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U.S.-INDIA EMERGING CLIMATE LEADERS

THE FUTURE OF CLIMATE COOPERATION BETWEEN THE UNITED STATES AND INDIA

A SPECIAL REPORT BY ORF AMERICA'S EMERGING CLIMATE LEADERS

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PREFACE
ADVANCING U.S.-INDIA CLIMATE AND ENERGY COOPERATION

BY MEDHA PRASANNA AND DHRUVA JAISHANKAR

The United States and India are the second- and third-largest emitters of greenhouse gases respectively. Cooperation between them will be vital to achieving an energy transition to cleaner and greener sources of energy, objectives that would help not just with emissions, but also energy security and availability, domestic employment, and competition in critical and emerging technologies. Both countries have made tremendous strides, but much more will need to be done. India will need a five-fold increase in its renewable energy capacity of 200 gigawatts (GW) by 2030 to achieve its own stated targets, while the United States will need to triple its 388 GW capacity over the same period.

In 2024, the Observer Research Foundation America (ORF America) convened a cohort of ten emerging climate leaders from the United States and India, representing government, business, academia, think tanks, civil society, and the media. This group participated in a nine-month-long program and a study trip to New Delhi, India, with the objectives of raising awareness about climate challenges in each other's countries, developing joint solutions, and elevating diverse voices. This special report of short working papers is a culmination of this program and attempts to develop ideas around climate collaboration and communication for the United States and India.

Spanning nine chapters on a wide range of topics that include capacity building, green hydrogen, urban planning, methane mitigation, media coverage of climate change, electric tractors, rooftop solar power, critical mineral supply chains, digital public infrastructure (DPI), and climate and health, each chapter identifies and outlines recommendations for U.S.-India cooperation.

Public Opinion: The first two chapters take on a macro approach, with the first examining how public opinion is shaped by media coverage of climate change, the gaps it faces in both countries, and recommendations that would improve climate journalism.

Capacity Building: In a similar vein, Chapter 2 addresses the human factor in scaling up national efforts to achieve net zero goals, including recommendations to develop, attract, and cultivate human and digital resources to equip each level with the capacity essential for a successful green transition.

Methane Emissions: Chapter 3 through Chapter 7 look at the scalability of clean energy technologies, exploring what each country has to offer to make renewable energy accessible at the grassroots level. Chapter 3 addresses the lack of scalable, low-cost energy solutions in agriculture, impeding the mitigation of methane emissions.

Rooftop Solar: Chapter 4 addresses why India missed its 2022 target for rooftop solar panel deployment and recommends financing solutions for distributed rooftop solar power in both the United States and India.

Green Hydrogen: The US India Hydrogen Task Force, launched in 2021, was quickly followed by the National Green Hydrogen Mission in India, and the passage of the Bipartisan Infrastructure Law and Inflation Reduction Act in the United States. Each will accelerate industrial growth, but there will also be challenges. Chapter 5 surveys the role of the private sector and corresponding government policies that will support the nascent hydrogen industry as it matures.

Electric Tractors: Chapter 6 looks deeply into the practical implications of mechanization and the electrification of India's agriculture through electric tractors. It outlines the prospects of leveraging India's manufacturing expertise to lead in electric tractor production through cooperation with the United States.

Critical Minerals and DPI: To ensure the availability of key inputs and supporting infrastructure for the implementation of clean technologies, Chapter 7 focuses on two areas of U.S.-India climate cooperation: critical minerals and DPI.

Urban Planning: The final two chapters peel back the complexity of decarbonizing two of the largest growing energy consumers: cities and the health sector. Two-thirds of the world's population will reside in cities by 2050, and urban agglomerations will create a significant demand for housing, industries, and infrastructure, further increasing energy demand. Chapter 8 borrows lessons from both the United States and India for building better buildings by cooperatively formulating building codes.

Climate and Health: Climate change has also affected public health, costing over $1.5 trillion over thirty years. In parallel, the health sector accounts for over 5 percent of global emissions. The last chapter sounds the alarms on twin emergencies presented by the health sector, highlighting the lack of prioritization of climate and health in U.S.-India bilateral initiatives. It recommends bottom-up and top-down opportunities for collaboration on low-carbon health for the United States, India, and the world.

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CHAPTER 1
BRIDGING GAPS IN U.S. AND INDIAN MEDIA COVERAGE OF CLIMATE CHANGE

BY LINDSAY MAIZLAND AND VANDITA SARIYA

1.1 INTRODUCTION

Journalists are arguably the main actors who explain climate change to the public. When a hurricane approaches, local meteorologists publicize the storm's path. When scientists release data on the Earth's rising average temperature, climate beat reporters explain the trend. And when lawmakers consider new climate legislation, political commentators break down the implications.

Studies have suggested that the media's coverage does influence how audiences perceive climate change: A 2022 U.S. study found that participants were more likely to support government climate action after reading accurate reporting.[1] Another study of Chinese youth documented that the amount of climate coverage correlated with the amount of concern and donations to environmental organizations.[2]

As media coverage of climate change increases worldwide, it should follow that there would be more climate legislation and action.[3] However, problems with the media's climate coverage could explain the lag.[4] This paper focuses on gaps in climate coverage in the United States and India. Based on interviews with journalists in both countries and the authors' experiences covering climate change, the paper analyzes those gaps. It then proposes policy recommendations for U.S. and Indian government officials and lawmakers on how they can support climate journalists:

- Organize exchange programs
- Increase funding for local climate newsrooms and organizations through tax breaks and other mechanisms
- Invest in capacity building for climate journalists, including educational programs and tailored resources

1.2 WHAT IS CLIMATE COVERAGE?

"Climate coverage" refers to media outlets' reporting on climate change and its effects, including warmer temperatures, sea-level rise, and health consequences. To be considered climate coverage, journalists should refer to human-caused, long-term changes in the planet's temperature and weather patterns. However, they do not have to use the phrase "climate change" in their reporting.[5] Several journalists interviewed for this paper, particularly in the United States, noted they sometimes avoided mentioning "climate change" because it could alienate their audiences.

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[1] Brendan Nyhan, Ethan Porter, and Thomas J. Wood, "Time and skeptical opinion content erode the effects of science coverage on climate beliefs and attitudes," Proceedings of the National Academy of Sciences, June 21, 2022, https://doi.org/10.1073/pnas.2122069119.

[2] Lei Shao and Guoliang Yu, "Media coverage of climate change, eco-anxiety and pro-environmental behavior: Experimental evidence and the resilience paradox," Journal of Environmental Psychology, November 2023, https://doi.org/10.1016/j.jenvp.2023.102130.

[3] United Nations, "Five ways media and journalists can support climate action while tackling misinformation," *UN News*, October 3, 2022, https://news.un.org/en/story/2022/10/1129162.

[4] Parker Bolstad and David G. Victor, "The growing divide in media coverage of climate change," Brookings, July 24, 2024, https://www.brookings.edu/articles/the-growing-divide-in-media-coverage-of-climate-change.

[5] Mike Shanahan et al., "Climate change in Africa: a guidebook for journalists," United Nations Educational, Scientific and Cultural Organization, 2013, 122, https://unesdoc.unesco.org/ark:/48223/pf0000225451.

1.3 NARRATIVES IN THE GLOBAL NORTH AND GLOBAL SOUTH

Similar to how journalists might use different language to discuss climate change to reflect local contexts, coverage varies around the world.[6] Consequently, how audiences — including policymakers and officials — discuss climate change also varies. This is evident at the annual United Nations climate conferences. The divide between high-emitting countries in the Global North and low-emitting countries in the Global South has been entrenched in these conferences.[7]

Two broad narratives have emerged: The Global North emphasizes collective responsibility and the growing emissions of China and India. The Global South maintains that developed countries should curb their emissions first and calls for immediate financing assistance, so that they can mitigate and adapt to climate change.[8]

These conflicting narratives were evident in 2015 ahead of the conference that resulted in the Paris Agreement on climate change. Then-U.S. secretary of state John Kerry said India would pose a "challenge" to a successful conference.[9] Then-Indian environment minister Prakash Javadekar responded, "We know the developed nations are used to flexing their muscles and having their way. They are worried that India's proactive role in [other climate] negotiations is yielding results."[10]

These narratives form an undercurrent to climate coverage in the United States and India, as seen below.

1.4 CLIMATE COVERAGE IN THE UNITED STATES

The United States is the world's top historic emitter of carbon dioxide and was the second-top emitter after China in 2022.[11] The country has suffered nearly 400 weather and climate disasters that caused more than $1 billion each in losses since the 1980s.[12] Despite the country's major role in the climate crisis and the devastation it has experienced, climate change has only recently emerged as a major topic of conversation in the U.S. media landscape. The following trends and gaps exemplify U.S. journalists' coverage of climate change.

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[6] Gabi Mocatta et al., "Covering the Planet: Assessing the State of Climate and Environmental Journalism Globally," Earth Journalism Network, June 2024, https://earthjournalism.net/sites/default/files/2024-06/covering-the-planet-assessing-the-state-of-climate-and-environmental-journalism-globally-report3_1.pdf.

[7] Council on Foreign Relations, "UN Climate Talks: 1992–2023," Council on Foreign Relations, December 2023, https://www.cfr.org/timeline/un-climate-talks.

[8] Sinan Ülgen, "How Deep Is the North-South Divide on Climate Negotiations?," Carnegie Endowment for International Peace, October 6, 2021, https://carnegieendowment.org/research/2021/10/how-deep-is-the-north-south-divide-on-climate-negotiations?lang=en.

[9] Vibha Sharma, "Climate change summit: India hits back at Kerry's remark," *The Tribune*, November 26, 2015, https://www.tribuneindia.com/news/archive/nation/climate-change-summit-india-hits-back-at-kerrys-remark-16300.

[10] Ibid.

[11] Hannah Ritchie, Pablo Rosado, and Max Roser, "Per capita, national, historical: how do countries compare on CO2 metrics?," Our World in Data, September 26, 2023, https://ourworldindata.org/co2-emissions-metrics.

[12] National Centers for Environmental Information, "U.S. Billion-Dollar Weather and Climate Disasters," National Centers for Environmental Information, October 2024, https://www.ncei.noaa.gov/access/billions.

Climate Coverage Increases, but Local Reporting Lags

U.S. climate coverage has increased significantly. In the past decade, five major newspapers' coverage more than doubled.[13] Several national nonprofit media outlets that solely focus on climate change have also emerged in recent years. These include Grist, Climate Central, and Inside Climate News. Independent journalists have joined the landscape as well, adding unique perspectives through newsletters, social media threads, and videos.[14]

However, a notable gap is that the rate of growth in climate coverage by state and local media organizations has been slower than national outlets such as the *New York Times* and the *Wall Street Journal*.[15] Local journalists have noted that budget cuts or consolidation efforts resulted in the end of potentially life-saving climate coverage in several small towns.[16]

Fewer journalists also degrades the media's ability to fulfill its watchdog role, particularly in minority communities most affected by climate change and fossil fuel extraction. Media organizations provide accountability for government disaster response and call attention to injustices. For instance, prolonged media coverage and local organizing focused on the devastation affecting Black communities in Louisiana's "cancer alley" contributed to the Environmental Protection Agency launching an investigation.[17] (The investigation was unexpectedly shut down in mid-2023.[18])

Audience Denial and Special Interests Influence Coverage

Many Americans do not recognize the urgency of the climate crisis. Only 37 percent of respondents to a 2023 Pew Research Center survey said that climate change should be elected officials' top priority.[19] The survey also found that some respondents did not trust media organizations' climate coverage. Even more concerning is that some Americans continue to deny that climate change is caused by humans, though that number is falling.[20] This has affected how journalists cover climate, especially those in smaller communities.

In an interview with one of the authors, a meteorologist at a Californian TV station said that while she often reports on how climate change influences weather events, she avoids using the phrase "climate change," opting instead for language like "climate extremes" or "dangerous climate conditions."[21] She said some of the station's viewers

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[13] Max Boykoff et al., "United States Newspaper Coverage of Climate Change or Global Warming, 2000-2024," accessed on October 23, 2024, https://sciencepolicy.colorado.edu/icecaps/research/media_coverage/usa/index.html.

[14] Emily Atkin, "HEATED," accessed on October 22, 2024, https://heated.world.

[15] Parker Bolstad and David G. Victor, "Growing deviations between elite and non-elite media coverage of climate change in the United States," Climatic Change, June 13, 2024, https://doi.org/10.1007/s10584-024-03750-1.

[16] Jane Braxton Little, "Local Newspapers Are Lifelines for Climate-Disaster Communities," Fair Observer, May 14, 2024, https://www.fairobserver.com/world-news/local-newspapers-are-lifelines-for-climate-disaster-communities.

[17] Human Rights Watch, "'We're Dying Here,'" Human Rights Watch, January 25, 2024, https://www.hrw.org/report/2024/01/25/were-dying-here/fight-life-louisiana-fossil-fuel-sacrifice-zone.

[18] Halle Parker and WWNO, "Shuttered EPA investigation could've brought 'meaningful reform' in Cancer Alley, documents show," *AP News*, September 6, 2023, https://apnews.com/article/epa-louisiana-cancer-alley-black-discrimination-606c6803175792576d8cfcd5db55638c.

[19] Giancarlo Pasquini et al., "Why Some Americans Do Not See Urgency on Climate Change," Pew Research Center, August 9, 2023, https://www.pewresearch.org/science/2023/08/09/why-some-americans-do-not-see-urgency-on-climate-change.

[20] Matthew Ballew et al., "Public understanding of climate change has grown in the U.S.," Yale Program on Climate Change Communication, May 21, 2024, https://climatecommunication.yale.edu/publications/ccam-explorer-2023.

[21] Phone interview with a California-based meteorologist at a local TV station, July 29, 2024.

— particularly Republican viewers — can "feel a little attacked" when she reports on climate change, and she has received feedback "along the lines of 'stop pushing your climate change agenda on us.'"

Oil and gas companies are at least partly to blame for this climate denial.[22] For decades, companies such as Exxon misled the public about the dangers of burning fossil fuels, spending billions on advertising and lobbying efforts.[23] Local officials and real estate developers, too, are often reluctant to admit that, "even if we stopped burning fossil fuels tomorrow, some parts of America would already be under water," a climate change researcher and former columnist based in Washington, DC, told one of the authors. "Certain groups benefit from not admitting this." Sometimes the narratives of special interest groups whose industries or livelihoods are disrupted by climate change make their way into journalists' coverage.

Attribution of Disasters Remains Challenging

Until recently, media organizations often neglected to report on whether an extreme weather event was influenced by human-caused climate change. There are many potential reasons for this, including a lack of audience receptivity for such information, as mentioned above. Even today, attribution often happens long after the disaster is over because of the time it takes to research.

However, bolstered by legislation such as the Inflation Reduction Act and the CHIPS and Science Act, scientists are increasingly addressing this gap.[24] Journalists have also contributed to this work. In 2022, Climate Central created an index to determine attribution in the days after a disaster when public attention is highest.[25] Covering Climate Now, an initiative that supports newsrooms worldwide, produced an English- and Spanish-language guide "to help journalists make the connection between extreme weather and climate change."[26] These resources encourage journalists to explain extreme event attribution to their audiences.[27]

1.5 CLIMATE COVERAGE IN INDIA

Climate coverage has noticeably increased in India, particularly since 2007 around the theme of "climate change impacts."[28] India has increasingly witnessed extreme weather

[22] FRONTLINE, "The Power of Big Oil," PBS, April 19, 2022, https://www.pbs.org/wgbh/frontline/documentary/the-power-of-big-oil.

[23] Geoffrey Supran and Naomi Oreskes, "The forgotten oil ads that told us climate change was nothing," *The Guardian*, November 18, 2021, https://www.theguardian.com/environment/2021/nov/18/the-forgotten-oil-ads-that-told-us-climate-change-was-nothing.

[24] Jonathan D. Haskett, "Is That Climate Change? The Science of Extreme Event Attribution," Congressional Research Service, June 1, 2023, https://crsreports.congress.gov/product/pdf/R/R47583.

[25] Climate Central, "Climate Shift Index," Climate Central, accessed on August 21, 2024, https://www.climatecentral.org/climate-shift-index.

[26] Covering Climate Now, "Making the Climate Connection," Covering Climate Now, October 12, 2023, https://coveringclimatenow.org/resource/your-guide-to-making-the-climate-connection.

[27] María Mónica Monsalve, "Journalists should help audiences understand extreme weather — even when they lack climate data," Reuters Institute, July 28, 2023, https://reutersinstitute.politics.ox.ac.uk/news/journalists-should-help-audiences-understand-extreme-weather-even-when-they-lack-climate-data.

[28] Tobias R. Keller et al., "News Media Coverage of Climate Change in India 1997–2016: Using Automated Content Analysis to Assess Themes and Topics," Environmental Communication, August 14, 2019, https://www.tandfonline.com/doi/abs/10.1080/17524032.2019.1643383.

events induced by climate change. It is the seventh-most-climate-vulnerable country in the world, with nine of its states among the top 50 most vulnerable regions globally.[29] Over 85 percent of Indian districts are at risk from climate extremes.[30] In 2023, the country saw a disaster nearly every day from January to September.[31] Consequently, the coverage of such events has increased.

India's Narrative on Climate Change

While Indian publications strongly criticize wealthy nations for their emissions, they are less critical of local government agencies that manage pollution and emissions.[32] In India's national narrative on responsibility, the primary responsibility has often been assigned to the Global North.[33]

However, the debate in India has shifted from externalizing the problem and its remedies to a co-benefits strategy that addresses economic development and climate change concerns.[34] Lately, news outlets have centered the concept of domestic self-determination, which is similar to the strategy outlined in the Paris Agreement. The conversation to hold developed countries responsible is strong, but there is also a parallel discourse that advocates action by developing countries in accordance with their local development priorities. In India-led discourse on climate, there has been a change in emphasis from "looking out" to "looking in."[35]

In general, coverage in Global South countries, including India, emphasizes the societal aspects of climate change, specifically its contribution to water scarcity, unpredictable weather patterns, disruptions to agriculture, and dangers to livable areas.[36] This might be because these nations are more susceptible to the effects of climate change.

Rise in Climate Coverage

A climate journalist whom the authors spoke to said that "about a decade ago, climate change never made it to the front page. Now, it's being covered everywhere, across business, agriculture, finance, sports, gender, city — intersecting with all themes."

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[29] Sudeshna Chatterjee, Ike Uri, and Lubaina Rangwala, "Differential Vulnerability and its Importance in Resilience Planning," World Resources Institute India, February 26, 2024, https://wri-india.org/blog/differential-vulnerability-and-its-importance-resilience-planning.

[30] India Today, "Over 85% of Indian districts at risk from climate extremes: Study," *India Today*, September 6, 2024, https://www.indiatoday.in/environment/story/over-85-of-indian-districts-at-risk-from-climate-extremes-study-2595018-2024-09-06.

[31] Rajit Sengupta and Kiran Pandey, "Extreme weather 2023: India saw a disaster nearly every day from January-September," *Down To Earth*, November 27, 2023, https://www.downtoearth.org.in/climate-change/extreme-weather-2023-india-saw-a-disaster-nearly-every-day-from-january-september-93024.

[32] Jahnnabi Das, "The Struggle for Climate Justice: Three Indian News Media Coverage of Climate Change," Environmental Communication, August 8, 2019, https://www.tandfonline.com/doi/abs/10.1080/17524032.2019.1629976.

[33] Ranjini Murali, Aishwarya Kuwar, and Harini Nagendra, "Who's responsible for climate change? Untangling threads of media discussions in India, Nigeria, Australia, and the USA," Climatic Change, February 22, 2021, https://doi.org/10.1007/s10584-021-03031-1.

[34] Jagadish Thaker, "Climate Change Communication in India," Climate Science, Oxford Research Encyclopedia, October 26, 2017, https://oxfordre.com/climatescience/display/10.1093/acrefore/9780190228620.001.0001/acrefore-9780190228620-e-471.

[35] Anu Jogesh, *India in a Warming World: Integrating Climate Change and Development*, Oxford University Press, November 21, 2019, https://academic.oup.com/book/35227.

[36] Valerie Hase et al., "Climate change in news media across the globe: An automated analysis of issue attention and themes in climate change coverage in 10 countries (2006–2018)," Global Environmental Change, September 2021, https://www.sciencedirect.com/science/article/pii/S0959378021001321.

Indian media has taken long strides when it comes to climate journalism, moving the beat from the sidelines of the newsroom to near the center. Many outlets have emerged that report solely on climate and environmental issues like *Down to Earth, Mongabay India, CarbonCopy, and The Third Pole.*

The rise in climate coverage is also driven by coverage of domestic policies, with research finding stories on climate policies formed the biggest chunk of Indian climate coverage.[37] India released nearly 50 climate policies between 2015 and 2022 — the highest in the world in the given period.[38]

Existing Gaps: Elite Circles, Lack of Data

Despite growing coverage in India, these stories have focused more on national and international concerns than local ones.[39] Most coverage is limited to elite English news outlets that cover global and national developments. News outlets operating in Hindi and other languages mostly do not have dedicated climate staff. Because there is a limited volume of work done by Global South–based experts because of a lack of funding, among other reasons, Indian journalists often cite studies by authors who are not from the region and lose specific nuances and local contexts.

