower performance on an attention task involving distractions. At right, directly exposed individuals show hyper-aroused brain function suggesting a chronic hyper-alert state.

In further work, we have also shown that cognition and brain health can be chronically impacted by extreme climate events such as wildfires [6]. Specifically, we find that the ability to process cognitively interfering information, i.e., distractions, is impacted in individuals who have been directly or even indirectly exposed to the wildfire event relative to non-exposed controls (Figure 3). Overall, these objective cognitive outcomes dovetail with qualitative lived experience reports of individuals not being able to attentively focus on tasks and goals in their daily lives in the aftermath of the extreme climate event. Underlying the significant cognitive effects, we also find a hyper-aroused brain response in individuals who self-reported experiencing climate trauma from the wildfire event. Such a hyper-aroused brain response is also observed in PTSD and potentially suggests a hyper-alert brain that is constantly scanning for threats in the environment. Additional findings from our research show that the wildfire impact further influences long-term decision-making abilities. We find that individuals directly exposed to an extreme climate event have difficulty making choices that have

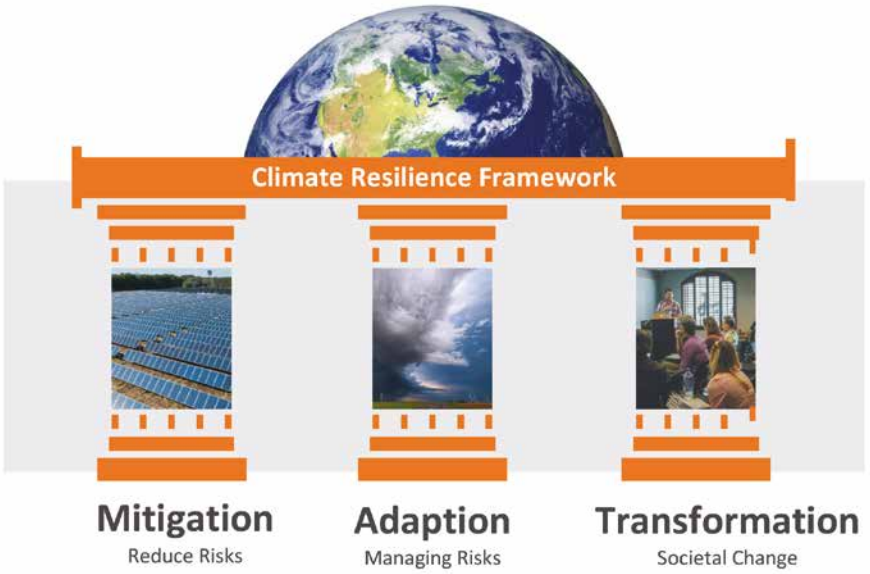

Figure 4. The Climate Resilience framework has important mental health co-benefits.

greater expected value rewards in the long-term; instead they choose decisions that give small immediate rewards but not long-term large rewards. These serious impacts can greatly influence daily life decisions.

Overall, climate trauma is a relatively new term that has come to define the mental health impacts of climate change accelerated extreme events [7]. Climate trauma deeply impacts vulnerable communities and adds to the impact of existing stressors, as shown by studies of floods and wildfires occurring concurrently with the COVID-19 pandemic [3]. Climate trauma also impacts community health in terms of increased risk of suicide, violence and homicide within the community [8,9]. In its definition and psychological understanding, the term climate trauma suggests that we are not separate from the Earth, its ecosystems and climate. We as humans are both the problem and the providers of potential solutions. We humans are the traumatizers as well as the traumatized – what affects the planet reciprocally affects us. And most importantly, climate trauma represents a form of trauma that supersedes or intersects with all other trauma, illustrating how it is another layer of disadvantage for the communities that will be facing the worst of climate change, but have done the least cause it. In this sense addressing climate trauma is intertwined with the goals of climate justice.

Building community resilience is critical for addressing climate (mental health) trauma. The climate resilience framework aims for three essential pillars including (1) mitigation efforts to reduce future risks, (2) adaptation to ongoing climate change impacts, and (3) societal transformation. It is important to note that mitigation efforts such as providing access to clean air, energy, green environments has co-benefits for mental health and well-being. Similarly, adaptation efforts that provide refuge in the face of existing changes – heat and air quality warning systems, improved building design with green and blue infrastructure, passive cooling systems, as well as preparing shelters, infrastructure and resources for an upcoming extreme climate event – all bring mental health and well-being co-benefits [4]. Per the IPCC, societal transformation is a profound and often deliberate shift initiated by communities toward sustainability, facilitated by changes in individual and collective values and behaviors, and a fairer balance of political, cultural, and institutional power in society. For such societal transformation, climate education for the masses is essential as is greater social connection between our communities and building interdisciplinary coalitions bridging scientific, medical, technological and even religious and spiritual leadership as exemplified by the Vatican summit.