Other gaps include lack of access to data for journalists. In 2023, the environment ministry stopped public access to its portal that provided details on the environmental effect of projects.[40] The ministry said that such information would be provided only when sought under the Right to Information Act.

Audience: Worried About False News

A survey by the Oxford Climate Journalism Network found that major parts of the Indian audience believe that news media play a significant role in influencing climate change decisions, business actions, government policies, and public attitudes.[41] While trust in the media for information about climate change has risen, there is concern about false or misleading news, with respondents saying they encountered false news and misleading information online.

1.6 POLICY RECOMMENDATIONS

Although the United States and India face unique challenges, they both struggle with gaps in climate coverage. This results in citizens being ill-informed and potentially less likely to vote in favor of climate-related policies at the local, state, and federal levels. The

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[37] Anu Jogesh, *India in a Warming World: Integrating Climate Change and Development.*

[38] World Bank Group, "Reality Check: Lessons from 25 Policies Advancing a Low-Carbon Future," World Bank Group, September 2023, https://openknowledge.worldbank.org/server/api/core/bitstreams/b98ee473-12bb-4ff7-bb46-9fcdcb7d72c6/content.

[39] Nirmala Thirumalaiah and Arul Aram, "Framing of environment in English and Tamil newspapers in India," Journal of Media and Communication Studies, January 2017, https://academicjournals.org/journal/JMCS/article-full-text/AE99E9262205.

[40] Jayashree Nandi, "Govt stops portal to track green impact of projects," *Hindustan Times*, April 21, 2023, https://www.hindustantimes.com/india-news/indias-environment-ministry-stops-providing-project-impact-details-on-parivesh-website-citing-confidentiality-and-sensitivity-and-will-only-disclose-information-under-rti-act-101682024303352.html.

[41] Waqas Ejaz, Mitali Mukherjee, and Richard Fletcher, "Climate change news audiences: Analysis of news use and attitudes in eight countries," Reuters Institute, November 14, 2023, https://reutersinstitute.politics.ox.ac.uk/climate-change-news-audiences-analysis-news-use-and-attitudes-eight-countries.

below recommendations focus on how U.S. and Indian government officials and lawmakers can better support journalists covering climate change.

Organize an Exchange Program

To improve journalists' understanding of climate change, the U.S. Department of State and the Indian Ministry of External Affairs, along with the Indian Ministry of Forest, Environment and Climate Change, could launch a professional development exchange program for journalists in both countries. Through the program, journalists could learn from researchers, practitioners, and policymakers in the other country to enhance their knowledge of the country's media landscape, climate science and technology, and policy positions. In addition, the United States could prioritize bringing Indian journalists to the country through its Fulbright Program.

Increase Funding for Local Climate Newsrooms and Organizations

U.S. and Indian policymakers could propose or vote in favor of legislation that bolsters local newsrooms. This could address gaps in climate coverage in small, minority, or non-English-speaking communities in both countries.

For example, members of Congress could reintroduce the Local Journalism Sustainability Act, which would have allowed individuals to claim a $250 tax credit for subscribing to local newspapers and given local newsrooms a payroll tax credit.[42] Other bills brought forward in previous congressional sessions could also be reintroduced.[43] Although these bills do not specifically mention climate coverage, larger budgets could empower local newsrooms to prioritize such coverage.

Internationally, development agencies in both countries could increase funding for initiatives that provide funds to increase the access of or boost the profiles of journalists in the Global South. For instance, the Earth Journalism Network provides funding and training to journalists in over 100 countries. The network already receives funding from the U.S. Agency for International Development; the agency could increase its funding.[44] However, because of concerns about foreign government funding in India, these programs should not target Indian media outlets.

Invest in Capacity Building for Climate Journalists

To strengthen the skills and knowledge of climate journalists, governments in both countries could invest in capacity building and improve their access to climate data.

In India, substantial climate coverage happens in English, primarily because the global policy ecosystem operates in English. This presents challenges for translating technical terms into vernacular languages, and educational courses for journalists reporting in languages other than English could be beneficial. Greater access to government data on climate and bolstering local capacities for data collection would also be helpful.

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[42] "Local Journalism Sustainability Act," H.R. 3940, 117th Congress, June 16, 2021, https://www.congress.gov/bill/117th-congress/house-bill/3940.

[43] Catherine Buni, "Meet The States Using Public Funding to Support Local Journalism," Nieman Reports, February 8, 2023, https://niemanreports.org/articles/state-public-funding-local-news.

[44] Earth Journalism Network, "Funders," accessed on August 20, 2024, https://earthjournalism.net/who-we-are/funders.

In the United States, agencies such as the National Aeronautics and Space Administration and the National Oceanic and Atmospheric Administration could publish educational resources for journalists, including information on how to counter climate denial. They could directly communicate with journalists before, during, and after climate disasters by creating an emailed newsletter or text service that journalists can subscribe to for updates. This could address the current problem of U.S. journalists not attributing disasters to human-caused climate change.

CHAPTER 2
SCALING CLIMATE CAPACITY: HUMAN, INSTITUTIONAL, AND NATIONAL TRANSFORMATIONS THROUGH U.S.-INDIA COLLABORATION

BY AMOL KAPOOR AND PAUL GORDON

2.1 INTRODUCTION

With nations around the world expanding efforts to combat climate change, many are focusing on nationally determined contributions (NDCs), driving a transition towards sustainable energy sources and low-carbon economies. India and the United States, as leading players in this global movement, have established strategic frameworks to enhance their capacities and respond to the punishing socioeconomic effects of climate change. Signed in 2008, India's National Action Plan on Climate Change and the U.S. Climate Change Science Program are significant in signaling action, building coalitions, and cultivating innovation to maneuver through intensifying climate change.

Achieving effective climate action requires not only strategic commitments but also robust capacity building to drive transformation at human, institutional, and national levels. At the core these efforts are imperative to develop, attract, and cultivate human and digital resources within academia, industry, and government equipping each level with the capacity essential for a successful green transition.

Focusing on capacity building can enable effective policy adaptation, industry transition, and local innovation. It also empowers community and social and-economic systems and strengthens resilience.

2.2 TRANSFORMING HUMAN CAPITAL

A significant emphasis on educational and professional development in the green sector is evident in the U.S. Energy and Employment Report (USEER) of 2023.[1] The report underlines substantial growth in the U.S. energy sector, particularly in clean energy, which is outpacing general economic growth. Between 2021 and 2022, the energy sector experienced a 3.8 percent increase in employment, surpassing the overall economy-wide growth rate of 3.1 percent.[2] Additionally, strides in gender diversity are notable, with a 7.8 percent increase in female workers in 2022 alone.[3]Unionized environments within the energy sector are experiencing less difficulty in sourcing skilled labor, largely because of proactive diversity, equity, inclusion, and access initiatives.[4]

India has committed to ambitious targets while already ranked fourth in renewable energy production in the world. India is aiming to meet 50 percent of its complete electricity needs from renewable sources by 2030, with projections suggesting the potential creation of 35 million green jobs by 2047.[5] Meanwhile, the United States has already rapidly grown employment in clean energy tech.

The "Gearing up the Indian Workforce for a Green Economy" report by the Skill Council for Green Jobs India (SCGJ) highlights significant potential for job growth across green sectors. Solar energy is expected to create 3.26 million jobs by 2050, while wind and bioenergy sectors could add 180,000 and 270,000 jobs respectively, by 2030. Green

[1] U.S. Department of Energy, "2023 U.S. Energy & Employment Report (USEER)," U.S. Department of Energy, 2023, https://www.energy.gov/policy/2023-us-energy-employment-jobs-report-useer.
[2] Ibid.
[3] U.S. Department of Energy, "2023 U.S. Energy & Employment Report (USEER)."
[4] Ibid.
[5] Palagati Lekhya Reddy et al., "Gearing up the Indian Workforce for a Green Economy," Skill Council for Green Jobs, May 2023, https://sscgj.in/wp-content/uploads/2023/05/Skills-Lanscape-for-Green-Jobs-Report.pdf.

hydrogen in India has shown much potential, with the capability to add 600,000 jobs by 2030.[6] The transition to labor-intensive sectors like electric vehicle production, construction, and textiles are likely to transform the job landscape, providing new opportunities for economic growth and social equity.

These developments highlight the vital nature of investing in human capital. For policymakers and interested parties, the trends observed in the USEER and SCGJ reports provide a foundation to create millions of green jobs. To systematically address talent gaps and advance a green transition, establishing a green skills consortium is essential. The consortium could pinpoint current skills and emerging sectors with green job potential, assessing which skills can transition through additive (low intervention), reformative (medium intervention), or replacement (high intervention) approaches. This initiative ensures the workforce is equipped to meet the demands of the green economy.

To ensure that this is a sustainable model, education channels need to be aligned with green careers. A comprehensive overview of existing education channels in the STEM field should be conducted to identify necessary adjustments and focus on which needs are not being met. This alignment will better prepare students for green job roles, supporting the economy's shift toward sustainability.

Advancing green leadership training for those in positions of power, whether government or industry, is vital. When leaders have a shared vocabulary to talk about climate change, policy and collaboration can be streamlined. Training programs focused on climate finance, carbon pricing, green hydrogen, circular economy, and emerging climate issues will equip leaders with a plethora of insights and tangible actions to effectively drive investments and policy implementation.

An inclusive, resilient and prepared workforce is vital for a green transition. As the world continues to navigate the complexities of climate change, the experiences of the United States and India serve as a powerful testament to the transformative potential of talent and skill development.

Fulbright-Kalam Climate Fellowship

A prominent example of U.S.-India collaboration in climate education and research and development (R&D) is the Fulbright-Kalam Climate Fellowship. The Fulbright-Kalam Climate Fellowship is administered by the United States-India Educational Foundation and enhances research and capacity-building across climate-related fields. It provides American and Indian scholars, faculty, and professionals opportunities to collaborate with leading U.S. institutions, contributing to global climate research.[7]

Fellowship recipients engage in cutting-edge research, such as employing the use of novel satellite observations to improve soil and crop information for agricultural systems in India, aimed at enhancing food security and sustainable agricultural practices. Another project is the integration of hydrogen and heat production with small modular nuclear

[6] Ibid.

[7] United States-India Educational Foundation, "2025-2026 Fulbright-Kalam Climate Fellowships for Doctoral Research," United States-India Educational Foundation, accessed on August 21, 2024, https://www.usief.org.in/Fulbright-Kalam-Climate-Fellowship.aspx.

reactors. This demonstrates the fellowship's role in fostering technological innovations that support clean energy and climate action.

According to the United States-India Educational Foundation database, the current program includes thirty-two Indian participants in 2024, primarily focused on climate studies (53.1 percent), with additional representation in materials science, energy studies, and environmental policy.[8] In essence, the Fulbright-Kalam Climate Fellowship is more than just academic exchanges it is a strategic platform for strengthening the educational and research ties between India and the United States.

Expanding capacity is crucial to advance climate and sustainability research. The goal is to increase the number of fellows to fifty by 2025 and develop a roadmap to further scale the platform. The process requires forming a funding consortium supported by government, private, and philanthropic partners, focusing on key areas like climate effects, circular economy, energy transition and sustainable materials, with annual reviews to align research with evolving needs.

Strengthening partnerships with leading universities in India and the United States is key to building a talent pipeline. Collaborating with top Indian universities and organizing workshops to showcase fellowship projects can promote further research into select topics. Bolstering alumni ambassadors will further promote initiatives, foster connections and community, and bridge academia and research, which in turn enhances climate-focused program sustainability.

2.3 TRANSFORMING INSTITUTIONAL CAPACITY

Looking beyond individual talent, institutions provide the infrastructure and frameworks that sustain climate action at scale. Institutional memory is a critical piece to long-term capacity building. Even when individuals come and go from governments and institutions, the work can continue because there is a framework in place. In the climate domain, institutions possess a dynamic capacity for fostering change. India and the United States have developed effective joint national programs aimed at enhancing collaborative research, advancing clean energy, building capacity, and coordinating intergovernmental action.

Creating New Centers of Excellence for Strengthening Bilateral Ties

Centers of Excellence (CoEs) are designed to provide platforms for industry, start-ups, and researchers to share data, methodologies, and findings, accelerating research and innovation. These centers attract talent from around the world, spurring collaborations across many borders. These initiatives promote cross-cultural understanding and prepare industry and academia to tackle global issues collaboratively.

For instance, the U.S.-India Joint Clean Energy Research and Development Center has facilitated collaboration, leading to over thirty patents and 200 publications in solar energy technologies, engaging more than twenty industry partners to accelerate commercial-

[8] Ibid.

ization efforts.[9] The success of CoEs in producing impactful results also fosters goodwill, enhancing the perception of partner nations globally.[10]

To leverage shared expertise, we propose four critical areas for CoEs, selected by strategic importance and future trends, based on the shared interests of India and the United States, and the need for capacity building and socioeconomic development. The proposed new COEs include centers for 1). climate monitoring, 2). sustainable lifestyles, 3). reducing freight and shipping emissions, and 4). applying artificial intelligence (AI).

The India-U.S. Climate Monitoring Center in India would work to enhance climate data collection and analysis by expanding NASA-ISRO SAR collaboration, deploying advanced sensors, and providing data for climate modeling, aligning with $59 million allocated in India's 2024-25 budget to support similar efforts. India can leverage U.S. expertise in the field.[11]

Establishing a new India-U.S. Center for LiFE could promote sustainable behavior through economic research, developing nudges and incentives to support India's new LiFE mission and reduce emissions, such as through LED adoption and such activities. Key initiatives, like the distribution of 367.9 million LED bulbs across India, resulted in reduction of 38.70 million tons of CO_2 emissions.[12] The CoE can focus on enhancing energy efficiency through super-efficient appliances and advanced heating, ventilation, and air conditioning (HVAC) technology by promoting efficiency standards in sectors, advancing accessibility and sustainability in energy use.

A new U.S.-India Center for Decarbonizing Heavy Freight and Shipping in the United States would focus on reducing freight emissions through alternative fuels, electrification pilots, and supportive policies in both nations. This is a particular challenge for India and the globe as freight trucking emissions having risen by 83 percent from 1990 to 2021. With the U.S. Department of Transportation, dedicating $27 billion to emission reduction programs, with the aim of transitioning to zero emission trucking technologies, India could work toward reducing trucking carbon emissions by 46 percent by 2050, marking a crucial advancement toward sustainable freight infrastructure which would bring significant environmental and economic benefits.[13],[14]

Creating a new U.S.-India Center for Climate Artificial Intelligence would push the two countries toward using AI for collaborative climate modeling, energy optimization, and risk assessment. AI is a highly valued industry, estimated at $136.5 billion in 2022 and growing at 37.3 percent annually. Integrating AI into climate efforts would spur large

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[9] The Indo-U.S. Science and Technology Forum, "Indo-U.S. Joint Clean Energy Research & Development Centre (JCERDC) - Phase II," The Indo-U.S. Science and Technology Forum, accessed on October 31, 2024, https://iusstf.org/indo-u-s-joint-clean-energy-research-development-centre.

[10] Ibid.

[11] Ministry of Finance Budget Division, "Expenditure Profile 2024-2025," Government of India, July 2024, https://www.indiabudget.gov.in/doc/eb/vol1.pdf.

[12] Press Information Bureau, "Salient features of UJALA and SLNP programmes," Government of India, March 2022, https://pib.gov.in/PressReleseDetailm.aspx?PRID=1808264&reg=3&lang=1.

[13] U.S. Department of Transportation, "Dot Report to Congress: Decarbonizing U.S. Transportation," U.S. Department of Transportation, July 2024, https://www.transportation.gov/sites/dot.gov/files/2024-07/Decarbonizing%20U.S.%20Transportation_July%202024.pdf.

[14] NITI Aayog and RMI, "Transforming Trucking in India: Pathways to Zero Emission Truck Deployment," NITI Aayog and RMI, September 2022, https://www.niti.gov.in/sites/default/files/2023-02/ZETReport09092022.pdf.

leaps for sectors like predictive modeling, energy management, resource efficiency, and disaster resilience.[15]

By focusing on areas where both countries have existing competencies and can mutually benefit, these CoEs will not only enhance climate resilience but also strengthen economic ties through joint R&D. The focus on these four areas ensures that resources are efficiently leveraged between sectors with the highest potential for impact, innovation, and the creation of new economic opportunities for the United States and India.

2.4 TRANSFORMING NATIONAL CAPACITY: BUILDING AN INDIA NODAL CLIMATE ACTION STACK (INCAS)

India's climate action has progressed significantly through regulatory capacity-building, ambitious targets, autonomous institutions, and collaborative, multi-stakeholder approaches. To meet its ambitious NDCs, India has an opportunity to adopt a more cohesive, transformative approach to policymaking and institutional integration. Currently, fragmented cross-ministerial coordination, limited local authority, and financial constraints at the sub-national level present challenges to unified climate action.[16] Focusing on these areas will be crucial for alignment across levels of government so that national goals are in sync with private sector contributions, therefore creating a cohesive and effective climate strategy.

A notable absence in India's climate infrastructure is the lack of a unified digital platform, which has resulted in fragmented data management across the nation. Without a streamlined way to communicate across sectors, this fragmentation restricts information accessibility, complicates policymaking, and weakens India's potential to collaborate on capacity building by limiting effective communication. With an interconnected system, access to international climate finance can be shared and compliance with mechanisms like the European Union's Carbon Border Adjustment Mechanism can be implemented, potentially affecting trade. By aligning and unifying through a single digital platform, these problems can be addressed.

To address these gaps, this paper proposes creating the India Nodal Climate Action Stack (INCAS). This new platform can bring together government entities, climate organizations, industry players, and local authorities, creating a one-stop shop that strengthens policy execution and enhances India's climate resilience and leadership.

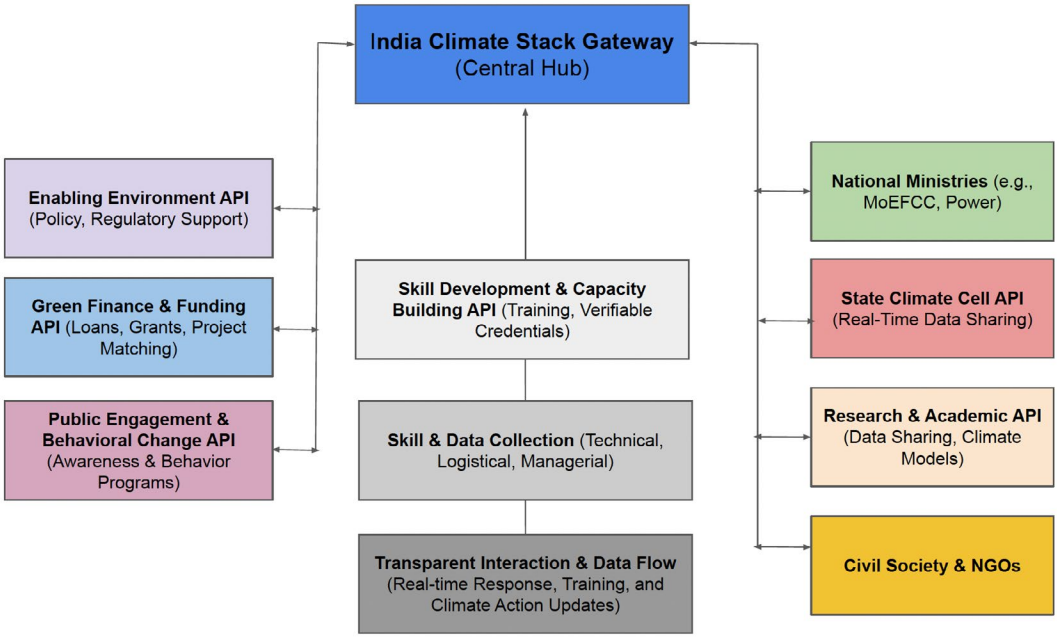
India has had success with platforms like Open Network for Digital Commerce and the Unified Payments Interface. It is clear that leveraging this expertise with a digital initiative can amplify climate action nationally and regionally and effectively harness global initiatives and partnerships. The Beckn Protocol is a decentralized network that would form the backbone of INCAS and offer an open-source framework for seamless data and

[15] Grand View Research, "Artificial Intelligence Market Size, Share & Trends Analysis Report By Solution, By Technology (Deep Learning, Machine Learning, NLP, Machine Vision, Generative AI), By Function, By End-use, By Region, And Segment Forecasts, 2024 – 2030 Artificial Intelligence Market Size, Share," Grand View Research, 2023, https://www.grandviewresearch.com/industry-analysis/artificial-intelligence-ai-market.

[16] Prabhat Upadhyaya et al., "Capacity Building for Proportionate Climate Policy: Lessons from India and South Africa," International Political Science Review, November 2020, https://doi.org/10.1177/0192512120963883.

resource sharing.[17] Its interoperability allows state agencies and research institutions to access real-time data, policy updates, and training resources. The centralization of this information would help to stimulate enhanced transparency and accountability, fostering cross-departmental collaboration.