In our work in Californian communities affected by wildfires, we have also investigated the personal factors that contribute resiliency in the face of disasters (Figure 5). These include belief in personal resilience – the ability to bounce back from stressors, mindfulness – the ability to stay in the present moment, as well as physical fitness [1,10]. We have observed that individuals with these traits have reduced symptom severity of PTSD, depression and anxiety observed in the aftermath of a traumatic climate event. Furthermore, we find that those with close family ties and those who have a strong sense of community show greater well-being in the aftermath of

Figure 5. Personal factors that promote mental health resilience in the context of climate trauma.

the traumatic climate event. Thus, community-based infrastructure and resources that foster personal resiliency by providing opportunities for mindfulness skills development, physical activity as well as opportunities for community bonding can be vital for resiliency development. In this context, nature-based resiliency skills development can also emerge as an important avenue to boost mental health. In fact, in eco-therapy practice, individuals learn to connect with nature in a mindful way and can restore their personal associations with the environment that may have previously become traumatic due to the extreme climate event [11]. California communities are now adopting eco-therapeutic practices alongside eco-stewardship for both personal and environmental sustainability [12].

Finally, efforts to integrate mental health skills development within climate education are also very important for individuals to participate in sustained climate action and prevent individual burnout. As the co-lead of the University of California Climate Mental Health Initiative, we have recently launched coursework that integrates mindfulness practices as well as mental health education to develop personal resilience and thereby, transform the climate anxiety felt by our youth to collective climate action [13]. This year, hundreds of students across 8 University of California campuses participated in the course – they immersed themselves in the inner work of building personal resilience alongside the outer work of undertaking collective climate action projects. Empirically, we found that this Climate Resilience education significantly reduced climate anxiety in youth and further enhanced their self-efficacy for climate action. More of such scalable education models are needed. I am hopeful that the upcoming Climate Resilience regional summits, which will be a confluence of community leaders, researchers, governance, philanthropists and entrepreneurs, will include a focus on mental health and well-being of the people and the eco-system. Collaborative climate action projects emerging from these summits can focus on building a blueprint for resilience, engaging cities and counties from the ground-up.

In summary, climate change-driven disasters have real and chronic mental health impacts: PTSD, depression, anxiety as well as impacts on cognitive functions and brain health. In this context, developing plans for community mental health resiliency is critical. It is important to emphasize that climate mitigation and adaptation efforts bring co-benefits for mental health and well-being and should be appropriately assessed in this context. Finally, societal transformation initiatives must embed mental health focused interventions & education.

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Programmable Medicines to Tackle Emerging Health Threats

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1. Introduction

Climate change has immeasurable impact on our planet. These repercussions occur not only as direct effects from climate hazards such as droughts, wildfires and heatwaves, but also as cascading downstream secondary, tertiary and long-term effects. This is not a theoretical future set of consequences and dominoes that are going to fall, they are falling now.

Importantly, while we don't always see it, many of these cascading paths lead to impacts on human health, including morbidity and mortality. In fact, it is unequivocal that climate change impacts human health. Changes in temperature, rainfall and sea levels, changes in pathogen growth, survival and virulence, and changes to human and animal interaction through encroachment, overpopulation and migration are already leading to increased incidences of zoonotic transmission.[1] In addition, although the exacerbation of transmissible disease is the most oft mentioned consequence of climate change, the epidemiology of other non-communicable diseases are also shifting dramatically – respiratory diseases, cancer, auto-immune diseases and metabolic disease to name a few.[2]

2. Drug Development Historically

Science has made tremendous strides in the understanding of biology and the molecular basis of disease, and the global biopharma industry has developed many breakthroughs that address the developed world. Yet the current approach to developing new medicines is inadequate to globally address the speed and scale of the health implications of climate change.

With our current drug development approaches, it takes on average 10-12 years to develop a single new medicine.[3] In response to an emerging threat, this timeline is unreasonable. It can also cost up to $2 billion to develop a new medicine, a significant economic hurdle.[4] Further, despite the timelines and cost, 2 billion people globally still do not have access to essential medicines,[5] and even more don't have access to critical but non-essential medicines.

One challenge to addressing these limitations of current processes is that the drug development industry continues to use nearly century-old approaches in some cases. For example, vaccine development is currently an arduous and time-consuming process that is still done in eggs, first in one, then in many. It takes nine months to develop a vaccine, and given the rapid pace at which viruses evolve, just 40% to 60% efficacy is tolerated depending on the year.[6]

These old approaches reflect a "discovery" process. The definition of the word "discover" is to find something unexpectedly or in the course of a search. The high-tech, industrialized version of an archeological search for a valuable relic, drug discovery is fraught with serendipity, trial-and-error. As a result, to get to a viable medicine, drug developers must consider a million, even a billion, different possible drug candidates. This is a burdensome process that takes significant time and money, two things that cannot be wasted in a climate-impacted world.

3. Drug Generation, Not Drug Discovery

3.1 Programmable Medicines

A new paradigm of medicine can address these shortcomings of the historic drug development process: drug generation, rather than drug discovery. With a broader and deeper understanding of biology, advanced tools to analyze biological samples and computational power to interpret biological data, designing medicines at speed and scale, not discovering them, is possible.

Programmable medicines, or medicines derived directly from an understanding of a disease or threat that can be designed and deployed deliberately, as opposed to using serendipity and chance, are the future. If drugs are intentionally, purposefully and precisely generated, the cost and time it takes to develop new medicines dramatically reduces, making medicines more affordable and scalable for the global population.

3.2 Biological Programs

In order to develop programmable medicines, the various programs that drive biology must be understood. For example, the central dogma of biology is a program. In every cell in the body, the blueprint for all of our building blocks, DNA, exists. When reading this blueprint, DNA gets converted into RNA and then RNA into proteins, the workhorses of life. This program is relatively simple, and well understood (Fig. 1).

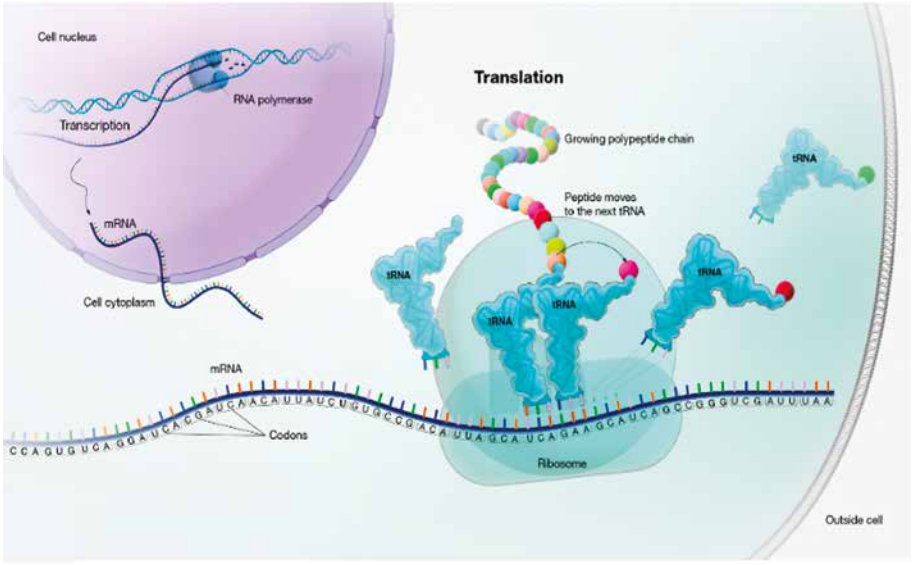

Figure 1. The central dogma of biology.[7]

There are many different programs in biology, and some are much more complex than the central dogma, including those inside cells and across and among cells. These are only beginning to be elucidated due to their complexity. A computer and data are needed to train algorithms to understand and use this information. Only then can better, programmable drugs, drugs that are more likely to work on the first try and drugs that are safer, be created.

4. DNA and RNA as Programmable Medicines

DNA and RNA as programmable medicines take advantage of multiple biological programs, from the central dogma of biology to programs governing our complex immune systems. Equipped with an understanding of the central dogma of biology, it is known that if mRNA is delivered into a cell, the protein that mRNA encodes will be generated. This means drug developers have the code to make virtually any building block in the human body.

Moderna, a biotechnology company founded by Flagship Pioneering, and its COVID-19 vaccine is a well-known example of programmable RNA medicines. In this vaccine, RNA encoding parts of the SARS-CoV-2 virus were delivered to cells to trigger an immune reaction. Not only was this the first achievement of its kind, but it was achieved in under 48 hours

from the moment the biology of the virus was described to the moment the first prototype medicine was generated. This speed is unprecedented and made possible only through the creation of a programmable medicine.

As the direct and indirect effects of climate change impact zoonotic transmission, programmable medicines will become more critical tools in the fight for protection.

5. Proteins as Programmable Medicines

Proteins are the building blocks of life. Pharmaceutical companies have harnessed proteins in the form of antibodies, which are natural molecules of the immune system, and turned them into medicines. While these medicines are crucial tools in the defense from pathogens, creating antibody therapeutics is historically an arduous and timing-consuming trial-and-error process.

Generate:Biomedicines, a Flagship Pioneering company, was founded to address this hurdle by leveraging artificial intelligence. Using the vast compendium of information scientists have gathered about protein sequences and their respective structures and functions, Generate has trained an artificial intelligence algorithm to learn the rules connecting the language of DNA to the language of protein structure and function. As a result, the computer can traverse the central dogma of biology between DNA and protein.