Figure 1: INCAS Beckn Protocol Structure



Source: Author's creation. Data from Beckn Protocol, "Create open and decentralized digital ecosystems with beckn."[18]

The proposed INCAS platform would operate on five foundational principles:

Discovery: Real-time identification of stakeholders, solutions, research, and case studies to promote collaboration. For instance, enabling banks, industries, and philanthropies to enhance funding and technology transfer, such as using INCAS in India's National Green Hydrogen Mission to improve supply chain capacity and transparency.

Network: Connecting climate data, insights, and resources to enable coordination aligned with India's NDCs, delivering updates from initiatives like NITI Aayog's Atal Innovation Mission to start-ups and academic institutions.

Data and policy: Integrating local climate data into national policies and centralizing important reports like the Biennial Update Reports, supporting ministries in sharing climate finance taxonomies, ensuring standardized, real-time updates for stakeholders.[19]

Technology and finance: Linking industries and universities for collaborative research and development in energy projects, connecting users with funding partners to foster

[17] Beckn Protocol, "Create open and decentralized digital ecosystems with beckn," Beckn Protocol, accessed October 30, 2024, https://becknprotocol.io/.
[18] Beckn Protocol, "Create open and decentralized digital ecosystems with beckn."
[19] Ministry of Environment, Forest and Climate Change Government of India, "India: Third Biennial Update Report to the United Nations Framework Convention on Climate Change," Ministry of Environment, Forest and Climate Change Government of India, February 2021, https://unfccc.int/sites/default/files/resource/INDIA_%20BUR-3_20.02.2021_High.pdf.

blended finance opportunities, attracting investment, and enabling collaborations with institutions like Council of Scientific and Industrial Research, Indian Institute of Technology, and India Institutes of Management.

Skill and tool building: Providing open access to tools, data, and technologies such as climate modeling software and geographic information systems, aligning stakeholders with global standards, enhancing resilience, and building necessary skills through resources like video libraries and training modules.

Establishing an integrated digital infrastructure will strengthen domestic policy implementation, enhance coordination among interested parties, and bolster India's leadership on the global stage. The integration of real-time monitoring on climate action and finance will accelerate nationwide capacity growth collaboration. INCAS's scalability and synergism ensure that the platform can adapt to changing needs over time.

2.5 CONCLUSION

Scaling climate capacity through systemic efforts at the individual, institutional, and national levels is crucial for effective climate action. The collaboration between India and the United States sets a resounding and powerful example for addressing human-caused climate change. With significant investment in human resources and aligning educational systems with green career pathways, both nations can nurture a workforce equipped to push the limits on innovation and identify the sustainable solutions of tomorrow. Programs like the Fulbright-Kalam Climate Fellowship not only strengthen research ties, but they also foster a culture of innovation in climate studies and technology development.

Enhancing institutional capacities through the establishment of Centers of Excellence promotes deeper collaboration and accelerates advancements in clean energy and sustainable practices. The development of INCAS represents a leap toward unifying efforts across government bodies, industry, and academia. INCAS enhances policy implementation, fosters climate resilience, and improves transparency and accountability by integrating data, policies, and resources into a cohesive digital platform.

These steps would not only advance domestic climate goals but also set the bar for global cooperation. By embracing comprehensive approaches to capacity building, India and the United States can inspire other nations to adopt similar initiatives, amplifying the collaborative Global North-South response to climate change.

CHAPTER 3
ADDRESSING THE LACK OF SCALABLE, LOW-COST ENERGY SOLUTIONS IN AGRICULTURE TO MITIGATE METHANE EMISSIONS

BY PANKAJ MAHALLE AND MEENAKSHI VENKATRAMAN

3.1 INTRODUCTION

Agriculture is a major source of methane emissions in both the United States and India. While farmers might contribute to methane emissions from this sector, they are also particularly vulnerable to the health and economic consequences of these emissions. Policy changes that focus primarily on farmers could both address the environmental problem of methane emissions and improve the livelihoods of farmers, many of whom are particularly vulnerable to climate change. To truly improve farmers' livelihoods, governments should focus on reducing methane emissions in an equitable way. This would require policy solutions that are 1) fair and achievable for farmers, particularly smallholder and rural farmers, and 2) effective at reducing methane emissions from agriculture.

Both the United States and India have existing policies that address these two aims, but these policies fall short mainly because they focus either on agriculture or on energy, instead of holistically on both elements. An equitable approach to tackling the problem of global methane emissions would be to integrate and expand U.S.-India policy collaboration on agriculture and energy to promote low-cost, scalable, and accessible solutions.

3.2 BALANCING EMISSIONS REDUCTION AND AGRICULTURAL PRODUCTION

As far as greenhouse gases go, methane is one of the most potent and harmful pollutants to farmers. It is twenty-five times more effective at trapping heat in the atmosphere than carbon dioxide over a 100-year period. Since methane is also comparatively short-lived in the atmosphere, addressing it can be crucial in reducing short-term temperature rise.[1] Farmers face increasing vulnerability because of the climate change effects of methane, including worsened severe weather and extreme temperatures.[2,3]

Beyond exacerbating climate change effects, methane emissions from agriculture also have local environmental effects on farmers. Methane can contribute to the formation of ground-level ozone, which is harmful to human health, crops, and ecosystems. In rural areas, where livestock farming is prevalent, the degradation of air quality can affect the health of communities and reduce agricultural yields, further challenging food security in addition to farmers' physical and economic well-being.[4]

The United States and India, two of the largest methane emitters globally, urgently need to to reduce methane emissions, but they also need to increase agricultural production to accommodate growth in population and food demand.[5] This tension has led to significant political and cultural sensitivity towards reducing methane emissions in both

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[1] Frank Dentener et al., "Atmospheric Chemistry and Greenhouse Gases," Intergovernmental Panel on Climate Change, March 2018, https://www.ipcc.ch/site/assets/uploads/2018/03/TAR-04.pdf.

[2] Pradeep H. Kurukulasuriya and Shane J. Rosenthal, "Climate change and agriculture: a review of impacts and adaptations," The World Bank, June 1, 2013, https://documents.worldbank.org/en/publication/documents-reports/documentdetail/757601468332407727/climate-change-and-agriculture-a-review-of-impacts-and-adaptations.

[3] World Health Organization, "Climate change," World Health Organization, October 12, 2023, https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health.

[4] NASA, "Flooding Stunted 2019 Cropland Growing Season, Resulting in More Atmospheric Carbon Dioxide," NASA, April 3, 2020, https://science.nasa.gov/science-research/earth-science/climate-science/flooding-stunted-2019-cropland-growing-season-resulting-in-more-atmospheric-carbon-dioxide.

[5] United States Environmental Protection Agency, "Importance of Methane," United States Environmental Protection Agency, October 2024, https://www.epa.gov/gmi/importance-methane.

countries, hindering progress towards meeting climate targets and improving human and environmental health.

In the United States, methane from livestock accounts for a significant proportion of the country's agricultural greenhouse gas emissions, at 36 percent. Although overall methane emissions in the United States decreased by 19 percent from 1990 to 2022, emissions from agricultural activities increased by 8 percent. In part, this is due to increased methane emissions from a rising cattle population in the United States since 1990.[6] Changes in food production and consumption practices could play a key role in mitigating methane emissions, but these efforts are prone to the pressures of politically powerful meat and dairy corporations and their lobbies.[7] As a result, existing climate solutions for reducing methane emissions focus more on carbon sequestration and less on low-cost, easily accessible technologies.

With an estimated 300 million cattle, roughly three times that of the United States' cattle population and 30 percent of the global population, India faces even more significant challenges in reducing methane emissions and feeding its population.[8,9] According to the Food and Agriculture Organization, Indian cattle produce around 15 million tons of methane annually, roughly 12 percent of the world's livestock-related methane emissions.[10] The high levels of methane emissions exacerbate the challenges of meeting the country's climate commitments under the Paris Agreement. Despite ongoing efforts, India faces difficulties in balancing economic growth, agricultural productivity, and environmental sustainability.

3.3 CURRENT EFFORTS FOCUS ON AGRICULTURE OR ENERGY—BUT RARELY BOTH

While navigating the competing priorities between reducing methane emissions, economic growth, agricultural productivity, and food demand from a growing population, both countries have taken steps to reduce methane emissions. These steps, however, tend to focus myopically on either agriculture or energy.

On the agricultural side, U.S. initiatives include promoting the research and usage of feed additives and manure management systems. In India, the National Livestock Mission encourages the adoption of sustainable livestock management practices to reduce methane emissions.[11] Previous agriculture-related initiatives between the two countries, the India-US Agriculture Dialogue and the U.S.–India Knowledge Initiative on Agricultural

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[6] United States Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks," United States Environmental Protection Agency, October 2024, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

[7] Ben Lilliston, "Meeting the Methane Pledge: The U.S. can do more on agriculture," Institute for Agriculture and Trade Policy, June 21, 2022, https://www.iatp.org/meeting-methane-pledge-us-can-do-more-agriculture.

[8] "Livestock Census," Ministry of Fisheries, Animal Husbandry & Dairying, April 5 2022, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1813802.

[9] National Agricultural Statistics Service, "January 1 Cattle Inventory Down 2 Percent," National Agricultural Statistics Service, Agricultural Statistics Board, United States Department of Agriculture, January 31 2024, https://downloads.usda.library.cornell.edu/usda-esmis/files/h702q636h/6108x003v/kk91h696g/catl0124.pdf.

[10] Food and Agriculture Organization of the United Nations, "Food and agriculture data," accessed on August 2024, http://www.fao.org/faostat.

[11] Ministry of Fisheries, Animal Husbandry & Dairying, "National Livestock Mission," Government of India, December 14, 2021, https://pib.gov.in/Pressreleaseshare.aspx?PRID=1781374.

Education, Teaching, Research, Service, and Commercial Linkages, focused more on connecting Indian and U.S. institutions with experience in agricultural research, training, and extension, rather than explicitly on methane or climate change.[12] Agricultural research partnerships still continue across universities in both countries, but collaborative government initiatives on agriculture have since become less common in general, let alone initiatives integrating methane emissions or energy.

On the energy side, policy intended to reduce methane emissions focuses on providing incentives to farmers for installing renewable sources of energy generation. Both governments provide federal tax credits, loans, and grants that encourage farmers to install renewable energy systems such as solar, wind, and biogas.[13] In certain areas, farmers can take advantage of renewable energy certificates by selling energy back to utilities at a premium or selling carbon credits based on the emissions reduced through these technologies.[14,15] Of these renewable energy technologies, only biogas can simultaneously address agricultural and energy goals by capturing the methane from manure and generating electricity.

3.4 BIOGAS POLICY IS LEAVING RURAL AND SMALLHOLDER FARMERS BEHIND

Current policy in both countries favour biogas implementation for large-scale farms. The U.S. and Indian governments have placed a heavy emphasis on promoting the usage of biogas plants through the expansion of existing programs and providing government subsidies, as in the AgSTAR program in the United States and the National Biofuels Policy in India.[16] The lengthy application and permitting processes for these subsidy programs are much easier for larger operations to handle. The emphasis on compressed biogas (CBG) further demonstrates favorability towards large farms. The Indian government actively promotes the use of CBG as part of its broader renewable energy goals.[17] In the United States, biogas output is mainly used for electricity generation, but some biogas plants are also turning to CBG because existing renewable fuel policies have not done enough to keep biogas prices competitive with decreasing solar and wind prices.[18] CBG requires additional processing because it needs to be more pure than the output from anaerobic digesters, making it more inaccessible as a revenue stream for small-scale farmers.[19]

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[12] Afeena Ashfaque, "U.S.-India Agricultural Cooperation," Center for Strategic and International Studies, February 11, 2021, https://www.csis.org/blogs/adapt-advance-refreshed-agenda-us-india-relations/us-india-agricultural-cooperation.

[13] White House, "Fact Sheet: President Biden Announces Over $5 Billion to Support Rural Communities During Investing in Rural America Event Series," White House, October 31, 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2023/10/31/fact-sheet-president-biden-announces-over-5-billion-to-support-rural-communities-during-investing-in-rural-america-event-series.

[14] Ibid.

[15] U.S. Environmental Protection Agency, "Frequent Questions about Livestock Biogas Projects," U.S. Environmental Protection Agency," accessed on November 18, 2024, https://www.epa.gov/agstar/frequent-questions-about-livestock-biogas-projects.

[16] Ministry of New and Renewable Energy, "Administrative approval for implementation of Biomass Programme under the Umbrella scheme of National Bioenergy Programme for duration of FY 2021-22 to 2025-26 (Phase-I)- Reg," Ministry of New and Renewable Energy, November 2, 2022, https://mnre.gov.in/policies-and-regulations/schemes-and-guidelines/schemes/.

[17] Ibid.

[18] Fiona Kurylowicz, "The additionality argument for bringing defunct anaerobic digesters back online," Carbon Containment Lab, December 9, 2022, https://carboncontainmentlab.org/updates/posts/retrofitting-defunct-digesters-part-1.

[19] U.S. Department of Energy, "Renewable Natural Gas Production," Alternative Fuels Data Center, https://afdc.energy.gov/fuels/natural-gas-renewable.

Smallholder and rural farmers are also more affected by the general challenges that make it difficult for even large biogas plants to operate. In India, although farmers can take advantage of incentives and guaranteed pricing, those that adopt biogas are hampered by operational challenges. These include feedstock supply chain issues, technological adaptation to local conditions, and financial viability. Similar barriers have impeded biogas plant feasibility in the United States. Difficulties such as high maintenance costs and securing organic waste supplies led to thirty-seven anaerobic digester projects supported by the AgSTAR program to go offline since the mid-2000s.[20]

Supportive policy mainly for large-scale biogas could encourage the continued expansion, or at least status quo continuation of operations, of large-scale dairy farms because biogas plants attach a monetary incentive to generating more manure.[21] The U.S. and Indian governments' energy policies, while meant to reduce methane emissions and provide additional sources of income for farmers, could have the unintended consequence of increasing the wealth gap between rural or smallholder farmers and large-scale farmers, who are able to take advantage of the available incentives and credits.

3.5 GROWING THE EXISTING COLLABORATION

Although the two governments have collaborated less often on agriculture-focused initiatives in recent years, they have increased collaboration on energy. The U.S.-India Clean Energy Finance Task Force is one such example, focusing on mobilizing finance for clean energy projects and potentially benefiting the agricultural sector in both countries.[22] U.S.-India strategic energy planning has also included biogas-related initiatives. Notably, both countries are part of the core membership of the recently launched Global Biofuels Alliance, which aims to drive the development and deployment of biofuels as a key technology in the energy transition.[23]

Without significant changes to existing policy, methane emissions from agriculture will continue to rise, exacerbating global warming and resulting in more frequent extreme weather events. Smallholder farmers will face increased economic instability because of crop failures and unpredictable weather patterns, threatening livelihoods and food security. To address these issues, this paper proposes areas on which the United States and India could focus.

3.6 FARMER-FIRST INITIATIVES TO ENSURE A JUST ENERGY TRANSITION

Policy changes should first focus on farmers and farming communities who are struggling the most because of the consequences of climate change and who lack adequate resources to transition to renewable energy. To reduce potential barriers, such as the need

[20] Kurylowicz, "The additionality argument for bringing defunct anaerobic digesters back online."
[21] Lilliston, "Meeting the Methane Pledge: The U.S. can do more on agriculture."
[22] U.S. Department of State, "U.S.-India Clean Energy Finance Task Force Holds Industry Roundtable to Advance Gas-Electric Coordination Under the Flexible Resources Initiative (FRI)," U.S. Department of State, October 26, 2020, https://2017-2021.state.gov/u-s-india-clean-energy-finance-task-force-holds-industry-roundtable-to-advance-gas-electric-coordination-under-the-flexible-resources-initiative-fri.
[23] Ministry of Petroleum and Natural Gas, "New Phase of Leadership on Energy Transition," Ministry of Petroleum and Natural Gas, https://mopng.gov.in/en/page/68.

to pass new legislation or obtain large amounts of funding, these changes can come in the form of expanding existing policies and programs with equity in mind.

The changes should include building in robust technical assistance for farmers interested in biogas. Resource-constrained and limited-capacity farms might need more assistance with feasibility studies, accessing financing and operation and maintenance of the biogas system once installed.[24] The U.S. Department of Energy's Clean Energy to Communities program, which connects National Laboratory experts to local organizations with clean energy transition projects, offers an exemplary model for technical assistance with partnership and duration options. However, the program notably excludes biogas from its list of clean power technologies encompassing solar, wind, hydropower, geothermal, and hydrogen.[25] To support a just energy transition for farmers, more agriculture- and energy-specific programs offering technical assistance should expand that support to include biogas and focus on rural or under-resourced communities.

Recognizing that farmers need relief from climate change and high energy prices urgently, national governments could investigate the ability of local cooperatives to access financing for biogas projects in the absence of scalable technologies that individual farmers can use. For example, both countries could focus on research into third-party ownership or operation models because the uptake of these models is better understood for other applications of renewable energy, such as rooftop solar, and less commonly studied for agricultural applications.[26,27,28] Research on third-party ownership and other types of financing could inform and improve existing incentives programs, using data and case studies from both countries. This could be tied into existing research partnerships between U.S. and Indian institutions on agriculture, which have a long history and ability to withstand administrative changes.[29]

3.7 SAME RENEWABLE ENERGY SOLUTIONS, SMALLER SCALE

Existing renewable technologies like wind, solar, and biogas are desirable because they allow farmers to access an additional income stream and potentially carbon credits where available. The problem lies not in the technologies themselves but in their scale of implementation. Small-scale solar panels, wind turbines, or biogas plants on farms can lower energy costs for farmers with limited access to land and capital and offer additional revenue through surplus energy sales.

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[24] United States Environmental Protection Agency, "Anaerobic Digestion on Dairy Farms," United States Environmental Protection Agency, September 2021, https://www.epa.gov/agstar/anaerobic-digestion-dairy-farms.

[25] U.S. Department of Energy, "C2C: Clean Energy to Communities Annual Highlights 2023," U.S. Department of Energy, 2023, https://www.nrel.gov/docs/fy24osti/88541.pdf.

[26] United States Environmental Protection Agency, "Understanding Third-Party Ownership Financing Structures for Renewable Energy," United States Environmental Protection Agency, March 2024, https://www.epa.gov/greenpower/understanding-third-party-ownership-financing-structures-renewable-energy.

[27] Informa Economics, "Anaerobic Digester Business Model and Financing Options for Dairy Farms in New York State," New York State Energy Research and Development Authority, May 2014, https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Research/Clean-Power-Innovation/anaerobic-digester-business-model-financing-options.pdf

[28] Sandeep Gupta, Jai Sharda, and Gireesh Shrimali, "The Drivers and Challenges of Third Party Financing for Rooftop Solar Power in India," Climate Policy Initiative, September 7, 2016, https://www.climatepolicyinitiative.org/publication/third-party-financing-rooftop-solar-power-india/.

[29] Afeena Ashfaque, "U.S.-India Agricultural Cooperation."

Explicit incentives and research and development (R&D) funding set-asides for small-scale renewable energy could help to encourage further innovation and adoption of these systems. For incentives, this could work similarly to how funding is scaled for different project sizes in the U.S. Green and Resilient Retrofit Program. The program provides set-asides for rural areas and separate categories of funding for projects with smaller units of housing and estimated upgrade costs.[30]

Both countries could increase collaboration on R&D initiatives to develop cost-effective and efficient biogas technologies, specifically. This includes creating scalable models that can be adapted to different environments, from large dairy farms in the United States to small rural communities in India.

Since farmer livelihoods are an important concern politically in both countries, tying R&D funding for methane reduction to improving energy access for farmers could help this type of research collaboration outlast changes in government attitudes towards climate change.

3.8 ENABLE CARBON CREDITS TO FLOW TO FARMER COMMUNITIES

Enabling carbon credits to flow to smallholder farmers through decentralized small-scale biogas units can enhance the financial accessibility of this technology. Farmers, even on small farms, can already take advantage of carbon credits in exchange for methane reduction from biogas in the United States.[31] India's plans to implement a voluntary carbon market for agriculture should also consider how such an initiative can account for biogas as a key technology to reduce methane emissions and improve farmers' livelihoods.[32]

To make this initiative effective, it is crucial to establish robust systems for carbon credit certification and create accessible monitoring mechanisms for small-scale farmers. Although this may be infeasible to implement for individual farmers, forming cooperatives can help farmers aggregate their projects, making them more attractive to carbon credit buyers and easier to monitor. Key recommendations include integrating carbon credit programs with existing rural development schemes, engaging private sector partners, and educating farmers on biogas technology and the benefits of carbon credits.

Capacity building and education: partner with NGOs and educational institutions to provide training, resources, and tailored programs to help farmers learn about carbon credit mechanisms and benefits.

Simplifying certification processes: advocate for streamlined, low-cost certification processes, particularly for group certifications or cooperative models that are accessible to smallholder and rural farmers.

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[30] U.S. Department of Housing and Urban Development, "HUD Green and Resilient Retrofit Program," U.S. Department of Housing and Urban Development, accessed on November 18, 2024, https://www.hud.gov/sites/dfiles/Housing/documents/GRRP_Overview_FactSheet.pdf.

[31] U.S. Environmental Protection Agency, "Frequent Questions about Livestock Biogas Projects."