Armed with this capability, Generate can now develop a drug of interest by giving the computer a prompt. This is analogous to how large language models can go from English to Italian and back, or can create a paragraph out

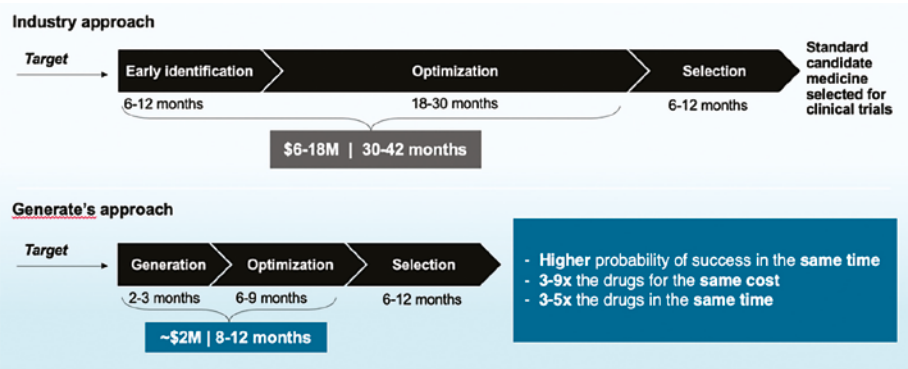

Figure 2. Industry approach to therapeutic protein development (top) versus Generate:Biomedicines' approach (bottom).

of a prompt. As a result, Generate has been able to shrink the paradigm of drug discovery for antibodies from on average 30-42 months down to 8-12 months, and can continue to get faster. Further, the candidates produced have a higher probability of success because they were programmed for a specific function (Fig. 2). Generate applied its model to more than 50 top industry targets, including a portion of the SARS-CoV-2 virus, in just 3 months.

New technologies such as Generate's allow for the design of better medicines faster, a necessity in the fight against the health consequences of climate change.

6. Small Molecules as Programmable Medicines

Small molecules are attractive as medicines in the age of climate change for many reasons, including the fact that they can be taken as oral pills, making them easy to deliver and scale. Programmable small molecules are therefore critical for increasing accessibility to essential medicines.

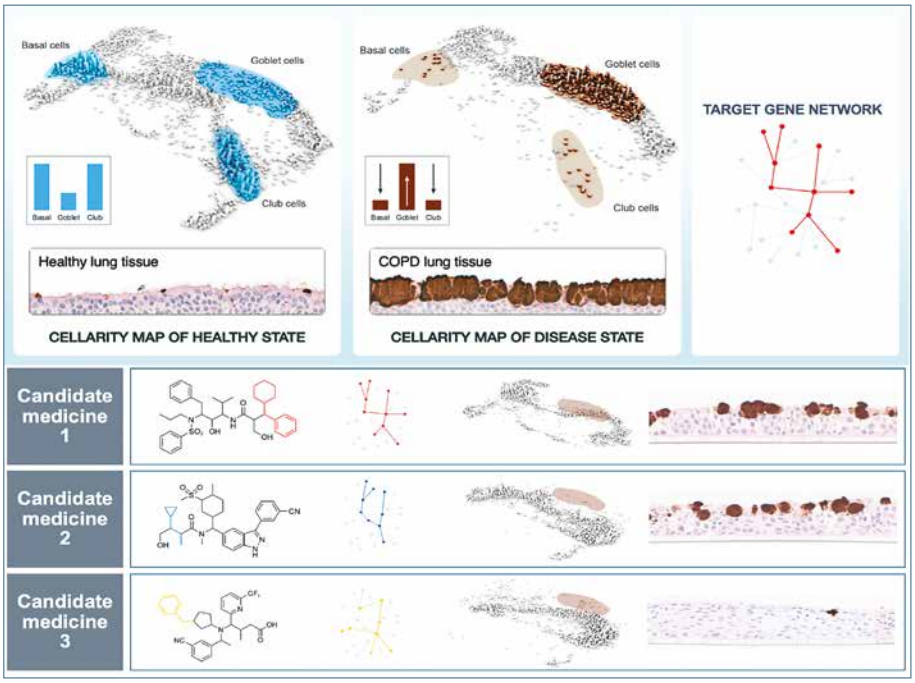

Figure 3. Cellarity map demonstrating differences between healthy and diseased COPD tissue (top) and three new potential medicines (bottom).

However, making small molecules programmable is no small feat. Cellarity, a Flagship Pioneering company, was founded to devise a computational system to understand cellular biology and decode it, thus elucidating the multidimensional changes that are occurring in health and disease. From there, artificial intelligence can propose the small molecules that are most likely to reverse cellular changes that occur in disease.

One example is in chronic obstructive pulmonary disease (COPD), a disease with no cure. There are clear differences between healthy and diseased cells, but a deep understanding of the multidimensional cellular changes is missing. Cellarity has encoded the molecular biology underpinning the health to disease transition and created digital maps of these changes. With these data, a network emerges from the platform outlining the multidimensional changes that are happening in disease, and finally, suggested small molecules that are likely to drive cells back towards health. In this case, the platform suggested three new potential medicines that had never been used before in the COPD setting (Fig. 3).

This approach is applicable to a range of diseases, anywhere cellular dysfunction is known to underly an illness, and will be a paradigm shifting way of designing and discovering drugs in a world where global access to essential medicines is of utmost importance.