[32] Ministry of Agriculture & Farmers Welfare, "Launch of Framework for Voluntary Carbon Market in Agriculture Sector and Accreditation Protocol of Agroforestry Nurseries," Government of India, January 29, 2024, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2000331.

Developing local and regional carbon markets: develop local or regional carbon credit exchanges, using standardized frameworks that specifically cater to the needs of smallholder farmers and allow them to participate across state or national boundaries.

By focusing on these recommendations, India can build robust systems and infrastructure that empower farmer communities to benefit from carbon credits. The United States and India could also take advantage of their mutual involvement in carbon credit markets. This could include joint participation in international carbon trading schemes, where biogas projects contribute to reducing greenhouse gas emissions.

3.9 METHANE REDUCTION SOLUTIONS THAT OUTLAST POLITICAL CHANGES?

Addressing methane emissions and energy access in agriculture is critical for environmental sustainability and economic stability. Integrating the agriculture and energy dimensions in particular will help policy more effectively address methane emissions and farmer livelihoods. There are promising technological solutions already available, such as biogas, but these solutions need to be scalable, low-cost, and more accessible so that rural and smallholder farmers are also able to take advantage of them. Policy collaboration between the United States and India can address this by taking a farmer-first approach to expanding existing initiatives, directing R&D funding towards smaller scale renewable energy solutions, and establishing robust and implementable carbon credit systems that work for smallholder farmers. Energy security will always be important to both countries, and pursuing policies that emphasise the contributions to energy security and lowering energy costs in addition to improving farmers' lives could be the key to resilient, long-lasting policies that address methane emissions.

CHAPTER 4
UNITED POWER: FINANCING SOLUTIONS FOR DISTRIBUTED ROOFTOP SOLAR ADOPTION IN U.S. AND INDIAN CITIES

BY PERRIN KRISKO AND SABAREESH SURESH

4.1 INTRODUCTION

Distributed rooftop solar photovoltaic (RTPV) is a pliable technology that can be deployed on residential and commercial buildings. With the rapid urbanization of cities and their increasing energy demands, these systems offer promising potential to meet city climate action goals of decarbonization and decentralized energy resilience. This article investigates financial levers that have been successfully implemented in cities in the United States and India over the last five years to drive the transition toward distributed rooftop solar markets and makes recommendations for ways in which these strategies can be used by other cities in both countries to mitigate financial barriers for entry into rooftop solar energy adoption by 2030. Below are our top three recommendations from this investigation:

- **Expand incentives for low-income and small business clients:** Financial incentives need to be tailored for individuals, small businesses, and households that lack start-up capital or information needed to install rooftop solar systems.
- **Develop innovative financing models:** Cities should adopt flexible financing models, like third-party ownership (TPO), to reduce upfront costs and spread payments over time, making solar energy accessible.
- **Establish public-private and international partnerships:** Economic collaboration among governments, utilities, and private organizations is essential in creating funding mechanisms and financial incentives, like the South Asia Regional Energy Partnership (SAREP), that accelerate rooftop solar adoption.[1]

4.2 INDIA'S RENEWABLE ENERGY TARGETS

Achieving India's renewable energy goal of 500 gigawatts (GW) of non-fossil fuel by 2030 will require overcoming significant financing hurdles to develop a diverse portfolio of renewable energy, including an anticipated 290 GW of solar demand.[2] To put this number into perspective, India produced roughly 60 GW total of solar by 2022, meaning an additional 29 GW will need to be added to the grid each year until 2030 to meet national targets.[3] Additionally, the government mandates that 40 GW of RTPV be added by the end of March 2026, representing at least 15 percent of the new solar capacity by 2030.[4]

This target is ambitious, but not unprecedented, given India's advantage of entering this energy transition when the cost of rooftop solar has become cheaper than fossil fuels.[5] Moreover, countries like the United States have demonstrated successful transitions to renewable energy, offering valuable insights into scaling solar power adoption. For in-

[1] U.S. Agency for International Development, "About SAREP," U.S. Agency for International Development, accessed on October 28, 2024, https://sarepenergy.net.
[2] Government of India Ministry of Power, "500GW Nonfossil Fuel Target," Government of India Ministry of Power, accessed on October 30, 2024, https://powermin.gov.in/en/content/500gw-nonfossil-fuel-target.
[3] International Energy Agency, "World Energy Outlook 2023," International Energy Agency, October 2023, https://www.iea.org/reports/world-energy-outlook-2023.
[4] Government of India Ministry of New and Renewable Energy, "Green Energy from Rooftop Solar Sector," Government of India Ministry of New and Renewable Energy, December 22, 2022, https://eparlib.nic.in/bitstream/123456789/1465781/1/AU2673.pdf.
[5] Siddharth Joshi et al., "High resolution global spatiotemporal assessment of rooftop solar photovoltaics potential for renewable electricity generation," Nature Communications, October 5, 2021, https://doi.org/10.1038/s41467-021-25720-2.

stance, in 2022-23, the United States successfully added 26 GW of solar to its electric grid—approximately 33 percent of that, 8.6 GW, was furnished by rooftop solar.[6]

Another factor driving solar adoption is India's Renewable Purchase Obligations (RPOs), particularly at the state level, because under this framework, states are required to procure a certain percentage of their electricity from renewable sources.[7] However, compliance has been uneven across the country, with only four states achieving more than 90 percent RPO compliance, while at least eight states demonstrated less than 50 percent compliance as of 2023.[8] States such as Rajasthan, Karnataka, and Gujarat, with their more urbanized landscapes, have demonstrated stronger RPO compliance, driven by better infrastructure and greater financial capacity to adopt distributed solar solutions.

Table 1: Status of Renewable Purchase Obligation Compliance, 2023

STATES CONSISTENTLY MEETING RPO TARGETS (> 90 PERCENT COMPLIANCE)	STATES WITH > 80 PERCENT COMPLIANCE	STATES WITH < 60 PERCENT COMPLIANCE	STATES WITH < 40 PERCENT COMPLIANCE
Karnataka, Gujarat, Rajasthan, and Uttar Pradesh	Himachal Pradesh, Maharashtra, Goa, Tamil Nadu, Andhra Pradesh, and Madhya Pradesh	Bihar, Chattisgarh, Jharkhand, and Telangana	Haryana, Uttarakhand, Punjab, Meghalaya, Jammu and Kashmir, Delhi, West Bengal, and Odisha
Total = 4	Total = 6	Total = 4	Total = 8

Source: Author's creation. Data from India R.E., "Compliance Overview." [9]
Note: Approximations have been made due to data unavailability.

4.3 ROOFTOP SOLAR ENERGY PROCUREMENT IN THE UNITED STATES

Over the last five years, solar energy in the United States has scaled up tremendously. As of 2023, utility-scale solar represented 43 percent of all new energy capacity in the United States, and distributed rooftop solar represented 21 percent (64 percent in total).[10] This compared with solar representing only 27 percent of new U.S. energy capacity in 2018 demonstrates America's success in transitioning its energy away from coal.[11]

The U.S. energy market is driven mainly by state- and city-level initiatives; no national-level solar energy goal has been issued to date. Although, there have been some federal

[6] Bloomberg New Energy Finance, "The 2024 Sustainable Energy in America Factbook," Bloomberg New Energy Finance, February 28, 2024, https://about.bnef.com/blog/the-2024-sustainable-energy-in-america-factbook.
[7] Saloni Jain, "What are RPOs and RECs?," Council on Energy, Environment and Water, Centre for Energy Finance, March 23, 2021, https://www.ceew.in/cef/quick-reads/explains/what-are-rpo-and-rec.
[8] Sarthak Takyar, "Missed Targets: Low RPO compliance calls for a policy relook," *Indian Infrastructure*, April 25, 2024, https://indianinfrastructure.com/2024/04/25/missed-targets-low-rpo-compliance-calls-for-a-policy-relook.
[9] India R.E., "Compliance Overview," India R.E., accessed on October 30, 2024, https://indiaredata.org/rpo/compliance-visualisation/compliance-overview.
[10] Bloomberg New Energy Finance, "The 2024 Sustainable Energy in America Factbook."
[11] U.S. Energy Information Administration, "Short-Term Energy Outlook Data Browser," U.S. Energy Information Administration, accessed on October 28, 2024, https://www.eia.gov/outlooks/steo/data/browser/.

funding mechanisms, like the Inflation Reduction Action (IRA), which establishes a 30 percent investment tax credit on solar expenditure (Part 3, Section 13301).[12] The IRA, however, is shaped as an incentive rather than a mandate, and it also does not provide upfront capital assistance to those interested in investing in solar—rather, it rewards buyers with a tax credit *after* they pay the money upfront to buy a solar power system.

Private and public electric utilities have also played a key role: providing compensation to residential solar generators for their power production (called "net metering").[13,14] Some states and cities offer residential solar generators additional compensation through a green policy or energy resilience objective funded by the government. This, in turn, makes the payoff for residential solar more attractive for homeowners or developers, and has accelerated the growth of residential solar in the United States.

A major challenge to net metering programs in the United States is that utilities are typically opposed to "set compensation rates" for residential solar. Utilities argue that set compensation rates give them less control over spending because they are obligated to offer compensation to any number of eligible solar customers. Additional concerns about equity have been raised in regard to net metering since these programs rely on customers to invest start-up capital in solar power systems that are often financially inaccessible to lower-income demographics, resulting in solar deserts across some communities. One study, for example, found that even after correcting for household income and home ownership, majority Black or Hispanic census tracts had 30-69 percent less solar installed.[15]

4.4 BARRIERS TO ROOFTOP SOLAR ADOPTION IN INDIA

As of 2023, 11 GW of solar panels were installed on Indian rooftops; but with an estimated 250 million rooftops available for solar as of 2023, there is nearly 640 GW of additional rooftop solar potential in India.[16] So, what has prevented Indians from capitalizing on their rooftop areas for solar production? Both *perceived* and *actual* costs create barriers to rooftop solar adoption in India.

As for the perceived risks associated with rooftop solar, a survey of 14,850 households across 21 states in India was conducted in 2020, and it showed that the perceived financial barriers and lack of knowledge about rooftop solar were leading reasons that individuals did not purchase solar panels for their homes. The average Indian household would need to invest about one tenth to one fourth of its average annual income to install a solar

[12] 117th Congress of the United States of America, "Inflation Reduction Act," H.R. 5376, 117th Congress of the United States of America, August 16, 2022, https://www.congress.gov/117/bills/hr5376/BILLS-117hr5376enr.pdf.
[13] Dominion Energy, "Solar for Your Home and Business," Dominion Energy, accessed on October 28, 2024, https://www.dominionenergy.com/virginia/renewable-energy-programs/net-metering.
[14] PG&E, "Net Energy Metering (NEM) program," PG&E, accessed on October 28, 2024, https://www.pge.com/en/about/doing-business-with-pge/interconnections/net-energy-metering-program.html.
[15] Deborah A. Sunter, Sergio Castellanos, and Daniel M. Kammen, "Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity," Nature Sustainability, January 2019, https://www.nature.com/articles/s41893-018-0204-z.
[16] Sachin Zachariah, Bhawna Tyagi, and Neeraj Kuldeep, "Mapping India's Residential Rooftop Solar Potential," Council on Energy, Environment and Water, November 2023, https://www.ceew.in/publications/residential-rooftop-solar-market-potential-in-indian-households.

power system on their house, and the payback period would be about three to seven years without any external financial assistance to offset the initial costs.[17]

Even for a savvy solar buyer, there are additional costs to consider, including maintenance costs, returns on investment, and opportunity cost. A solar energy system could be expected to cost up to $300 per kilowatt in repairs over a ten-year time frame.[18] Additionally, studies have demonstrated the negative effects that anthropogenic smog imposes on rooftop solar capacity, reducing potential solar generation output by 26-41 percent.[19,20] So, the risk on returns for investment can be uncertain and unnerving. For investors or developers, other financial concerns include low customer credit, limited collateral for financing, default risk due to delayed payments, and high cost of capital for small developers.

At the national level, India will need to invest $115 billion over the next six years to meet its 2030 solar energy goals, requiring widespread cooperation and buy-in from a number of diverse stakeholders.[21]

4.5 SOLAR SUCCESS IN SAN JOSE

San Jose is one of the most expensive large cities to live in the United States. In 2023, more than 33 percent of households in San Jose earned over $200,000 per year, while more than 9 percent earned less than the federal poverty level ($35,000).[22] The Absolute Gini coefficient, a measure of income distribution, was 82 (zero being perfectly distributed) in 2023.[23] In light of this economic backdrop, San Jose committed in 2018 to becoming the world's first one GW solar city by 2040.[24] As of 2023, San Jose was on track to meet its goal with nearly 297 MW of installed solar.[25]

San Jose incentivized rooftop solar adoption for low-income households by promoting federal tax incentives for solar panels, home battery storage, and stand-alone storage.[26]

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[17] JMK Research & Analytics, "Indian Residential Rooftops: A Vast Trove of Solar Energy Potential: Resurgent Demand and Strong Supply-Side Enablers Support a Highly Favourable Market Outlook," Institute for Energy Economics and Financial Analysis, October 2022, https://ieefa.org/sites/default/files/2022-10/Indian%20Residential%20Rooftops-%20A%20vast%20Trove%20of%20Solar%20Energy%20Potential_Oct2022.pdf.

[18] Vignesh Ramasamy et al., "U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks, With Minimum Sustainable Price Analysis: Q1 2022," National Renewable Energy Laboratory, September 2022, https://www.google.com/url?q=https://www.nrel.gov/docs/fy22osti/83586.pdf&sa=D&source=docs&ust=1729564425144272&usg=AOvVaw3i3UiItXEtSmsI9jSy9yfZ.

[19] Sushovan Ghosh et al., "India's photovoltaic potential amidst air pollution and land constraints," iScience, October 2023, https://pmc.ncbi.nlm.nih.gov/articles/PMC10561047.

[20] Sushovan Ghosh et al., "Cleaner air would enhance India's annual solar energy production by 6–28 TWh," Environmental Research Letters, April 19, 2022, https://iopscience.iop.org/article/10.1088/1748-9326/ac5d9a.

[21] Neshwin Rodrigues and Aditya Lolla, "Beyond Tripling: India needs $101bn additional financing for the net-zero pathway," Ember, November 28, 2023, https://ember-energy.org/latest-insights/beyond-tripling-india.

[22] United States Census Bureau, "S1901 Income in the Past 12 Months (in 2023 Inflation-Adjusted Dollars)," United States Census Bureau, accessed on October 19, 2024, https://data.census.gov/table/ACSST1Y2023.S1901?g=160XX00US0668000.

[23] Anji Buckner-Capone and Scott Myers-Lipton, "2024 Silicon Valley Pain Index," San Jose State University Human Rights Institute, June 2024, https://www.sjsu.edu/hri/docs/2024%20SVPI_Final.pdf.

[24] City of San Jose, "Bold Campaigns to Activate Climate Smart San José," City of San Jose, accessed on November 4, 2024, https://www.sanjoseca.gov/home/showpublisheddocument?id=66591.

[25] City of San Jose, "Energy: Local Renewables," City of San Jose, accessed on October 28, 2024, https://www.sanjoseca.gov/your-government/departments-offices/environmental-services/climate-smart-san-jos/climate-smart-data-dashboard/energy-local-renewables.

[26] San Jose Clean Energy, "Going Solar," San Jose Clean Energy, accessed on October 28, 2024, https://sanjosecleanenergy.org/going-solar.

San Jose works with the California Public Utilities Commission to offer programs that help low-income households benefit from solar, including no-cost solar for low-income residents, solar on multifamily affordable housing, and 20 percent green tariff discounts for disadvantaged communities.[27] Participants in these programs receive training on solar panels and access to "green-collar" jobs, and sponsors may receive incentives for their contributions as well.

San Jose's no-cost solar program, called DAC-SASH, is funded by a combination of state, local government, and private philanthropy financial contributions.[28] It follows a third-party ownership (TPO) structure where a program administrator prepays the cost of a 25-year power contract with a third-party solar developer on behalf of a low-income customer. Afterwards, the third-party solar developer constructs and maintains the solar photovoltaic (PV) device for the customer, allowing the customer to save on their electricity bill. Over time, the customer shares a percentage of their electricity bill savings with the program administrator to help cover solar installation costs. The no-cost solar program provides a 60 percent subsidy per kilowatt (kW) to each customer, but through the TPO structure, the no-cost solar program is able to cover 75-85 percent of total installation costs; the remaining financing costs (15-25 percent) are covered by additional grants.[29]

If San Jose's no-cost solar subsidy program were established for 10 percent of New Delhi households, it would cost the city an estimated $4.2-7.0 million (just 0.05-0.08 percent of the 2024-2025 city budget).[30] Delhi has a target of 750 MW of rooftop solar by 2030, of which 250 MW has been installed to date.[31] To close the gap, New Delhi will need to add a minimum of three kW rooftop solar devices to an approximate 166,000 households.

4.6 DELHI'S SOLAR STATUS

Delhi is one example of a city that has been rolling out innovative subnational financial strategies to support rooftop solar power since 2016. Delhi is focused on providing substantial subsidies and streamlining installation processes through the national power scheme. In 2023, up to 60 percent subsidies for two kW installed capacity and 40 percent for the next one kW were offered in Delhi, rendering solar energy easier, more accessible, and affordable.[32] Moreover, Delhi's Group Net Metering allows for shared production of electricity from rooftop solar panels, which is particularly beneficial in congested urban

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[27] California Public Utilities Commission, "Solar in Disadvantaged Communities," California Public Utilities Commission, accessed on October 28, 2024, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/customer-generation/solar-in-disadvantaged-communities.

[28] GRID Alternatives, "DAC-SASH," GRID Alternatives, accessed on October 28, 2024, https://gridalternatives.org/what-we-do/program-administration/dac-sash.

[29] California Public Utilities Commission, "Process and Load Impact Evaluation of the Disadvantaged Communities-Single-Family Affordable Solar Housing Program (DAC-SASH)," Evergreen Economics, April 28, 2023, https://www.calmac.org/%5C%5C/publications/DAC-SASH_Evaluation_2023.pdf.

[30] PRS Legislative Research, "Delhi Budget Analysis 2024-25," March 2024, https://prsindia.org/files/budget/budget_state/delhi/2024/Delhi_Budget_Analysis_2024-25.pdf.

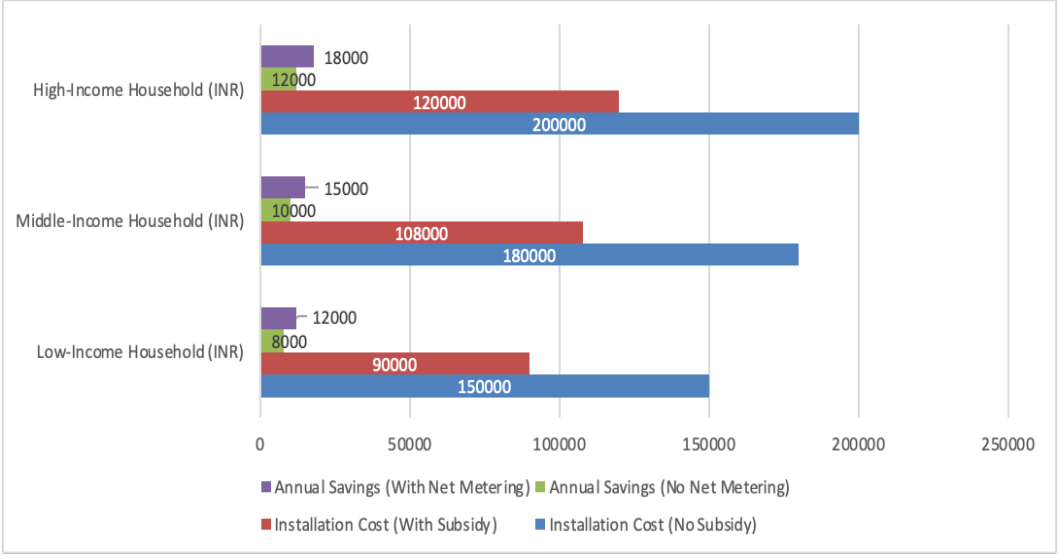
[31] Paras Singh, "Delhi govt's aim: Meet 20% of power demand through solar by 2027," *Hindustan Times*, January 30, 2024, https://www.hindustantimes.com/cities/delhi-news/delhi-govt-s-aim-meet-20-of-power-demand-through-solar-by-2027-101706552653135.html.

[32] Department of Power, "Delhi Solar Energy Policy, 2023," Department of Power, March 14, 2024, https://eerem.delhi.gov.in/eerem/delhi-solarenergy-policy-2023-english-version.

areas.[33] By maximizing the use of available space, this policy enables even low-income households with limited rooftop access to participate in solar energy generation.

In terms of financing, cost-benefit analysis suggests that Delhi households installing rooftop solar could save ₹8,000-10,000 (~$100) annually on their electricity bills.[34] Savings would be even more substantial—₹12,000-15,000 (~$160) per year—for those using the Group Net Metering system, which allows excess power to be sold back to the grid, increasing returns on investment for participating households. The example in Delhi has demonstrated that scaling such programs can bring both widespread financial relief while contributing to India's broader renewable energy targets.