7. Conclusion

Programmable medicines are here, and they represent an important solution to the health challenges that result from climate change. There is now technology to start revealing new biology, decoding molecular changes and using these insights to generate drugs as opposed to serendipitously discovering them. However, this is just the beginning. The last important step is deploying these medicines to people across the globe. Many pieces need to come together to take advantage of these technological revolutions.

Public-private partnerships are crucial. The work that allowed the rapid creation, testing, manufacturing and deployment of the COVID-19 vaccine could not have happened without a coordinated, multi-institutional, multi-disciplinary effort. Collapsing the time to detect the virus, sequence it, and make the first prototype through work similar to that described above is only the first step. Clinical testing and deployment of a medicine is another. It typically takes 73 months to deploy a new vaccine. However, with Operation Warp Speed that timeline was significantly compressed. This was

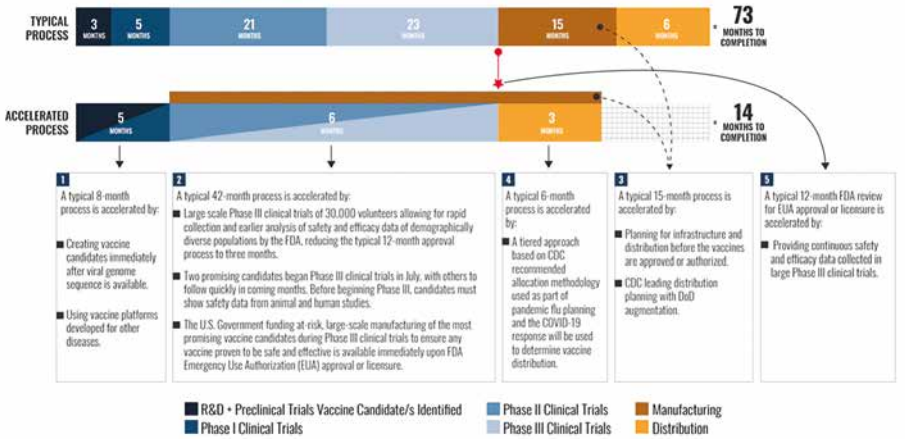

Figure 4. Standard timelines (top) versus Operation Warp Speed timelines (bottom).[8]

a monumental effort, taking scientists, corporations, small companies, big companies, manufacturing companies, governments and global organizations to collaborate, align, speak different languages and more (Fig. 4).

It is now clear that efforts such as these are possible. The key now, however, is not to forget them and go back to old ways once threats are gone. This is what it's going to take to address emerging health threats in the future, but as the theme and spirit of the conference demonstrated, to also develop and deploy innovation to tackle climate change.

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YOUTUBE PRESENTATIONS

Public Health, Introduction

Dr. Vanessa Kerry

Climate Change and Population Health

https://youtu.be/0ucEjKQvE3M?si=t_fSirSr2E3DxuOb

The Strong Health Argument for Climate Action

Dr. Maria Neira

Director of the Department of Environment, Climate Change and Health, WHO

https://youtu.be/4MGnbTqZ6ko?si=Z7A6YHb9NHTvJBmM

Changing the Narrative to Health for Urgent Climate Actions: Chairs' Perspective

Sir Jeremy Farrar

Chief Scientist, WHO

https://youtu.be/Pz2JEzv1ics?si=BwXKvAiSRBWPzKi9

Planetary Call to Action for Climate Change Resilience

We are a diverse international group of researchers, faith leaders, policymakers, and heads of cities, towns, governorates, and provinces, assembled under the auspices of the Vatican's Pontifical Academy of Sciences and Pontifical Academy of Social Sciences. Pope Francis presided over a summit in May of 2024 which led to this Call to Action.

The Rationale for the Call to Action

We recognize that 2023 was the hottest year on record, resulting in severe global impacts due to extreme weather events. By February 2024, ocean temperatures soared to levels never seen (21°C), continuing a pattern that persisted throughout the preceding year. Climate experts now forecast that the Earth is very likely to exceed the critical global heating threshold of 1.5°C by 2030 to 2035. We have a limited time frame to proactively prepare for and respond to the crisis, rather than simply reacting to it.

Qua climate change, we see the world population as incredibly diverse, yet, when considering climate change and its impacts, it arrays into three distinct groups: the Top One billion who are contributing more than 50% of heat-trapping pollutants; the Middle Four billion; and the Bottom Three billion. The adjectives Top, Middle, and Bottom denote the position of each group in the energy and wealth pyramid and are not used as pejorative terms. The Top One billion and the Middle Four billion together contribute about 90% of the pollution. On the other hand, the Bottom Three billion contributed less than 10% yet suffered 75% of the losses. The 46 Least Developed Countries (LDCs), most of them in Africa, with 15% of the population of the world, contribute only 1% of the world's CO_2 emissions. The G20 group of countries are responsible for 80% of the world's CO_2 emissions.