Figure 2: Cost-Benefit Analysis for High-Income, Middle-Income, and Low-Income Households to Switch to Rooftop Solar in Delhi



Source: Author's creation. Data from various sources collated, 1. Installation Costs and Subsidies: MNRE.[35] 2. Annual savings estimate—Delhi energy reports.[36]
Note: Costs mentioned in the figure are in Indian rupees not U.S. dollars.

4.7 INNOVATIVE FINANCIAL MODELS TO ACCELERATE ROOFTOP SOLAR ADOPTION IN CITIES

To accelerate the adoption of rooftop solar in cities, a variety of financial models have been applied successfully in both the United States and India. These models aim to lower

[33] Delhi Electricity Regulatory Commission, "Delhi Electricity Regulatory Commission (Group Net Metering and Virtual Net Metering for Renewable Energy) Guidelines, 2019," Delhi Electricity Regulatory Commission, May 2019, https://www.derc.gov.in/sites/default/files/DERC%28Group%20Net%20Metering%20and%20Virtual%20Net%20Metering%20for%20Renewable%20Energy%29%20Guidelines%2C%202019.pdf.
[34] Tanvi Deshpande, "Explained: The Fine-Print In Modi Govt's Rooftop Solar/Free Electricity Scheme," *IndiaSpend*, March 15, 2024, https://www.indiaspend.com/explainers/explained-the-fine-print-in-modi-govts-rooftop-solarfree-electricity-scheme-899893.
[35] Government of India Ministry of New And Renewable Energy, "PM – Surya Ghar: Muft Bijli Yojana, National Portal," Government of India Ministry of New and Renewable Energy, accessed on October 31, 2024, https://www.pmsuryaghar.gov.in.
[36] Energy Efficiency & Renewable Energy Management Centre, Government of NCT of Delhi, "Delhi Solar Policy 2023," Energy Efficiency & Renewable Energy Management Centre, Government of NCT of Delhi, March 14, 2024, https://eerem.delhi.gov.in/eerem/about-delhi-solar-energy-policy.

financial barriers to entry for consumers and create sustainable financing options that are tailored to different income levels and market conditions. Below is a table showcasing some of these financial levers and their real-world applications.

Table 2: Innovative Financial Models and Their Use Cases—A City Snapshot

EX.	FINANCIAL MODEL	DESCRIPTION	USE CASE
1	**Lease-to-own**	Customers lease solar power systems with the option to own them over time, easing upfront costs.	SolarCity, based in Foster City, California, is actively marketing its solar lease program in California.[37]
2	**Usage-based payment (PAYGO)**	Consumers pay for the solar energy they use, without owning the system.	California's solar PV capacity has increased more than 16-fold since its enactment.[38]
3	**Roof rental model**	Property owners lease rooftops to solar developers for installation and operation of solar systems.	Gandhinagar, a city in Gujarat, India, introduced the model in 2010.[39]
4	**Solar PPA (power purchase agreement)**	Third parties install and maintain solar systems, selling energy generated to users at a reduced rate.	Denver, Colorado, has a solar power purchase agreement (SPPA) that allows the Denver Housing Authority to install solar panels on residential buildings.[40]
5	**On-bill financing**	Solar installation costs are repaid through utility bills, spreading the financial burden over time.	Tallahassee, Florida's energy efficiency loan program offers on-bill financing for both residential and commercial solar projects.[41]
6	**Payment assurance/ RESCO model**	Guarantees investor payments through escrow accounts or third-party assurances.	PM Surya Ghar: Muft Bijli Yojana in 10 million households.[42]

Source: Author's creation.

4.8 STRENGTHENING REGIONAL ENERGY COOPERATION

These examples illustrate that solar transition is advancing in cities like San Jose and New Delhi. A question remains whether other cities can adopt similar initiatives to meet national climate goals. One viable option is the U.S.-India energy cooperation

[37] National Renewable Energy Laboratory, "Solar Leasing for Residential Photovoltaic Systems," National Renewable Energy Laboratory, January 2019, https://www.nrel.gov/docs/fy09osti/43572.pdf.
[38] Jean Rodrigo Schmidt-Costa, Mauricio Uriona-Maldonado, and Osmar Possamai, "Product-service systems in solar PV deployment programs: What can we learn from the California Solar Initiative?," Resources, Conservation and Recycling, January 2019, https://www.sciencedirect.com/science/article/abs/pii/S0921344918303458.
[39] Apolitical, "Gujarati cities go green with "rent a roof" solar power," Apolitical, March 2017, https://apolitical.co/solution-articles/en/rent-roof-turns-gujarat-solar-state.
[40] U.S. Environmental Protection Agency, "Solar Power Purchase Agreements," U.S. Environmental Protection Agency, accessed on October 28, 2024, https://www.epa.gov/green-power-markets/solar-power-purchase-agreements.
[41] U.S. Environmental Protection Agency, "Clean Energy Finance: On-bill Programs," Environmental Protection Agency, September 2019, https://www.epa.gov/sites/default/files/2018-12/documents/usepa_on_billprograms.pdf.
[42] Rituraj Baruah, "Draft norms for financial assistance, payment security under PM Surya Ghar," *Mint*, September 9, 2024, https://www.livemint.com/politics/policy/resco-ula-rooftop-solar-renewable-energy-pm-surya-ghar-scheme-centre-11725886848845.html.

through SAREP, especially for cities with limited budgets.[43] Launched in 2021 by the U.S. Agency for International Development, SAREP provides a range of financial levers and tools that empower cities to advance their clean energy transitions, including rooftop solar. By promoting access to concessional loans and grants and spreading the costs of energy projects over time, SAREP alleviates financial burden placed on city governments.[44] This is crucial for cities that want to implement equitable energy solutions to ensure that traditionally underserved communities benefit from distributed solar installations.[45] The program demonstrates how innovative financial tools and shared expertise can accelerate clean energy transitions and bridge the financial gap for cities without large-scale resources.[46]

4.9 SOLAR RTPV: A PILLAR OF U.S.-INDIA ENERGY COLLABORATION

Financing levers at the city level offer unique advantages that private or national implementation does not. For one, financing distributed rooftop solar energy generation in cities encourages multilateral collaboration and energy decentralization. Though investment from city governments will be necessary to achieve national climate action goals, there are opportunities on which cities can capitalize to bridge the financing gap, including incentives for low-income and small business clients, innovative financing models, and public-private and international partnerships.

The views expressed by the authors in this chapter do not necessarily represent the views of the United States Environmental Protection Agency or the United States.

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[43] U.S. Agency for International Development, "About SAREP," U.S. Agency for International Development, accessed on November 4, 2024, https://sarepenergy.net/.

[44] U.S. Agency for International Development, "USAID and DFC Announce $41M Loan Guarantee Program to Finance Rooftop Solar," U.S. Agency for International Development, accessed on October 21, 2024, https://www.usaid.gov/india/press-release/usaid-and-dfc-announce-41m-loan-guarantee-program-finance-rooftop-solar.

[45] U.S. Agency for International Development, "Deploying Solar PV Rooftop on Low Paying Consumers' Premises in Jharkhand," U.S. Agency for International Development, April 2021, https://sarepenergy.net/wp-content/uploads/2022/04/Report-on-Deploying-Solar-PV-Rooftop-on-Low-Paying-Consumers-Premises-in-Jharkhand-_Final_Version.pdf.

[46] U.S. Department of Energy "U.S.-India Strategic Clean Energy Partnership Renewable Energy Pillar," U.S. Department of Energy, July 2023, https://www.energy.gov/sites/default/files/2023-07/USISCEP-RenewableEnergy.pdf.

CHAPTER 5
GOVERNMENT POLICIES TO ENCOURAGE PRIVATE SECTOR INVOLVEMENT IN INDIA'S GREEN HYDROGEN ECOSYSTEM

BY MIAORU GUAN AND VEDANT PATIL

5.1 INTRODUCTION

Green hydrogen is a versatile zero-emissions fuel that can be used to decarbonize many hard-to-abate sectors like steel manufacturing, fertilizer production, and transportation. It is a rapidly growing clean fuel solution ($8.8 billion in 2024, up 40 percent from 2023, and a projected growth compounded rate of nearly 39 percent from 2024 to 2033).[1] India can establish itself as an attractive market for global green hydrogen production to maximize this economic opportunity. Additionally, green hydrogen can mitigate India's growing emissions by as much as 50 million metric tons of carbon dioxide annually, making it an important component of India's goal of achieving net zero by 2070.[2]

Although India has strategic natural advantages to produce green hydrogen, it also faces challenges in high production costs and low demand. This paper recommends several policy initiatives to encourage private sector investment in green hydrogen, such as increasing financial incentives, creating mandates for certain sectors to use green hydrogen, and business bilateral cooperation. If successful, these policies would enable India to benefit from more capital investments, from foreign and domestic private sector, and reduced emissions.

5.2 INDIA'S STRATEGIC OPPORTUNITIES FOR GREEN HYDROGEN PRODUCTION

India is poised to become a global hub of green hydrogen production because of natural advantages for solar production and water availability, particularly in western and southern India. In 2019, India ranked as the third-largest solar producer because of its location near the equator and year-round sunlight.[3] India also has wind production projects in Tamil Nadu and Gujarat. These existing renewable energy plants could supply clean energy to power electrolysis to produce green hydrogen. Water availability is another key in producing green hydrogen. Gujarat and Maharashtra both have ample ground and surface water that is uncommitted meaning it is not depleted and is available for use.[4] Therefore, high water availability and strong existing renewable projects in western and southern India provide opportunities for green hydrogen production. Additionally, India is strategically located near major Asian markets. When green hydrogen costs decrease in the future, India could export green hydrogen to other countries in the Asia-Pacific and the Middle East.

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[1] Precedence Research, "Green Hydrogen Market Size to Hit Around USD 165.84 Bn by 2033," March 2024, https://www.precedenceresearch.com/green-hydrogen-market.

[2] Ministry of New and Renewable Energy, "National Green Hydrogen Mission," Ministry of New and Renewable Energy, January 2023, https://mnre.gov.in/national-green-hydrogen-mission.

[3] *The Times of India*, "India surpasses Japan as world's third-largest solar power generator: Report," *The Times of India*, May 8, 2024, https://timesofindia.indiatimes.com/india/india-surpasses-japan-becomes-worlds-3rd-largest-solar-power-producer/articleshow/109945435.cms.

[4] Hemant Mallya et al., "Unlocking India's RE and Green Hydrogen Potential: An Assessment of Land, Water, and Climate Nexus," Council on Energy, Environment and Water, September 10, 2024, https://www.ceew.in/publications/how-can-india-unlock-renewable-energy-and-green-hydrogen-potential.

5.3 THE INDIAN GOVERNMENT HAS ESTABLISHED AMBITIOUS GREEN HYDROGEN GOALS

The India National Green Hydrogen Mission aims to make the country a manufacturing and export hub for hydrogen (with a goal of 5 million metric tons of hydrogen production by 2030).[5] It focuses on developing the domestic hydrogen supply chain, including production, storage, and distribution infrastructure. The mission introduced the Strategic Interventions for Green Hydrogen Transition program, which provides financial incentives of 175 billion rupees ($2.1 billion) for electrolyzer manufacturing and green hydrogen production.[6] To qualify for the financial subsidies, applicants apply through government auctions. Electrolyzer manufacturers would receive production-based monetary awards over five years, and producers would receive monetary compensation over three years. The Ministry of New and Renewable Energy (MNRE) held auctions in January 2023 and awarded subsidies to companies.

The MNRE and U.S. Department of Energy jointly established the US India Hydrogen Task Force (HTF) in June 2021.[7] This HTF is a high-level bilateral collaboration under the U.S.-India Strategic Clean Energy Partnership. This task force aims to enable a robust hydrogen economy in India by 1) making policy recommendations to the Indian government, 2) promoting research and development in new technologies across the hydrogen value chain, and 3) conceptualizing pilots and scaling up their adoption.

5.4 THE GREEN HYDROGEN VALUE CHAIN IS COMPLEX

The green hydrogen value chain can be broken down into three key stages: production, transportation, and end use.

Production: Green hydrogen is produced through electrolysis, splitting water into hydrogen and oxygen using electricity from renewable sources like solar, wind, or hydro power. This process results in zero greenhouse gas emissions. High energy requirements, costly electrolyzers, and the need for pure water make hydrogen production complex and expensive.

Transportation: After production, hydrogen is typically compressed into high-pressure cylinders for transport by trucks or trains. Alternatively, it can be liquefied for transportation in specialized cryogenic tankers. To simplify handling, hydrogen can also be converted into ammonia for transport and later reconverted back into hydrogen at its destination. Compressing, liquefying, and converting hydrogen for safe and efficient storage and transportation requires advanced technology and infrastructure.

End use: Hydrogen is a versatile energy carrier with multiple applications. Hydrogen serves as a vital component in the manufacturing of ammonia, methanol, steel, and various chemical products. Hydrogen can also produce electricity in fuel cells, which can be used to power buildings and vehicles.

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[5] Ministry of New and Renewable Energy, "National Green Hydrogen Mission."
[6] Ibid.
[7] U.S.-India Strategic Partnership Forum's (USISPF), "US India Hydrogen Task Force," U.S.-India Strategic Partnership Forum's (USISPF), accessed November 18, 2024, https://usispf.org/us-india-hydrogen-task-force/#:~:text=The%20US%20India%20Hydrogen%20Task,and%20academia%2C%20The%20taskforce%20was.

5.5 GREEN HYDROGEN FINANCIAL BARRIERS INHIBIT SCALING UP IN PRODUCTION AND END USAGE

Despite financial incentives, one barrier to scaling up green hydrogen is high production costs. Compared to gray hydrogen (hydrogen produced using natural gas), green hydrogen production is twice as expensive: $5/kilogram (kg) vs $2/kg.[8] In India, the cost of producing green hydrogen in India is $5.30-$6.70/kg, approximately 40 percent more expensive than producing green hydrogen in Australia.[9]

Although the Indian and U.S. federal governments provide financial subsidies, the value of incentives in India is lower ($0.30-0.60/kg) compared to the United States (up to $3/kg via a tax credit called 45V). Additionally, India's incentives are valid for three to five years of hydrogen production whereas U.S. incentives last ten years. As a result, producers are more likely to move to locations with higher incentives, like the United States and Europe. If India extends incentives past five years and increases the monetary value of the incentives, producers and investors would be more likely to produce green hydrogen in India.

One current advantage of the India financial incentive is the lack of hourly matching requirement. To qualify for the U.S. 45V tax credit, producers must match every hour of hydrogen production to clean energy generation by 2028. This regulation effectively disqualifies green hydrogen powered by nuclear and hydropower, which cannot be built by 2028, as well as solar and wind, which are intermittent producers.[10]

To encourage financing in green hydrogen, the Japanese government provides equity capital and liability guarantees for the production and storage of decarbonized fuels, including hydrogen.[11] If the Indian government adopts these policies, producers of green hydrogen could get cheaper, more attractive upfront financing to begin operations. Government liability guarantees would also encourage private (both domestic and international) investment into India by derisking the projects.

Hydrogen end use industries also face financial barriers to switching to green hydrogen because of its higher costs. Transportation, industry, and power generation industries would rather use current fossil fuels because of their lower cost. To encourage domestic producers of fertilizers and steel to use green hydrogen, the Indian government can enact mandates and create financial incentives. Although no country currently mandates a certain percentage of production come from green hydrogen, India can be a leader in setting production targets. Similar to India's target of blending biofuels in 20 percent of

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[8] Kamala Scheling, "Green Hydrogen to Undercut Gray Sibling by End of Decade," *Bloomberg New Energy Finance*, August 9, 2023, https://about.bnef.com/blog/green-hydrogen-to-undercut-gray-sibling-by-end-of-decade/..

[9] Raj Sawhney, "Decoding India's Green Hydrogen Potential," ORF America, May 1, 2024, https://orfamerica.org/newresearch/green-hydrogen-bp.

[10] Daniel Moore, "Zero-Carbon Hydrogen Tax Rules Spark Divide Over Grid Emissions," *Bloomberg Law*, January 26, 2024, https://news.bloomberglaw.com/environment-and-energy/zero-carbon-hydrogen-tax-rules-spark-divide-over-grid-emissions.

[11] Japan Organization for Metals and Energy Security (JOGMEC), "Providing equity capital and liability guarantees for the production and storage of decarbonized fuels (hydrogen, ammonia, and synthetic fuel)," Japan Organization for Metals and Energy Security (JOGMEC), accessed on November 6, 2024, https://www.jogmec.go.jp/english/carbonneutral/carbonneutral_10_00001.html.

ethanol (E20 by 2025), India could mandate that X percent of steel production be from green hydrogen.[12]

Refineries would benefit from green hydrogen. They use large amounts of hydrogen for hydrocracking and desulfurization processes. Currently, most of the hydrogen consumed in these processes is considered gray hydrogen and produced by steam methane reforming. This gray hydrogen generates carbon dioxide from reacting methane with natural gas.

To promote the use of green hydrogen in refining, the Indian government could impose mandatory blending quotas or incentivize refineries to shift by putting a price on carbon. Today, refining is considered as one of the "no-regrets" sectors for green hydrogen adoption because it already has a hydrogen demand, making the switch to green hydrogen straightforward. Moreover, refineries already have an existing infrastructure for transport and storage of hydrogen, making the transition more cost-effective compared to sectors starting from scratch.

Steel is a potentially good candidate for green hydrogen interruption through government production mandates. Reducing steel emissions through green hydrogen has a large effect on overall emissions because steel currently contributes 12 percent to India's total greenhouse gasses.[13] Additionally, green hydrogen is less expensive than other steel production decarbonization pathways, like carbon capture and storage. Lastly, steel mandates would complement the existing strategy of financial incentives, where the Ministry of Steel has been allocated 14.66 billion rupees ($177 million) in the National Green Hydrogen Mission to promote green hydrogen in steelmaking.[14]

The green ammonia industry is also viable to include green hydrogen-production mandates because India has already seen high demand for green ammonia. In June 2024, the MNRE expanded its supply auction to buy 36 percent more green hydrogen-based ammonia (750,000 tons versus the originally planned 550,000 tons) because the fertilizer industry expressed increased demand. Winners of the auction will receive a ten-year supply contract to sell ammonia to the government and three years of production-based subsidies.[15] As the subsidies phase out and production costs decrease, the government could introduce percentage mandates of green hydrogen in ammonia to encourage further development.

The government could also create financial incentives to encourage producers by closing the financial gap between green hydrogen and fossil fuels. India can follow examples from Germany and Japan in creating demand-side contracts for differences. In Germany, the government pays producers the difference between clean hydrogen costs and natural gas prices.[16] Similarly in Japan, the government pays producers the difference between

[12] Ministry of Petroleum & Natural Gas, "India has achieved the target of 10 percent ethanol blending, 5 months ahead of schedule," Ministry of Petroleum & Natural Gas, June 2022, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1831289.
[13] Vibhuti Garg et al., "Steel decarbonisation in India," Institute for Energy Economics and Financial Analysis, September 2023, https://ieefa.org/resources/steel-decarbonisation-india.
[14] Vibhuti Garg et al., "Steel decarbonisation in India."
[15] Rachel Parkes, "India to buy an extra 200,000 tonnes of green hydrogen-based ammonia on behalf of fertiliser producers," Hydrogeninsight, June 2024, https://www.hydrogeninsight.com/policy/india-to-buy-an-extra-200-000-tonnes-of-green-hydrogen-based-ammonia-on-behalf-of-fertiliser-producers/2-1-1666078.
[16] Victoria Cuming, "G-20 Zero-Carbon Policy Scoreboard 2024: Fuels and CCUS," *Bloomberg New Energy Finance*, May 2024, https://www.bnef.com/insights/33995.

strike (the agreed price for hydrogen and ammonia supply costs) and reference prices (price of counterfactuals such as coal and liquefied natural gas).[17] These government incentives would be a temporary measure to spur production until the price of hydrogen decreases from economies of scale.

5.6 U.S. AND INDIAN BUSINESSES BILATERAL COOPERATION

U.S. and Indian businesses could cooperate bilaterally to encourage India green hydrogen production to produce mutually beneficial scenarios. For example, U.S. businesses could sign investment or offtake agreements with Indian producers of green hydrogen. U.S. businesses would benefit from financial returns in hydrogen from India's natural advantages of solar, wind, and water. Indian producers would benefit from capital to fund new plants and offtake agreements to create demand.

The U.S. and Indian governments should sign a bilateral agreement to establish a joint credit system under Article 6 of the Paris Agreements. Under an agreement, if a U.S. business invests financially or signs an offtake agreement with an Indian producer of green hydrogen, the carbon credits from the hydrogen production plant could be transferred to the United States. These credits could be used to reduce the U.S. greenhouse gas emissions in their Paris Agreement nationally determined contributions goals. India has already begun talks of joint credit bilateral agreements for renewable energy technology investments with countries like Japan.[18] If the United States acts quickly to establish bilateral agreements with India, the U.S. government and businesses would benefit from more advantageous deals.

Another area of bilateral cooperation can be in the form of hub-to-hub collaboration, especially in coastal cities. Coastal hydrogen hubs are clusters where green hydrogen production is located near end-user consumers and ports to export hydrogen. Clustering producers with consumers helps streamline logistics for hydrogen delivery, create economies of scale, and enable the option of exporting hydrogen or ammonia for long distance shipping. Maritime businesses and states in both India and the United States can share knowledge to develop coastal hydrogen hubs. India is planning on developing the first green hydrogen hub in the V.O. Chidambaranar Port in Tamil Nadu to produce and eventually export green hydrogen.[19] The government of Tamil Nadu has supported hub development by providing land for the hydrogen/ammonia production plants to private developers, in addition to subsidies such as an exemption for electricity tax.[20] In the U.S., the Gulf Coast Hydrogen Hub is being negotiated for a $1.2 billion award from the

[17] Vipul Garg and Donavan Lim, "Clear guidelines, formation of CfD schemes likely to unlock Asian hydrogen market in 2024," S&P Global, December 2023, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/122923-clear-guidelines-formation-of-cfd-schemes-likely-to-unlock-asian-hydrogen-market-in-2024.

[18] Sarita Chaganti Singh and Shivangi Acharya, "India mulls bilateral deals for green hydrogen-linked carbon credits," *Reuters*, July 4, 2023, https://www.reuters.com/sustainability/india-mulls-bilateral-deals-green-hydrogen-linked-carbon-credits-sources-2023-07-04.

[19] Chirag Rathi and Janhavi Joshi, "Green hydrogen hubs: Unfolding India's potential," PV Magazine, June 12, 2024, https://www.pv-magazine-india.com/2024/06/12/green-hydrogen-hubs-unfolding-indias-potential/.

[20] Argus Media Group, "Tough race for green H2 projects in India's Tamil Nadu," Argus Media Group, January 19, 2024, https://www.argusmedia.com/en/news-and-insights/latest-market-news/2529366-tough-race-for-green-h2-projects-in-india-s-tamil-nadu.

Department of Energy.[21] This hub is located in Texas and considering producing green hydrogen for ammonia. Hub-to-hub collaboration could mean Tamil Nadu and Texas share best practices and knowledge for developing and transporting ammonia, to accelerate development of both hubs.

Additionally, trade groups could organize visits with government officials from both countries to facilitate knowledge sharing, engage in research and development, and encourage trade agreements. In March 2024, an Indian delegation visited South Korea to discuss green hydrogen. The trade group, India Sustainable Project Developers Association, and MNRE representatives benefited from touring a hydrogen bus refueling station in Incheon. The Korea Chamber of Commerce and Industry, the largest business chamber in South Korea, benefited from signing offtake agreements with India producers. Trade groups, such as the US India Hydrogen Task Force, could benefit from similar visits. Because the global hydrogen production industry is still nascent, growing the size of the total production industry benefits all countries. These opportunities aren't mutually exclusive.

5.7 CONCLUSION

To encourage India's green hydrogen development, the Indian government can improve incentives and enact mandates to encourage domestic and foreign businesses. The Indian government can reduce production costs through longer-term and higher value monetary incentives, loan guarantees, and market-based mechanisms, such as carbon trading and contracts for differences. Additionally, the government can create mandates and standards for refineries and domestic producers of fertilizers and steel to use green hydrogen to create demand for green hydrogen. Lastly, bilateral cooperation between Indian and U.S. states and businesses can encourage green hydrogen development through visits, trade agreements, and knowledge sharing.

[21] U.S. Department of Energy, "Regional Clean Hydrogen Hubs Selections for Award Negotiations," U.S. Department of Energy, Office of Clean Energy Demonstrations, accessed on November 6, 2024, https://www.energy.gov/oced/regional-clean-hydrogen-hubs-selections-award-negotiations#selected.

CHAPTER 6
REVOLUTIONIZING TRACTOR MANUFACTURING: ELECTRIFYING INDIAN AGRICULTURE MECHANIZATION FOR ECONOMIC GROWTH AND ENVIRONMENTAL SUSTAINABILITY

BY KARAN SINHA AND ABIGAIL DOERR

6.1 INTRODUCTION

As a global leader in diesel tractor manufacturing, India can pioneer the transition to electric tractors, strengthening its role in the global economy while improving air quality in rural areas and addressing climate change. India's tractor manufacturing accounts for about one-third of global production and is expected to grow.[1] Despite India's significant role in global tractor manufacturing, it has been slow to bring electric tractors to market. In 2023, over 900,000 tractors were sold in India and only four were electric.[2]

Diesel tractors have helped India's farms become more efficient and productive, but they cause far more air and climate pollution than on-road vehicles; one diesel tractor emits as much carbon and particulate volumes equal to fourteen cars.[3]

Tractors require considerable power to handle heavy loads and perform demanding tasks. Weaker emissions standards contribute to poor air quality in farming communities and rising global temperatures, causing drought and flooding that weaken food systems and agricultural output. India has set robust zero-emissions goals to decarbonize the on-road transportation network, but the central government has not included diesel tractors in any of these policies. While India's transportation electrification policies have largely overlooked tractors, policies promoting on-road electric vehicles have been effective: Electric car sales in India grew by 90 percent in the fiscal year 2022-23.[4] Expanding electric vehicle policies to include electric tractors, along with targeted subsidies and investments, will spur manufacturing and sales growth and bolster the nascent electric tractor industry.

Tractors in India serve a versatile role beyond farming. Classified as off-road vehicles, they also play a vital utility role in moving goods to market, farm labor, and municipal services like hauling water and collecting garbage. This broad utility explains why India is the largest global consumer of tractors. If battery-powered tractors were produced and adopted on a larger scale, they could enhance farming yields, improve air quality, and mitigate the effects of climate change. However, challenges exist: high purchase prices, uncertainty about battery life, and the need for reliable charging networks. With the right policy interventions and building on India's mechanization efforts over recent decades, the government can address these challenges and leverage India's manufacturing expertise to lead in electric tractor production for India, the United States, and the EU.

The widespread adoption of tractors across India was the result of decades-long government programs to promote mechanization of farm equipment to promote a larger yield of crops. Since 2000, India has seen the rapid growth of diesel tractor sales.[5] The Indian government deployed the National Food Security Mission in 2007, which strove to in-

[1] Aravind Harikumar, "India Needs a Policy Push to Harvest the Rich Benefits of Electric Tractors," The International Council on Clean Transportation, April 29, 2024, https://theicct.org/india-needs-a-policy-push-to-harvest-the-rich-benefits-of-electric-tractors-apr24/.

[2] Ag Equipment Intelligence, "New Holland Aims for Bigger Share of Indian Tractor Market," Ag Equipment Intelligence, January 25, 2024, https://www.agequipmentintelligence.com/articles/6393-new-holland-aims-for-bigger-share-of-indian-tractor-market.

[3] Naoki Nitta, "Could Electric Tractors Revolutionize Farming?," Smithsonian Magazine, April 19, 2023, https://www.smithsonianmag.com/innovation/could-electric-tractors-revolutionize-farming-180982012/.

[4] India Brand Equity Foundation, "Electric Vehicle Industry in India: Market Growth & Innovations," India Brand Equity Foundation, August 2024, https://www.ibef.org/industry/electric-vehicle.

[5] Zhenying Shao, "Emissions Inventory for Agricultural Tractors and Construction Equipment in India," The International Council on Clean Transportation, May 18, 2016, https://theicct.org/publication/emissions-inventory-for-agricultural-tractors-and-construction-equipment-in-india/.

crease yields of rice, wheat, and legumes by investing 49 billion over five years in seed technology, soil management, and farm mechanization.[6]

Through the Kisan Tractor Yojana scheme, started by the Indian central government in 2022, farmers are eligible for up to a 50 percent subsidy to purchase a diesel tractor.[7] Good harvests and prompt processing of the subsidy result in higher sales of tractors.[8] The government can advance the shift to electric tractors, akin to its mechanization efforts but the FAME-II scheme, India's current electric vehicle incentive policies, doesn't include electric tractors.[9]

Several Indian states incentivize electric tractors, Haryana's electric vehicle (EV) policy offers an incentive of 50 percent off the showroom price for the first 1,000 electric tractors, while Telangana's EV policy exempts electric tractors from road taxes and registration fees purchased and registered in the state.[10]

Opportunities for U.S. and India collaboration on tractor electrification are primarily at the state level. The United States is an important trade partner to India in tractor manufacturing and sales and is the third-largest consumer of tractors globally with over 250,000 sold annually. Like India, the United States has developed incentives for electrifying transportation networks but has yet to adopt a comprehensive federal policy for prioritizing the transition to electric tractors. Although there aren't comprehensive federal electric tractor programs, the U.S. Department of Agriculture has funded innovative grant programs, such as Conservation Innovation Grants, to help incubate companies like Monarch Tractor and resource collaborations between the tractor start-up and small farms.[11] Monarch has leveraged public grant funding with private investments to bring electric tractors to farms around the globe.[12]

The most formal initiative in the United States to prioritize tractor electrification is happening at the state level in California, the largest agricultural state in the country, where public and private capital has driven innovation in tractor electrification. California recently expanded a multimillion-dollar electric vehicle voucher program to include off-road vehicles, including electric tractors. The voucher program, the Clean Off-Road Equipment Voucher Incentive Project (CORE), is a streamlined subsidy to bring down the incremental price of a new electric tractor so that the purchase price is the same as the lower cost diesel tractor.[13]

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[6] Radhey Shyam Singh and Ramesh Kumar Sahni, "Transformation of Indian Agriculture through Mechanization," Economic Affairs, June 2019, https://economicaffairs.co.in/Journal/abstract/id/MzY5MQ==.

[7] kisantractoryojana, "Kisan Tractor Yojana," kisantractoryojana, accessed August 21, 2024, https://kisantractorsyojna.in/.

[8] *The Times of India*, "Easy subsidy gives July tractor sales 40% boost," *The Times of India*, August 9, 2023, https://timesofindia.indiatimes.com/city/ahmedabad/easy-subsidy-gives-july-tractor-sales-40-boost/articleshow/102556055.cms.

[9] *The Economic Times*, "FAME 3 scheme nears completion, timeline yet to be announced: Union Minister," *The Economic Times*, August 5, 2024, https://economictimes.indiatimes.com/industry/renewables/fame-iii-scheme-nears-completion-timeline-yet-to-be-announced-union-minister/articleshow/112277129.cms.

[10] Harikumar, "India Needs a Policy Push to Harvest the Rich Benefits of Electric Tractors"; Government of Telangana "Telangana Electric Vehicle and Energy Storage Policy 2020-2030," Government of Telangana, https://www.nsws.gov.in/s3fs/2021-08/Telangana%20EV%20policy.pdf.

[11] Monarch, "USDA Grant Funds Monarch Tractor Deployment and Partnership with Hopville Farms and Oregon State University," Monarch, July 21, 2021, https://www.monarchtractor.com/news/usda-grant-funds-monarch-tractor-deployment-and-partnership-with-hopville-farms-and-oregon-state-university.

[12] Monarch, "Monarch Tractor Announces $133M Series C Funding," Monarch, July 22, 2024, https://www.monarchtractor.com/news/monarch-tractor-announces-133m-series-c-funding.

[13] California Core, "Clean Off-Road Equipment Voucher Incentive Project," California Core, accessed on October 23, 2024, https://californiacore.org/.

Electric tractor manufacturing is in its early stages, with start-ups driving legacy manufacturers to compete in the evolving market by exclusively developing and producing electric tractors. These new companies include Monarch Tractors, which expanded its operations to Hyderabad, India, in 2023, along with Soletrac in the United States, AutoNxt Automation, Bull Work Mobility, and Powerland Agro in India.[14]

Longtime tractor manufacturers in India and the United States need to be faster in developing electric tractor models. Of India's six major manufacturers, three—Mahindra & Mahindra, International Tractors Ltd, and Escorts Kubota—are working on electric versions, but most are not yet available. Those focusing on electric models primarily target European markets with comprehensive decarbonization goals. While an electric tractor is at least twice the cost of a diesel tractor, the prices will drop with economies of scale as manufacturing increases and demand rises.

Only four of the 1.66 million electric vehicles sold in India last year were classified as agriculture tractors and about 150 more are operational as prototype models.[15] For electric tractors to become mainstream in India and the U.S. it will be necessary to target policy interventions to boost supply and demand.

6.2 MUNICIPAL GOVERNMENTS CAN BE STEWARDS OF TRACTOR ELECTRIFICATION

The city of Berkeley, California, became the first municipality in the United States to purchase a Monarch electric tractor and took advantage of California's CORE program.[16] Berkeley paid one-third of the tractor's cost — comparable to what they would pay for a diesel model — while Monarch coordinated a CORE voucher to cover the remaining two-thirds.

Delivered in December 2023, the electric tractor has since been used by Berkeley's landscaping staff to grade and remodel playfields across the city's 50 parks.

Berkeley is known for its environmental leadership, but the grounds staff were the real champions of change. Despite some operational challenges to overcome, they embraced the electric tractor and take pride in pioneering sustainable technology. The city saves money on diesel, staff enjoy cleaner air, and best of all, the tractor is impressively quiet.

Municipalities can play a critical role in piloting electric tractors by demonstrating the technology's viability and encouraging broader adoption. Funding incentives like CORE not only make electric models affordable for local governments but also incentivize manufacturers to innovate zero-emission options, helping to show municipalities and farmers that these solutions are both effective and accessible.

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[14] JKM Research & Analytics, "Electric Tractors in India: A Concept or Reality?," JKM Research & Analytics, August 2024, https://jmkresearch.com/electric-vehicles-published-reports/whitepaper-electric-tractor-market-in-india-a-concept-or-a-reality/.
[15] Harikumar, "India Needs a Policy Push to Harvest the Rich Benefits of Electric Tractors."
JKM Research & Analytics, "Electric Tractors in India: A Concept or Reality?"
[16] Monarch, "City of Berkeley Receives MK-V as First Municipal Customer," Monarch, January 16, 2024, https://www.monarchtractor.com/news/city-of-berkeley.

City of Berkeley Landscaping staff Melissa Parker, Fatimah Lewis, and Wayman Blocker stand in front of the city's fully electric MK-V Monarch Tractor at San Pablo Park in Berkeley, California. Source: Copyright Abigail Doerr, all rights reserved.

6.3 WHY ELECTRIC TRACTORS?

Electric tractors are emerging technologies that could replace diesel tractors, providing benefits for air quality, farming, and manufacturing. Despite challenges in their adoption by farmers and local governments, electric tractors offer environmental and operational advantages that could transform agriculture.

6.3.1 ENVIRONMENTAL URGENCY AND IMPACT OF DIESEL TRACTORS

- **Growing emissions from diesel tractors:** As diesel tractor sales rise, so does the environmental harm they cause. Diesel tractors emit pollutants that degrade air quality and contribute to climate change, posing a growing threat to ecosystems and food systems, especially in vulnerable regions in both India and the United States.
- **Agricultural climate impact:** While diesel tractors support crop yields, their emissions contribute to climate change consequences, such as droughts and flooding, which increasingly threaten India's agriculture and food security.
- **High diesel consumption in agriculture:** Agricultural diesel consumption in India represents 7.4 percent of the country's overall diesel use—nearly as much as buses.[17] Without clear plans to transition tractors to zero-emissions alternatives, diesel tractors will represent a growing share of India's carbon emissions.

[17] Zhenying Shao and Sunitha Anup, "Incentives for electrifying agricultural tractors in India," International Council on Clean Transportation, October 2022, https://theicct.org/wp-content/uploads/2022/10/india-hvs-evs-incentives-elec-tractors-India-oct22.pdf.

6.3.2 ELECTRIC TRACTORS COST LESS TO OPERATE

- **Lower total cost of ownership:** Despite higher upfront costs, electric tractors have a lower total cost of ownership—electric power trains have fewer parts than diesel motors, which results in lower maintenance costs (20 percent less than diesel models).[18] Electricity is often less expensive and more reliable than diesel, and early testing has shown that electric models use significantly less energy than their diesel counterparts, resulting in even more savings.[19]
- **Simplified operation and labor benefits:** Electric tractors have simpler operations, requiring less specialized training—a benefit for areas facing agricultural labor shortages.
- **Superior torque performance:** Electric power trains deliver maximum torque faster than diesel engines, ideal for heavy-duty agricultural tasks. This improved performance can make electric tractors more effective in demanding farm environments and help improve crop yields.[20]

6.3.3 BATTERY STORAGE AND GRID DECARBONIZATION POTENTIAL

- **Battery storage as a decarbonization tool:** Electric tractor batteries have the potential to offer a valuable dual function as mobile storage units, especially useful as India builds solar networks. Batteries can provide backup power to the grid, especially in rural areas, where tractors can charge through solar power during the day and support the grid during peak demand or low-sunlight periods.

6.4 CHALLENGES OF ADOPTING ELECTRIC TRACTORS

Like most decarbonization efforts, major barriers inhibit the widespread adoption of electric tractors in India and beyond. Policymakers must design policy solutions to help overcome these barriers to reach climate and environmental goals.

- **High purchase price remains a primary barrier to widespread adoption:** Electric tractors cost over twice as much as diesel models. While increased manufacturing will eventually lower prices, they are expected to remain high in the coming years without policy action.
- **Building electric charging adds complexity to purchase:** Battery charging on farms and in rural areas presents a significant challenge. Diesel tractors can reliably run for sixteen hours on a single tank, but electric tractors require 220-volt charging, specialized electrical upgrades, and grid enhancements.[21] Electric tractors can use the same charging networks as electric cars but will require coordination to build out enough public charging. Meeting these demands will require creative solutions and collaboration from policy and industry leaders.

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[18] Zhenying Shao and Sunitha Anup, "Incentives for electrifying agricultural tractors in India."
[19] Cadeo Group, "Pacific Northwest Electric Tractor Barriers Study," Cadeo Group, April 22, 2022, https://www.cadeogroup.com/wp-content/uploads/2022/04/PNW-Tractor-Electrification-Study.pdf.
[20] Ashish Malik and Shivam Kohli, "Electric tractors: Survey of challenges and opportunities in India," Materials Today: Proceedings, May 2020, https://doi.org/10.1016/j.matpr.2020.04.585.
[21] Association of Equipment Manufacturers, "Farmers Take Aim at Net-Zero Emissions," July 28, 2022, https://www.aem.org/news/farmers-take-aim-at-netzero-emissions.

- **Trust in the technology and battery life will take time:** Uncertainty about battery life and range may deter farmers from adopting electric tractors. Monarch offers a fourteen-hour runtime, but manufacturers and policymakers will need to work to overcome concerns about battery life and degradation.[22] Farm-ng uses swappable electric bike batteries for quick replacement, while AGROMEC in the Netherlands has developed battery-swapping for light-duty tractors, which may gain traction with widespread use.[23] Although battery technology is improving, it remains less reliable than diesel, which has powered engines for over a century.
- **Electrifying tractors shifts carbon emissions from the pump to the grid:** Electric tractors are more efficient and use less energy than internal combustion engines, but they will rely on the energy grid instead of the fuel pump, meaning emissions are displaced rather than eliminated unless the grid is powered by clean energy. In India, despite ambitious plans to rapidly decarbonize, the electricity grid is still largely dependent on coal and natural gas.

6.5 STRATEGIES TO DRIVE INDIA'S ELECTRIC TRACTOR LEADERSHIP

India has an opportunity to establish itself as a leader in electric tractors. Strategic federal, state, and international policy actions can boost India's manufacturing sector, reduce emissions, and support the agricultural economy.

- **Federal-level strategies:** India's federal government should be more proactive in setting the tone for electric tractor adoption by providing the financial and regulatory foundation needed to accelerate this transition. National incentives should include:
  - **Prioritizing electric tractors in the Kisan Tractor Yojana scheme:** The Kisan Tractor Yojana scheme offers a 50 percent subsidy for tractor purchases but does not prioritize electric models. Updating this program to provide a deeper subsidy for electric tractors would enhance farmers' accessibility and boost the market for manufacturers. As electric tractors become more available, the program should phase out diesel subsidies, aligning with environmental goals. California's CORE voucher program is a model for structuring subsidies to promote the adoption of emerging technologies in agriculture.
  - **Including electric tractors in the future PM E-DRIVE scheme:** India's recent PM E-DRIVE initiative will channel over $438 million into incentives for battery-powered vehicles, yet no funds are allocated to support electric tractors or rural tractor charging infrastructure.[24] Including electric tractors in future rounds of the PM E-DRIVE scheme would bolster the central government's role in clean agricultural technology. This inclusion would accelerate production, build essential charging infrastructure for farming communities, and demonstrate national leadership in clean agriculture.

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[22] Monarch, "Support & FAQs," Monarch, accessed on August 21, 2024, https://www.monarchtractor.com/faq.

[23] farm-ng, "Meet the Amiga, Modular Robots for Every Arce," farm-ng, accessed on August 21, 2024, https://farm-ng.com/; Agromec Fendt Farming Op Maat, "700 Vario Electric," Agromec Fendt Farming Op Maat, accessed on October 23, 2024, https://www.fendtfarming.nl/producten/ elektrische-tractor/.

[24] *The Economic Times*, "Govt Launches PM E-DRIVE subsidy scheme with Rs 10,900 cr outlay," *The Economic Times*, October 1, 2024, https://economictimes.indiatimes.com/industry/renewables/govt-launches-pm-e-drive-subsidy-scheme-with-rs-10900-cr-outlay/articleshow/113852329.cms.