Women and children are more vulnerable than men to the impacts of climate change since 70% of the people living in poverty (about 1.3 billion) are women. Women have less access than men to resources that would help them to adapt to climate change. Women are dominant in the world's food production (50-80 percent) but own less than 10% of the land.

Home and childcare

Human inaction in the face of rapid climate change is immoral. Human inaction is also a violation of human rights, as ruled by the European Court of Human Rights (ECHR) on April 9, 2024. However, the global population is now increasingly sensitised to meaningful actions to solve the climate crisis. The accelerated progress we need is being hindered by increased misinformation and disinformation.

The data demonstrate that climate change poses a grave danger to every aspect of public health and safety, including mental health: global heating, high-intensity cyclones, monsoons, floods, hurricanes, droughts, heatwaves, forest fires, increased risks of zoonoses and food-, water- and vector-borne diseases, and non-communicable diseases (dementia, cardiovascular and respiratory conditions), maternal and child health and mental health issues. Furthermore, climate change is undermining many of the social determinants for good health, such as livelihoods, equity, access to healthcare and social support, and access to adequate food and nutritional security. Air pollution from fossil fuels alone leads to over five million premature deaths in children and adults every year.

We are particularly concerned that over 3.6 billion people live in areas highly susceptible to the effects of climate change. For them, extreme weather patterns are the new drivers of forced migrations. An average of 21.5 million people have been forcibly displaced by weather-related sudden onset hazards each year since 2008. The World Bank's Groundswell report estimates that climate change could force an additional 216 million people across six world regions to move within their countries or across borders by 2050. Over a billion people could be displaced globally by 2050. Therefore, protections for climate migrants are urgently needed.

Data available reveals that the climate crisis has resulted in a material loss of $4.3 trillion over the last 50 years. From 2010 to 2020, human mortality from extreme weather in vulnerable regions that did not contribute significantly to emissions was 15 times higher than in other regions. With unchecked emissions, the loss to be incurred during the next 50 years could be a staggering $178 trillion, and these losses are likely to be underestimated because most modeling approaches exclude or undervalue irreversible risks, such as crossing tipping points in natural and human systems.

Although strong mitigation actions, if applied globally as planned during COP-28, may slow down warming to under 2°C by 2060, this scenario is increasingly uncertain. With today's climate policy commitments world-

wide, we expect to approach 2.7°C warming by 2100. This would render about one-third of the currently habitable space on Earth uninhabitable – affecting more than 2 billion people.

Starting from 2023, with implemented policies, we face at least 25 years where global warming will inevitably surpass targets, reaching 1.5°C (2.7°F) to 2.0°C (3.7°F). This escalation heightens the risk of severe disruptions and crossing critical thresholds in both natural and social systems.

Current mitigation efforts are not enough to ensure the safety of people and ecosystems.Therefore, we must accelerate endeavors to bend down the warming curve by phasing out fossil fuels and rapidly reducing greenhouse gas emissions to enable sustainable living. At the same time, we must focus our efforts on strengthening the resilience of people and ecosystems. Following IPCC-AR6 (2023)

> *We define resilience as the capacity of social, economic, and environmental systems to cope with a hazardous event, trend, or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure while also maintaining the capacity for adaptation, learning, and transformation.*

The Call to Action

We call for the creation of a Planetary Call to Action for Climate Change Resilience, endorsed by experts in both the sciences and social sciences and, crucially, by those in direct service to the communities of the world, including mayors and governors. As evidenced by our signatures at the end of this document, we are committed to, and advocate for, the immediate implementation of these critical measures:

1) A One-Earth approach is needed to guide urgent action and speed up policy change and implementation. Amidst the climate emergency, it is imperative to acknowledge the fundamental right of every individual to climate change resilience.

2) We are dealing with separate but interconnected systemic challenges: climate change, large- scale biodiversity loss, environmental pollution, global inequity, and food insecurity. These issues, if not addressed collectively with great urgency, pose existential threats to humans and other living beings, as well as the ecosystems they depend upon. Poor people will be the most adversely affected.

3) We recognize that the climate crisis will get worse in the near-term, even if the most optimistic mitigation actions to bend the emissions curve are put into place now. Emissions already present in our atmosphere, will cause suffering that socio-political inertia will extend. We need both a short-term plan (a sprint over the next 25 years) and a long-term plan (a marathon over 25 to 100 years).

4) Bend the warming curve down rapidly, and rebound to sustainable living to survive and thrive in ways that are just and lasting. While current approaches to the climate crisis, especially climate finances, revolve mainly around mitigation, we need to do more, and faster. Global cooperation is essential, since emissions anywhere is global heating everywhere.

5) We advocate for a swift, multifaceted approach to climate resilience: rapidly reducing emissions, adapting to current climate shifts, and implementing innovative financing mechanisms. This effort demands global cooperation to address, for example, anticipated large-scale migrations, immediate behavioral shifts to cool the planet, transformative education, sustainable food and water practices and ocean and land restoration.

6) Wealthy nations and the global affluent must empower the poorest three billion, who contribute least to climate change, with access to clean energy, water, food, and air. They should also facilitate technology and resource transfers to developing countries, aiding them in the global effort to curb warming and tackle short-lived climate pollutants effectively. Both political and investment priority should be given to actions that achieve both fast mitigation, and rapid adaptation. We should strive for mandatory commitments and effective results. These actions will contribute to climate justice and peace, locally and globally.

7) We recognize that healthy natural systems underpin our physical, social, and economic resilience, and advocate for urgent action to scale implementation of nature-based climate solutions.

8) We acknowledge that the architecture of the P2C2R must be built on the three-pillar MAST principle, as described in our book, Resilience of People and Ecosystems under Climate Stress, and in the COP-28 statement of PAS and PASS.

I) Doing everything in our power to rapidly reduce global greenhouse gas emissions and bend the warming curve by 2050 to limit temporary

overshoot to below 2°C and to limit the warming to 1.5°C as soon as possible, is the first pillar of MAST... and also prioritizing nature-based solutions in the proactive removal of CO_2 from the atmosphere.

- We must drastically reduce four short-lived climate pollutants (methane, black carbon soot, tropospheric ozone, and HFCs) to reduce the rate of warming by half in the short term (<25 years). We need massive acceleration of the global decarbonization process by transitioning away from fossil fuels during the same time.
- We must remove about 300 billion tons of CO_2 from the atmosphere during the next 40 years (an ultra-marathon), ideally in nature-based ways as much as possible. The current weight of the CO_2 blanket that humans have contributed to is over 1,200 billion tons. Safe means of greenhouse gas capture and storage must be researched and developed, but is not an alternative to cutting emissions from fossil fuels.
- The design approach of climate solutions must broaden the current focus and include nature-based climate solutions that bring in oceans, mangroves, farmlands and forests, which will contribute to addressing the biodiversity loss and inequity crises, along with technological and institutional innovations.
- Construction and housing: transforming the built environment is a crucial factor in the climate equation. Buildings and infrastructure are directly responsible for up to 40% of the emissions. Transform settlements into carbon banks by prioritizing organic building materials in support of sustainable bioeconomy including such homes that transform today's depressed areas. Nature-based, clean affordable energy solutions should also be the basis for the transformation of the built environment.
- Agroforestry for resilient and productive landscapes: with its multifunctional properties, agroforestry should be scaled up in rural and urban settings to provide a sound framework for optimizing synergies to reduce climate risks –and, at the same time, enhance biodiversity at the interface of agriculture and forestry.

II) Adaptation to unavoidable climate change is the second pillar of MAST. Adaptation has three objectives: reducing sensitivity to climate change,

reducing exposure to climate threats, and enhancing adaptive capacity. However, there are limits to human and ecosystem adaptations, and to stay within these limits, adaptation must be tightly integrated with mitigation. Crucially, adaptation must be prioritized equally with mitigation and requires action, across all sectors and levels of society. Adaptation efforts should include a focus on public health, including mental health and well-being, along with the flourishing of other living beings and ecosystems - a critical priority in the design of adaptation solutions under P2C2R. Adapting to heat stress is essential to avoid large numbers of deaths in the coming decades.

- Reducing inequity: The milestones of adaptation for this group include access to affordable clean energy, clean water, sustainable farming, healthcare, early warning systems of weather extremes and, above all, education.
- Women should be decision-makers at national and local levels for resource allocation for climate change actions. Girls' and women's literacy promotes health and is a most powerful tool against poverty.
- Stability for ecosystems: the Amazon is one of the most important biomes on Earth in delivering ecosystem services that are essential to increase the resilience of global systems to climate change. But the Amazon is also suffering from a pronounced loss of resilience. A particular case for just land and natural resource management can be made for the Congo basin and the African drylands. Nearly a third of global drylands occur in Africa. These two-thirds of Africa's land area are home to the most vulnerable communities, ecosystems, and livelihoods.
- Ensuring food and water security and meeting WHO air quality standards should be a high priority. The plan should also include maintaining acceptable air quality in poor neighborhoods through air quality monitoring and indoor filtration systems.
- Nature-based solutions should be integral to both adaptation and mitigation of emissions. These include sustainable land and soil management, forest protection, agroforestry, water-use efficiency in farming, reduced inputs such as fertilizer to help farmers economically, and enhancing soil capacity for carbon sequestration. There

is an opportunity to scale up people-centered approaches to reduce deforestation, protect biodiversity, and reduce inequity in the Amazon, Africa, and Asia. Given the threats or a tipping point in the Amazon ecosystem, new and bold finance mechanisms are needed.