- **State-level strategies:** State governments, especially in India's agrarian regions, are in a unique position to accelerate local adoption of electric tractors, bridging federal programs with community needs and the specific requirements of agricultural regions.
  - **Leverage agrarian states to drive early adoption:** Agrarian states like Maharashtra, Madhya Pradesh, Gujarat, Haryana, Punjab, and Rajasthan are ideally suited to lead in electric tractor adoption. These states can offer state-level subsidies, expand financing options, and create pilot programs in partnership with manufacturers and electric utilities.
  - **Mandate electric models for municipal purchases:** State and local governments can support the electric tractor market by requiring that tractors purchased for municipal services be electric models. This approach will drive demand, setting an example for private adoption and reducing pollution in rural areas that typically have fewer emissions regulations.
- **Industry collaboration and public-private partnerships:** Public-private partnerships between the government and tractor manufacturers are essential for accelerating the development of electric tractors, particularly when they share financial risks and benefits. Co-investment in production and charging infrastructure will support rural economies. Training programs in electric vehicle technology and sustainable manufacturing will also create a skilled workforce for electric tractor assembly and maintenance, ensuring long-term growth in this emerging industry.
- **U.S.-India bilateral cooperation:** The United States and India could collaborate to accelerate electric tractor adoption, creating opportunities for trade, knowledge-sharing, and advancements in electric vehicle technology. Joint initiatives can leverage strengths in manufacturing and innovation, especially at the state level. While the incoming U.S. federal administration is unlikely to prioritize tractor electrification, proactive states like California—with large agricultural sectors and strong decarbonization policies—present promising avenues for collaboration and innovation.

Supriya Pawar of Mann Taluka, Maharashtra, drives her family's tractor. Her family relied on livestock to plow and till her family's farmland until she and her family took out a loan to purchase a diesel tractor. Transitioning to an electric tractor could save the Pawar's money on diesel and maintenance costs. Source: Copyright Karan Sinha, all rights reserved.

6.5 CONCLUSION

The Indian government successfully mechanized agriculture and grew a strong tractor manufacturing sector thanks to intentional subsidies and incentives that helped improve crop yields. Now is the time to do the same to electrify the machines that ensure that India has thriving farms. Manufacturers and farmers have much to gain from the electrification of tractors, but doing so will require more intentional policy engagement and incentives from both central and state governments to get the industry to move faster. By prioritizing the transition to electric tractors, India will grow more crops, have cleaner air, mitigate the effects of rising global temperatures, and build India's economic power in the tractor manufacturing industry.

CHAPTER 7
ACCELERATING CLIMATE ACTION THROUGH U.S.-INDIA COLLABORATION ON DIGITAL PUBLIC INFRASTRUCTURE AND CRITICAL MINERAL SUPPLY CHAINS

BY MRIDU JHANGIANI AND TANYA KAK

7.1 INTRODUCTION

India and the United States have set ambitious nationally determined climate and net zero goals. While there is significant policy traction and momentum, the Global Stocktake report highlights a glaring gap in emissions reductions across countries globally, with current national commitments falling short by 20.3 to 23.9 billion metric tons of CO2 equivalent compared to the levels required to limit warming to 1.5 degrees Celsius by 2030.[1] It is clear that current policies and interventions have been inadequate to cater to some of these goals and further delay could potentially lead to lock-in periods of high emissions systems for decades.[2] Therefore, access to successful climate resilient technologies and more effective deployment of low carbon technologies through strategic collaboration through financing, capacity building, and knowledge transfer offer one promising pathway to accelerate these goals.

Ensuring a solid foundation for the implementation of clean technologies across India and the United States is crucial for advancing global efforts to combat climate change and transition to sustainable energy systems. Central to this transition is securing the key inputs for manufacturing renewable energy technologies, such as solar cells, wind turbines, and batteries. These technologies rely heavily on critical minerals like lithium, cobalt, nickel, and rare earth elements, making the secure, ethical, and sustainable sourcing of these materials essential to scaling up clean energy solutions and achieving long-term economic and environmental goals. At the same time, adopting a digital public infrastructure (DPI) approach is vital for accelerating the deployment and integration of clean technologies across industries. By leveraging digital tools, platforms, and data systems, DPI can streamline the management of energy grids, optimize the use of renewable resources, and enhance supply chain transparency, especially in securing critical minerals for clean energy production.

This assessment evaluates these two emerging opportunities for the U.S.-India collaboration that will be essential to supporting a clean technology landscape: digital public infrastructure and critical mineral supply chains. It also identifies the need to shift from narrow technology transfer models, which often rely on power imbalances, to a more inclusive approach.

7.2 CHALLENGES AND OPPORTUNITIES IN U.S.-INDIA COLLABORATION FOR A SUCCESSFUL CLEAN ENERGY TRANSITION

As distributed and variable energy becomes increasingly common and the grid faces increasing pressures on integrating bi-directional flows of energy, there is both a challenge and an opportunity for the energy transition and the climate goals for India and the U.S. Stakeholders such as utilities, renewable energy developers, and technology providers often invest in specialized solutions that fail to integrate effectively with one another. This

[1] United Nations, "Global Stocktake reports highlight urgent need for accelerated action to reach climate goals," United Nations, accessed on November 18, 2024, https://www.un.org/en/climatechange/global-stocktake-reports-highlight-urgent-need-for-accelerated-action-to-reach-climate-goals.

[2] The Intergovernmental Panel on Climate Change, "The international dimension in technology development and deployment: technology transfer," The Intergovernmental Panel on Climate Change, 2007, https://archive.ipcc.ch/publications_and_data/ar4/wg3/en/ch2s2-7-3.html.

lack of integration leads to higher operational costs and inefficiencies, making it difficult to optimize grid management. The result is a fragmented and siloed ecosystem where efforts are duplicated. One possible solution could be to look at digital convergence and use a digital public infrastructure approach to make energy systems smart and efficient.

Another important aspect of the energy transition involves transitioning to a low carbon-economy for both countries by deploying clean energy technology at scale. This will require securing the critical minerals supply chain. Critical minerals are essential to the green energy transition given that several renewable technologies such as electric vehicle batteries and solar panels are heavily dependent on lithium, cobalt, and rare earth elements. A robust supply of these materials is required to scale production, remain competitive in the global market, and promote sustainable sourcing practices. Further, this stability can create new jobs and strengthen immunity to geopolitical tensions. Robust supply chains can initiate increased investment in research and development of new technologies used for extraction, processing, and recycling technologies that can be shared between India and United States to enhance their shared goals.

In the sections below are the challenges and possible pathways for these two emerging areas for cooperation that could accelerate technological collaboration for effective climate action across both countries.

7.2.1 Securing critical minerals supply chains: China's ban on the export of technology to extract and separate critical minerals creates opportunities for a robust Indo-U.S. partnership.

Critical minerals are key to various clean energy technologies central to decarbonization. China, the world's top processor of rare earths, banned the export of technology to make rare earth magnets in December 2023, adding it to a ban already in place on technology to extract and separate the critical materials. China has mastered the solvent extraction process to refine the strategic minerals, which MP Materials and other Western rare earth companies have struggled to deploy because of technical complexities and pollution concerns.[3] The concern for critical mineral supply chains looks particularly acute as both demand and geopolitical competition are increasing, giving an advantage to countries with significant reserves or, more importantly, dominant positions in processing and manufacturing. At the same time, we are seeing trends toward greater protectionism and resource nationalism around the world. But additional critical mineral mining capacity outside of China is only part of what would be required to build an ex-China supply chain that would serve global consumers and countries' needs. As it stands, even when those minerals are mined outside of China, based on the distribution of global capacity, they are almost always sent to China for processing and manufacturing. This asymmetric capacity represents a meaningful bottleneck that can be addressed only if other countries move quickly to develop their own downstream processing and manufacturing capacities.[4]

[3] Siyi Liu and Dominique Patton, "China bans export of rare earths processing tech over national security," *Reuters,* December 22, 2023, https://www.reuters.com/markets/commodities/china-bans-export-rare-earths-processing-technologies-2023-12-21.
[4] Jared Cohen, "Resource realism: The geopolitics of critical mineral supply chains," Goldman Sachs, September 13, 2023, https://www.goldmansachs.com/insights/articles/resource-realism-the-geopolitics-of-critical-mineral-supply-chains.

In the bid to counter China's dominance, India and the United States are seeking to bolster their partnership on critical minerals by jointly tapping third countries to secure their supply chains. While a memorandum of understanding is in place, there is a push for it to be converted into a critical minerals partnership and hence become a starting point for a free trade agreement.[5]

In June 2023, India joined the U.S.-led Minerals Security Partnership, a group of fourteen nations focused on boosting investments in critical mineral supply chains. Both countries reaffirmed their commitment to strengthening collaboration for resilient critical mineral supplies, especially as India shifts towards electric vehicles in its growth strategy.

President Joe Biden and Prime Minister Narendra Modi applauded the success of the Initiative on Critical and Emerging Technology in deepening and expanding strategic cooperation across key technology sectors. The leaders directed their governments to redouble efforts to address export controls, enhance high technology commerce, and reduce barriers to technology transfer between the two countries, while addressing technology security, including through the India-U.S. Strategic Trade Dialogue.[6]

However, the task is easier said than done. Processing facilities require expertise and advanced machinery. They also create environmental and social concerns, including water usage, carbon emissions, and radioactive waste produced by rare earth element magnet manufacturing.[7] Critical minerals are essential for the green energy transition, but it needs to be done sustainably and at scale.

Several hurdles exist before secure supply chains for critical minerals can be established through this partnership. India and the United States must align on uniform environmental, social, and governance (ESG) standards and protocols. Key priorities include funding new initiatives, mapping supply sources, enhancing project development, focusing on processing technologies, training the workforce, identifying complementary strengths, increasing research and development spending for new extraction and refining technologies, reducing trade barriers, and harmonizing tariffs.

7.2.2 Leveraging digital public infrastructure as a potential pathway for U.S.-India climate and energy cooperation: Under the Net Zero Emissions by 2050 Scenario (NZE), provided by the International Energy Agency, electrification is anticipated to rise from 20 percent to 50 percent, driven by the increased adoption of technologies that run on electricity.[8] At the same time, there is a rising global energy demand that is projected to grow significantly. For instance, by

[5] *The Times of India*, "To counter China, India eyes critical minerals pact with US," *The Times of India*, October 20, 2024, https://timesofindia.indiatimes.com/india/to-counter-china-india-eyes-critical-minerals-pact-with-us/articleshow/114382618.cms.

[6] "Joint Fact Sheet: The United States and India Continue to Expand Comprehensive and Global Strategic Partnership," White House, September 21, 2024, https://www.whitehouse.gov/briefing-room/statements-releases/2024/09/21/joint-fact-sheet-the-united-states-and-india-continue-to-expand-comprehensive-and-global-strategic-partnership.

[7] Jared Cohen, "Resource realism: The geopolitics of critical mineral supply chains."

[8] International Energy Agency, "Electricity — Energy System," International Energy Agency, accessed on November 5, 2024, https://www.iea.org/energy-system/electricity.

2040, India's energy demand is projected to increase by about 50 percent.[9] Efforts to advance energy security and climate action across India and the United States are leading to rapid electrification in both countries. The massive increase in power demand is causing dramatic shifts in how people consume and produce electricity and do so while ensuring that most of it is generated through renewables. In this context, decarbonization and modernization of the grid to accommodate this demand through clean energy sources across India and the United States offer a potential pathway for collaboration.

Currently, siloed and fragmented energy systems are limiting the ability of energy assets to enhance grid reliability, reduce costs, and support the energy transition across both countries. The United States and India face significant energy losses and cost inefficiencies because of outdated electricity grids and siloed ecosystems that do not allow for improved planning and coherence in information flows. The United States faces approximately 5 percent of transmission and distribution (T&D) losses, meaning about 5 percent of the energy produced is lost as it travels through the grid before reaching consumers.[10] The inefficiencies in energy transmission and distribution contribute to higher electricity prices for consumers. Studies show that if the grid were modernized to reduce T&D losses, the average household energy bill could be reduced by $300 to $500 annually.[11] India's national average T&D losses were 20.3 percent in 2021, but in some regions, this figure can exceed 30 percent.[12] The T&D losses in India result in substantial economic inefficiency, with the country losing approximately ₹1.2 lakh crore (around $15 billion annually) in lost energy.[13]

Over the last decade, the grids have also witnessed distinct transformative trends that will change how they are deployed, maintained, and operated in the United States and India. These include the rapid deployment of distributed energy resources, the evolving role of the consumer as an active energy participant with expanding agency in an energy system with bi-directional flows, the pursuit of NZE with promises turning into investments and regulations and the digitalization and instrumentation of load and generation resources. For example, the U.S. Department of Energy highlighted the potential of virtual power plants (VPPs) that could reduce annual grid costs by $10 billion. Peak demand on the U.S. grid is estimated to rise from 740 gigawatts (GW) to 800 GW by 2030, with factors including increased consumption by data centers. It estimated that a "lift-off" in the usage of VPPs could address as much as 20 percent of that peak demand.[14]

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[9] International Energy Agency, "Energy system of India," International Energy Agency, accessed on November 5, 2024, https://www.iea.org/countries/india.

[10] U.S. Energy Information Administration, "Frequently Asked Questions (FAQs)," U.S. Energy Information Administration, accessed on November 11, 2024, https://www.eia.gov/tools/faqs/faq.php?id=105&t=3.

[11] Conrad La Joie and Kristen Eberhard, "Transmission infrastructure lowers energy bills, creates jobs, and keeps Americans safe," Niskanen Center, November 1, 2022, https://www.niskanencenter.org/transmission-infrastructure-lowers-energy-bills-creates-jobs-and-keeps-americans-safe/.

[12] PTI, "Economic Survey 2020-2021 flags high T&D losses in the power sector, " *The Economic Times*, January 30, 2021, https://energy.economictimes.indiatimes.com/news/power/economic-survey-2020-21-flags-high-td-losses-in-power-sector/80595833.

[13] Ibid.

[14] U.S. Department of Energy, "The pathway to: Virtual Power Plants Commercial Liftoff," Liftoff Reports, accessed on November 11, 2024, https://liftoff.energy.gov/vpp/.

Digital public infrastructure (DPI) provides a modern, scalable, and efficient approach to collaboration between India and the United States to advance their energy security and climate goals. While the use cases can be many, experimenting with such an approach in the power sector can act as a promising pathway. In its G20 presidency, India championed the digital public infrastructure approach to advocate for a human-centric approach to technology and enhance collaboration with other countries, including the United States.[15] The United Nations Development Programme defines DPI as, "an evolving concept, but there is growing consensus on it being a combination of (i) networked open technology standards built for public interest, (ii) enabling governance, and (iii) a community of innovative and competitive market players working to drive innovation, especially across public programmes."[16] DPI can help in developing many successful use cases by registering and sharing data across independent systems.

By putting together digital building blocks that are minimal, interoperable, and help in accessing real-time data, enhancing coordination, and integrating advanced technologies, a DPI approach can enable more effective, inclusive, and cost-efficient solutions to climate and energy challenges across India and the United States. This can also help in bypassing several traditional challenges of data silos, fragmented nature of the ecosystem, and overreliance on physical hardware for technology transfer.

7.3 POLICY RECOMMENDATIONS FOR SECURING CRITICAL MINERAL SUPPLY CHAINS AND LEVERAGING DPI FOR ENERGY TOWARDS CLIMATE COLLABORATION

- **Implement open standards and protocols:** Adopt open standards and protocols to ensure effective communication of critical signals (supply, demand, pricing) among all energy system participants, enhancing system flexibility and adaptability.
- **Establish joint regulatory frameworks:** Both countries should set up a regulatory framework for open access platforms that can help in exchanging shared lessons, identifying unique points of collaboration for leveraging a DPI approach to securing critical minerals, and decarbonizing the power sector. Additionally, it is vital to align regulatory frameworks to tackle legislative barriers, ESG differences, and concerns about patent infringement and unauthorized use of technology or data. Governments should cover expenses related to legal and compliance procedures initially.
- **Foster digital convergence and initiate first of their kind digital convergence zones in the power sector:** Encourage digital convergence to adapt to decentralized energy models and facilitate integrated and real-time data exchange. For example, some efforts are underway by a few energy experts in India to create a unified energy interface (UEI).[17] A UEI is an open network for energy to enable transactions between digital energy systems. It allows for electric vehicle charging, energy warehousing, and battery monetization by using open networks that enable discovery, payment and transactions, verifiability, and interoperability.

[15] Astha Kapoor and Erin Watson, "Defining the Digital Public Infrastructure Approach," Think20, August 2023, https://t20ind.org/research/defining-the-digital-public-infrastructure-approach/.
[16] United Nations Development Program, "Digital Public Infrastructure," United Nations Development Program, accessed on November 11, 2024, https://www.undp.org/digital/digital-public-infrastructure.
[17] Unified Energy Interface, "The UEI Alliance is a collaborative group," Unified Energy Interface, accessed on November 4, 2024, https://ueialliance.org.

- **Bridging the talent gap for supply chain resilience:** India and the United States must collaborate to close the talent gap essential for transferring technology and securing critical mineral supply chains. This includes creating hands-on programs to upskill technical talent and addressing differences in knowledge, collaboration, work culture, and mindset. Creating joint standard operating procedures at a project level, identifying complementary strengths, and filling the existing gaps in the value chain through partnerships can lead to more effective and resilient outcomes.

7.4 CONCLUSION

It is important to promote inclusive technology co-development and co-ownership when relevant. The world needs to shift from narrow technology transfer models, which often rely on power imbalances, to a more inclusive approach. This new approach should emphasize co-development and co-ownership of the value chain when relevant, rather than just technological access. Several strategies can support this shift, including building financial and non-financial incentives, clarifying risks and liabilities, and enabling policies for governance and transparency. Additionally, a blanket strategy for co-developing technologies might be limiting. Instead, leveraging each country's comparative strengths in this process will be essential.

Another key component of this shift is building state capacity for inclusive technology deployment and establishing models of multi-level governance.[18] This involves viewing technological systems within a broader ecosystem that includes sociopolitical and economic contexts. More crucial than just technology transfer is enhancing a state's capacity to create its own solutions. U.S.-India collaboration on climate technology should prioritize strengthening India's capacity for climate innovation, sharing mutual insights, enhancing local governance and accountability, and pooling resources to achieve climate goals more efficiently and cost-effectively.

Finally, a dynamic and nuanced framework for technology transfer and collaboration is essential. Technology transfer should be defined and tailored by sector, industry, and use case, with the understanding that different technologies will mature at different rates and serve varying demands within the value chain. These definitions must be flexible, frequently updated, and specific in action to ensure they meet evolving needs and support sustainable, long-term innovation. This assessment has highlighted two areas and frameworks for cooperation between the United States and India that will support technology transfer and put forth recommendations to that end.

[18] United Nations Environment Programme, "The Climate Technology Progress Report 2023," United Nations Environment Programme, November 2023, https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TEC_tab_1_archive/2de6396f99394f22b08671ee85e11edc/1a08b7bfc55d45469ddd0d38e8708eb3.pdf.

CHAPTER 8
BUILDING BONDS FOR BETTER BUILDINGS

BY BHAGYASHRI KULKARNI AND PATRICK SOLTIS

8.1 INTRODUCTION

According to the United Nations, two-thirds of the world's population will reside in cities by 2050, a sizable share of which will be in developing countries like India.[1] Cities will have a significant demand for housing, industries, and infrastructure, increasing energy demand. Currently, cities account for 75 percent of the power produced globally, and this is expected to grow with population.[2] Additionally, buildings account for approximately 30 percent of the energy consumption in the cities, making it one of the largest consumer sectors.[3] Consequently, cities will need to increase energy efficiency to meet the demand sustainably.[4]

This paper asserts that policies meant to improve building efficiency depend on engaged local governments and industries to succeed. Together, the Indian and U.S. national governments can boost the effect of policies by supporting local governments with:

- Sub-national cooperative agreements to design codes with broad stakeholder input.
- Technical assistance for pilot projects and capacity strengthening.
- Improved feedback mechanisms to measure effectiveness of codes and policies.
- Funding conditioned on alignment with best practices.

The Indian and U.S. governments have proposed numerous policies aimed at enhancing the energy efficiency of buildings. Under the U.S.-India Agenda 2030 Partnership, both countries have committed to enhancing the energy efficiency of cities. The Indian government in recent years has introduced several initiatives in several sectors to reduce energy consumption influencing the building sector directly or indirectly, such as the Perform, Achieve and Trade scheme for industries and the UJALA scheme to encourage the use of LED lighting.[5] It has recognized energy efficiency in buildings to be critical for achieving India's global climate commitments. Similarly, the United States has made significant advancements through initiatives like the Better Cities Project and business innovations like energy savings performance contracts to encourage energy conservation measures.

Despite these successes, many cities in both countries are transitioning too slowly to efficient building standards. For example:

- Energy infrastructure is often planned without consideration of urban development policy, even though urban planning factors have a significant effect on energy consumption and infrastructure costs. Such factors include planning the spatial distribu-

[1] United Nations Department of Economic and Social Affairs, "Around 2.5 billion more people will be living in cities by 2050, projects new UN report," United Nations, accessed on August 20, 2024, https://www.un.org/en/desa/around-25-billion-more-people-will-be-living-cities-2050-projects-new-un-report.