- There is a need to increase the magnitude, efficiency, and speed of climate finance deployment including the need for adaptation/resilience-specific financing in addition to climate finance. Multilateral organizations should be challenged to reduce bureaucracy and increase on-the-ground impact through innovative governance and management arrangements. Donors from both the public and private sectors should be challenged to multiply the scale of funding. Investments in communities and cities must be prioritised.
- Regional climate hotspots, such as Amazonia, Small Island Nations, Drylands of Great Horn of Africa, West Africa, Southern Africa, South Asia, the Middle East, NE China, and Southwest USA, should receive special attention. Taking Africa as a major example of adaptation urgency, an integrated intervention in Africa's drylands should include the following actions and governance structure: establish new business models for inclusive economies, particularly in growing urban centers, to drive sustainable value chains. Create Green Enterprises (social enterprises) that become employers. Establish a high-level political commitment to land restoration and tenure security for local benefits.
- Building capacities of citizens and institutions in climate change adaptation at all levels through education, training, public awareness activities, and exchange of knowledge and best practices, including applications of climate resilience technologies and traditional knowledge.

III) Societal Transformation is the third pillar of MAST, which is essential for thriving in a sustainable future after surviving the crisis. Societal Transformation involves fundamental shifts in behavior, including consumption, and in socio-economic systems and governance. In Pope Francis' words, "This transformation is akin to an ecological conversion." The climate crisis presents us with an unparalleled opportunity to build a stronger, healthier, and more just world that reflects the fact that our thriving depends on the well-being of the natural world and other living beings.

- This transformation requires climate literacy for all, from children to adults; access to affordable energy, clean air and water, and education for the poorest three billion people on the planet so they can adapt to climate disasters and thrive in a post-global warming world; public-private partnerships to finance both mitigation and adaptation; provision of skills and training, to allow all access to the jobs needed to deliver these changes, and partnerships with faith-based institutions to garner strong public support for climate actions.
- Planning and policy initiatives must adopt and include child-centered approaches to fostering resilience.
- Comprehensive environmental and sustainability education should be integrated into school curricula worldwide, ensuring that all children develop a deep understanding of ecological issues, sustainable practices, and their roles in fostering a sustainable future from an early age. This should include the promotion of attitudes that encourage responsible stewardship of the planet, critical thinking about environmental challenges as well as preparation for future careers in sustainable industries.
- We must urgently transition from fossil fuel energy to clean energy.
- Harmful subsidies for fossil fuels must be shifted to support actions that can rapidly bend the warming curve, such as universal health coverage, public transportation, healthy food choices, reducing air and water pollution, and promoting equity.
- A firm commitment must be made to sustainable agriculture so as to rapidly bend the warming curve, promote equity and offer healthy food choices.
- Behavioral change in people, communities, and the private sector must be rooted through a new global initiative to educate everyone from childhood to old age.
- Researchers and policymakers working on solutions should adopt evidence-based trans-disciplinary collaborations that involve mayors, governors, and local NGOs to manage the resources available at various levels of government.
- Climate change is global, impacts locally, and requires local action. Therefore, we call upon heads of nations to facilitate stronger voices of mayors and governors in global climate policy.

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This book responds to Pope Francis's urgent call to address the climate crisis. In a rare joint endeavor of the Pontifical Academy of Sciences and the Pontifical Academy of Social Sciences, the volume brings together the voices of mayors, governors, scientists, NGOs, faith communities, Indigenous leaders, children, and youth from around the world. What do we need to know? What do we need to do? And what can we hope for to protect everyone—especially the most vulnerable from the climate crisis? How do we pursue a healing, sustainable, and more humane future? The book details a novel strategy for confronting the climate crisis that emphasizes Mitigation, Adaptation, and Social Transformation, known as the MAST approach. While necessary, mitigation efforts alone are insufficient; a more holistic approach involving adaptation and social transformation is vital to navigate the challenges of climate change and build resilience.

The MAST strategy is built on three pillars:

1. Mitigation: Reducing emissions to limit warming to below 2°C by 2050, focusing on short-lived climate pollutants, transitioning away from fossil fuels, and removing the accumulated pollution in the atmosphere through nature-based and technological solutions.

2. Adaptation: Preparing for unavoidable climate changes through local-level actions such as protecting against weather extremes, including heat stress and flooding, climate-proofing infrastructure, and developing smart & humane migration policies.

3. Societal Transformation: Shifting towards sustainable living practices, reducing waste, and promoting climate literacy.

The book highlights the new urgency to build climate resilience, noting that 2024 was the hottest year on record, with CO_2 emissions reaching 40.9 billion tons. Even with immediate action, warming will continue for at least 25 years due to inertia in natural and social systems.

The papers in this volume outline the efforts of the Pontifical Academy of Sciences (PAS) and the Pontifical Academy of Social Sciences (PASS) in promoting climate resilience. A key outcome was the "Planetary Call to Action for Climate Change Resilience," signed by various global stakeholders, including Pope Francis.

The editors and the authors propose implementing MAST through sub-regional summits in up to 10 jurisdictions worldwide. These summits will develop city-by-city or county-by-county blueprints for climate resilience, led by local leaders and supported by PAS and PASS.

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