[2] International Energy Agency, "Empowering Urban Energy Transitions," International Energy Agency, May 2024, https://iea.blob.core.windows.net/assets/00f7d520-d517-473d-b357-5adb43c4a57e/EmpoweringUrbanEnergyTransitions.pdf.

[3] International Energy Agency, "Buildings — Energy System," International Energy Agency, accessed on October 20, 2024, https://www.iea.org/energy-system/buildings.

[4] Stuti Haldar and Gautam Sharma, "Impact of urbanization on per capita energy use and emissions in India," International Journal of Energy Sector Management, July 16, 2021, https://doi.org/10.1108/ijesm-01-2021-0010.

[5] GBPN, "Country Policy Insights Towards Zero Carbon: Buildings Policies in India 2022," GBPN, August 2022, https://www.gbpn.org/wp-content/uploads/2022/08/GBPN-India-Country-Policy-Insight.pdf.

tion and density of buildings, parks, street networks, and even the design and layout of the building itself.[6]

- Many cities and buildings are built without consideration of the local climate conditions, resulting in increased use of cooling and heating equipment. Despite having a clear understanding of the heat island effect, planners of building clusters and city block plans do not commonly follow best practices to reduce it.
- The United States has numerous policies and programs, such as the home energy rebates that were part of the Inflation Reduction Act and the Better Buildings Project, which incentivize building owners to implement energy-saving measures. However, most of these initiatives focus on monitoring buildings only during the design and construction phases, not post-occupancy. This limited monitoring can affect the overall effectiveness of the programs.

Cities face many challenges in trying to achieve nationally set targets at the local level.[7] Limited financial resources and policy gaps make it difficult for the local governments to adopt these policies. Alone, most cities lack the necessary skills and expertise to make the transition. Since realization of energy efficiency policies depends heavily on local implementation, national governments must improve support for cities to succeed.

Fortunately, the strong collaborative framework between India and the United States offers an opportunity to enhance local support beyond which either could do alone:

1. Subnational cooperative agreements including cities from both countries would prove an invaluable forum for iteratively designing smart, locale-appropriate building codes.
2. Technical assistance from information-rich U.S. agencies would build regulator capacity to handle such codes and initiate pilot projects to de-risk the requisite technologies and business innovations.
3. An official feedback process backed by both countries' agencies would establish information pathways necessary to measure and critique the effectiveness of building codes.
4. Once effective codes are solidified, conditional funding from national to local governments would incentivize adherence to the collaboratively designed building codes.

A description of each mechanism follows, in the same order:

8.2 SUBNATIONAL COOPERATIVE AGREEMENTS

As mentioned, most urbanization will take place in developing nations such as India, and the inclusion of energy codes in building regulations should be implemented to achieve energy efficiency. It is also essential to incorporate passive design strategies and

[6] Energy Sector Management Assistance Program, "Planning Energy Efficient and Livable Cities," Knowledge Series, November 2014, https://www.esmap.org/sites/esmap.org/files/DocumentLibrary/ESMAP_CEETI_MayoralNote_6_PlanningEE%20Livable%20Cities_optimized.pdf.

[7] Sherine Ibrahim, "Energy Efficiency: Challenges and Solutions," Energy Central, April 12, 2023, https://energycentral.com/c/ee/energy-efficiency-challenges-and-solutions.

foster collaboration at the central level to revise model bylaws, which can then influence city-specific bylaws through effective policies. The bylaws should address the spatial planning of cities at the city level, neighborhood level, and street level to reduce the energy consumption of the cities. Secondly, integrating passive design strategies as part of energy conservation measures is crucial for both countries.

At the national level, organizations like the International Code Council and the Bureau of Energy Efficiency, along with development agencies in both countries, can collaboratively develop model bylaws responding to their local contexts while learning from each other's experiences.

At the subnational level, cities in both nations can work together to formulate building-energy codes based on the national model bylaws. This collaboration can extend to developing strategies for effectively implementing the bylaws. There is also a need to develop progressive building bylaws where the focus is not on being energy efficient but energy sufficient. This means the laws developed by both countries should focus on encouraging people to use less energy. For example, the construction of more multi-dwelling houses should be encouraged, creating dense neighborhoods, and the energy efficiency standard should not be directly proportional to the area of the house.

For collaborating at the subnational level, both government and private agencies can get involved. For instance, cities like Mumbai and New York City—both members of the C40 Network—can share insights on the challenges and discuss their respective strategies to achieve their goals. By doing so, they can collaboratively create model bylaws that support achieving the energy efficiency goals outlined in their climate action plans.

Additionally, the countries should reinstate sister cities and sister state agreements to work collectively in the areas of urban development and energy efficiency. These partnerships will enable cities to share best practices and technologies. Currently, Greater Noida in the state of Uttar Pradesh is collaborating with Loudoun County, Virginia in the United States. This partnership is focused on fostering collaboration in education, business, culture, agriculture, information, technology, and more, creating mutual benefits for both cities.[8] Building efficiency and urban planning initiatives should also feature in such agreements, which would help cities build more intelligently and become more energy efficient.

Furthermore, other cities and states could establish sister agreements to share experiences in energy-efficient urban planning and design. An interested Indian city's Urban Local Body (ULB's) should form a dedicated team that will collaborate with the partner city. This team should include city officials, experts from think tanks and universities, and NGOs who can collaborate with the partner city to develop tailored solutions.

8.3 TECHNICAL ASSISTANCE

Technical assistance (TA) from U.S. institutions to prove critical sustainable technologies, support code design, and train key professionals is a well-established pattern. For

[8] The Impressive Times. 2024. "Greater Noida Eyes Investment Opportunities Through Sister City Agreement With Loudoun County, USA." The Impressive Times, January 16, 2024, https://www.impressivetimes.com/national/news-174/.

example, the U.S. Agency for International Development's (USAID) Partnership to Advance Clean Energy-Deployment (PACE-D) supported India's National Smart Grid Mission (NSGM) on several fronts, including model regulations, pilot projects, and capacity strengthening.[9] The program supported development of model regulations for smart meters and also supported smart meter pilots with two distribution companies, including cost-benefit analysis of results. On the capacity front, the program organized over 5,000 hours of training hours for engineers and a study trip for executives to accustom key personnel with smart meter challenges and opportunities. At the very least, this support has helped Indian utilities stretch their available funds to roll out smart meters more quickly and effectively.

A similar program could undoubtedly offer a similar stretch for cities attempting to update building codes for efficiency. In fact, PACE-D itself includes energy efficiency as a priority.[10] Any renewal of this program should include provision for building code development. Just like with NSGM, a TA program could support model regulations for pro-efficiency building codes. The subnational cooperative agreements suggested above, which ideally would include a variety of different entities, could certainly use such facilitation assistance.

TA-supported pilot projects can also affect building energy efficiency. Energy savings performance contracts (ESPCs) are an excellent example. In an ESPC, a third-party assumes responsibility for making energy efficiency improvements in a building, and in return is entitled to a portion of the savings from said energy efficiency improvements. This contract structure empowers owners to initiate energy efficiency upgrades without upfront costs, as payments are made based on the savings generated from energy-efficient practices. While not a dominating market force, the United States sees significant ESPC activity, estimated around $6 billion a year.[11] In India, the practice is in its infancy.

This seems like a creative business process allowing private capital to supercharge efficiency retrofits, with a similar contract structure as the power purchase agreements that unleashed solar energy development in the early 21st century. However, at least in India, the model is unproven, and early adopters would face significant financial and regulatory risk. A pilot attempting this model would explore these risks, and technical support could extrapolate whether the risks are worth the effort and, if so, translate into appropriate regulatory recommendations.

PACE-D, like many TA programs, includes support for research and modeling. This is certainly welcome, but generally can be taken as a given in TA. Emphasis specifically on collaborative support, pilots, and capacity strengthening is an intentional message, since the production of information alone does not bring about local development. High-quality information products certainly came from PACE-D and should also come from the proposed programs. However, the research is significant because it supports practical efforts to build a consensus, build technical proofs-of-concept, and build capacity.

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[9] "Smart Grid: Towards an Intelligent Future," U.S. Agency for International Development, February 2018, https://pdf.usaid.gov/pdf_docs/PA00T542.pdf.

[10] Mishra, A., & Babu, N.Y.D. "Brochure: Partnership to Advance Clean Energy-Deployment (PACE-D) Technical Assistance Program," U.S. Agency for International Development, 2016, https://www.usaid.gov/india/document/brochure-partnership-advance-clean-energy-deployment-pace-d-technical-assistance-program.

[11] Better Buildings, "Energy Savings Performance Contract," U.S. Department of Energy, accessed on October 24, 2024, https://betterbuildingssolutioncenter.energy.gov/financing-navigator/option/espc-financing.

8.4 FEEDBACK MECHANISMS

Currently, very few policies in the building sector use feedback mechanisms to ensure compliance and assess the effectiveness of the energy codes and policies. In the United States, monitoring is done primarily during the design and construction phases. Post-occupancy evaluation remains challenging, making it difficult to assess the effectiveness of the policies or the codes proposed. Policies should extend to monitor buildings throughout their entire life cycle and provide incentives based on performance after construction.

There are many barriers to implementing post-occupancy evaluation that must be addressed to establish the feedback loop. Some of the most common are:

- Lack of reliable indicators that can be followed universally.
- Unclear ownership responsibility for implementing feedback mechanism.[12]

The U.S. Department of Energy (DOE) and the Ministry of New and Renewable Energy (MNRE) could establish a joint institute in charge of establishing and maintaining feedback mechanisms for building energy efficiency policies. This could be a quasi-public research institute in the model of the United States' national labs. As a research institute, this entity could more effectively hire the necessary technical staff to manage data and develop the technologies requisite for these new types of building monitoring. Such an institute would be more suited to support commercialization of relevant technologies directly. Depending on funding, the institute could even run its own technical assistance programs to help building managers take up the appropriate monitoring technologies and processes.

Of course, the national governments must establish guidelines that account for stakeholder needs identified in the cooperative policy design. Given the vast amount of data managed, directives for the institute on security and privacy measures are likely in order. In addition, the mechanism should clearly state the roles and responsibilities of the different actors, from collection to analysis and recommend changes to the policies based on the findings. However, details that are not politically sensitive can be left to the institute to set up.

8.5 CONDITIONAL FUNDING

Creating the process is only the start, however. Short of a mandate, national and local governments would have difficulty convincing a statistically significant share of either country's building managers to do the extra work to improve monitoring. In addition, some might be suspicious about why the government needs to collect more data.

Performance-based incentives could address these concerns. Even a slight financial benefit could motivate the owners to share the post-occupancy data and raise awareness about energy conservation measures. This would also help build trust in these programs. In India, where the adoption of sustainable energy practices is still limited, introducing performance-based funding could encourage more individuals to adopt these practices in

[12] Chris J. Roberts and David John Edwards, "Post-occupancy evaluation: Identifying and mitigating implementation barriers to reduce environmental impact," Journal of Cleaner Production, November 2022, https://doi.org/10.1016/j.jclepro.2022.133957.

their homes. Of course, this is not to mention the improved control over energy usage, which could lessen the rebound effect that can negate savings from energy conservation measures.

The Ministry of Housing and Urban Affairs and the MNRE in India could collaborate with the DOE to jointly develop an energy-efficient building benefit program. Such a program could be effectively adopted by local governments in India to encourage owners to adopt energy measures and strictly follow the standards. Meanwhile, the U.S. agencies should integrate the program into the existing policy to enhance energy efficiency in the building sector.

Collaboration between the Indian Railways (IR) and USAID under the Strategic Clean Energy Partnership's Renewable Energy pillar offers an example.[13] IR aims to achieve net-zero emissions by 2030, in large part by expanding renewable energy in IR operations. The IR-USAID partnership supported a procurement of 900 MW grid-connected renewable energy for IR.[14] When the criteria for winning such a contract is well-designed, industry has an incentive to enable policy goals. This partnership could expand to support procurement of energy efficiency upgrades for commercial and residential buildings under the Indian Railway. For example, the tender could request an energy savings performance contract, where payments are made periodically based on savings unlocked due to efficiency improvements.

8.6 CONCLUSION

Progress on any of these recommendations would be a step forward. Cooperative agreements, technical assistance, feedback mechanisms, and conditional funding are all established techniques that deliver results when correctly matched with the intended goals. However, they are presented together because they work much better in concert. Cooperative building code formulation would fail without adequate support or information. Productive technical assistance or feedback mechanisms would not begin if no one agreed on what technologies or business processes should be tested or measured. Conditional funding would offer counterproductive incentives if the code being promoted were bad. The U.S.-India Energy Dialogue should add these steps to its energy efficiency strategy at the earliest opportunity because cities need such support to play their key role in the energy transition.

[13] U.S. Agency for International Development, "U.S. And India Sign Memorandum of Understanding to Strengthen Climate And Clean Energy Cooperation," U.S. Agency for International Development, June 2023, https://www.usaid.gov/news-information/press-releases/jun-22-2023-us-and-india-sign-memorandum-understanding-strengthen-climate-and-clean-energy-cooperation#:~:text=On%20June%2022%2C%202023%2C%20the,zero%20carbon%20emissions%20by%202030.

[14] U.S. Department of Energy, "US-India Strategic Clean Energy Partnership: Renewable Energy Pillar," U.S. Department of Energy, July 2023, accessed on November 7, 2024, https://www.energy.gov/sites/default/files/2023-07/USISCEP-RenewableEnergy.pdf.

CHAPTER 9
UNLOCKING THE CLIMATE AND HEALTH INTERSECTION THROUGH THE U.S.-INDIA BILATERAL PARTNERSHIP

BY VANSHICA KANT AND JONIKA RATHI

9.1 INTRODUCTION

This paper showcases the critical nature of the climate and health twin emergencies and highlights an opportunity for the United States and India to work on this overlooked and under-addressed dimension. It recommends that both nations initiate and develop high-level bilateral relations on climate and health action, provide catalytic finance for climate-health adaptation and resilience, and amplify on-ground efforts to decarbonize health systems, facilities, and operations.

The World Health Assembly calls climate change "the biggest health threat in the 21st century."[1] Yet, despite 25 percent of the global disease burden being linked to environmental risk factors, merely 0.5 percent of international climate finance goes to health.[2] Climate change has affected 5.6 billion people and has cost $1.5 trillion over the past thirty years. As one of the largest and fastest-growing segments of the world economy, the health sector accounts for over 5.2 percent of global greenhouse gas emissions.[3] Under a business-as-usual scenario, health sector emissions will triple by 2050.[4] While a greater spotlight on the intersection of climate and health has recently begun to emerge, the role of bilateral relations is still a footnote.[5]

Thematic areas, development pathways, and solution packages across the climate and health continuum cover a wide spectrum.[6] On the climate-to-health side, extreme weather events, vector-borne, zoonotic, and non-communicable diseases, nature-based solutions, nutrition, and mental health are some of the key areas. On the health-to-climate side, climate-ready human resources for health, sustainable medical products and practices, biomedical waste, vaccines and technologies, and health information systems are several of the major areas.

Presently, U.S.-India bilateral relations are mature and long-standing with focuses on energy, technology, and education.[7] Frontier areas such as critical minerals, space cooper-

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[1] Arthur Wyns et al., "2023 WHO review of health in Nationally Determined Contributions and long-term strategies: health at the heart of the Paris Agreement," World Health Organization, May 2023, https://climahealth.info/resource-library/2023-who-review-of-health-in-nationally-determined-contributions-and-long-term-strategies-health-at-the-heart-of-the-paris-agreement/.

[2] Ibid.

[3] Josh Karliner et al., "Health care's climate footprint: the health sector contribution and opportunities for action," European Journal of Public Health, September 30, 2020, https://doi.org/10.1093/eurpub/ckaa165.843.

[4] Ibid.

[5] Marina Romanello et al.,"The 2024 report of the *Lancet* Countdown on health and climate change: facing record-breaking threats from delayed action," The Lancet, October 29, 2024, https://www.thelancet.com/action/showPdf?pii=S0140-6736%2824%2901822-1.

[6] Patrick Osewe and Dinesh Arora, "Five Ways the Health Sector Can Help Combat Climate Change," Asian Development Blog, December 1, 2023, https://blogs.adb.org/blog/five-ways-health-sector-can-help-combat-climate-change; Dinesh Arora, "Four Actions to Incorporate Climate and Health Care into Policy." Asian Development Blog, July 12, 2024, https://blogs.adb.org/blog/four-actions-incorporate-climate-and-health-care-policy.

[7] "India-US Working Group on Education and Skill Development virtually launched," Ministry of Education, Government of India and U.S. Department of State, May 22, 2023, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1926472; "Roadmap For U.S.-India Initiative to Build Safe and Secure Global Clean Energy Supply Chains," White House, September 21, 2024, https://www.whitehouse.gov/briefing-room/statements-releases/2024/09/21/roadmap-for-u-s-india-initiative-to-build-safe-and-secure-global-clean-energy-supply-chains/; "Joint Fact Sheet: The United States and India Continue to Expand Comprehensive and Global Strategic Partnership," White House, September 21, 2024, https://www.whitehouse.gov/briefing-room/statements-releases/2024/09/21/joint-fact-sheet-the-united-states-and-india-continue-to-expand-comprehensive-and-global-strategic-partnership.

ation, and green hydrogen are rapidly emerging.[8] However, there is a large gap to bridge when it comes to climate and health, both individually and collectively.

9.2 THE U.S.-INDIA CLIMATE AND HEALTH CONTEXT

The United States and India have divergent and convergent climate and health challenges specific to their geography, demography, and infrastructure. A climate- and health-focused cross-sectoral bilateral initiative is the need of the hour. It will strengthen the symbiotic relationship between both nations as well as close the gap in Global North-Global South efforts.

In the United States, the intensification of climate events increasingly threatens the ability of the health care system to deliver safe, effective, affordable, and efficient care.[9,10] The health care system in the United States is also a major contributor to greenhouse gas emissions and constitutes upwards of 10 percent of all national greenhouse gases.[11] Within this, the contribution of the health supply chain to health sector greenhouse gas (GHG) emissions stands at a global average of 71 percent.[12] Pollution from health care-associated energy use results in an estimated 405,000 disability-adjusted life-years annually.[13]

India ranks seventh in the world in terms of vulnerability to climate extremes. 75 percent of Indian districts fall under extreme event hotspots for hydro-met disasters.[14,15] There is an estimated loss of $80 billion that has been caused by extreme climate events in the last two decades in India.[16] As the most populous country undergoing rapid urbanization and industrialization, climate and health are a major challenge and opportunity for the country.

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[8] U.S. Mission India, "Secretary Raimondo and Minister Goyal Convene 6th U.S.-India Commercial Dialogue Meetings," U.S. Embassy and Consulates in India, October 4, 2024, https://in.usembassy.gov/secretary-raimondo-and-minister-goyal-convene-6th-u-s-india-commercial-dialogue-meetings; "Joint Statement from India and the United States," White House, September 08, 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2023/09/08/joint-statement-from-india-and-the-united-states; U.S. Department of Energy, "U.S.-India Strategic Clean Energy Partnership Ministerial Joint Statement," U.S. Department of Energy, September 16, 2024, https://www.energy.gov/articles/us-india-strategic-clean-energy-partnership-ministerial-joint-statement.

[9] Paulina Smolinski, "Extreme wildfire risk has doubled in the past 20 years, new study shows, as climate change accelerates," *CBS News*, June 24, 2024, https://www.cbsnews.com/news/extreme-wildfire-risk-climate-change.

[10] Doyle Rice, "'Sobering'" data shows US set record for natural disasters, climate catastrophes in 2023," *USA TODAY*, September 11, 2023, https://www.usatoday.com/story/news/nation/2023/09/11/us-sets-record-weather-climate-disasters-2023/70822661007.

[11] Matthew J. Eckelman and Jodi Sherman, "Environmental Impacts of the U.S. Health Care System and Effects on Public Health," PLOS ONE, June 9, 2016, https://doi.org/10.1371/journal.pone.0157014.

[12] Josh Karliner et al., "Health Care's Climate Footprint: How the Health Sector Contributes to The Global Climate Crisis and Opportunities for Action," Health Care Without Harm, September 2019, https://global.noharm.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf.

[13] Manfred Lenzen et al., "The environmental footprint of health care: a global assessment," The Lancet Planetary Health, July 2020, https://doi.org/10.1016/S2542-5196(20)30121-2.

[14] Abinash Mohanty and Shreya Wadhawan, "Mapping India's Climate Vulnerability: A District Level Assessment," Council on Energy, Environment and Water, October 2021, https://www.ceew.in/sites/default/files/ceew-study-on-climate-change-vulnerability-index-and-district-level-risk-assessment.pdf.

[15] Purvi Patel, "As India's summer begins, understanding the heat and health conundrum," *The Hindu*, April 01, 2024, https://www.thehindu.com/sci-tech/energy-and-environment/india-summer-heat-heatwave-health-indirect-impacts-preparation/article68015107.ece.

[16] Abinash Mohanty and Shreya Wadhawan, "Mapping India's Climate Vulnerability: A District Level Assessment."

Although accelerated engagement on climate and health is reflected among national political leadership, with a record 60 percent of countries focusing on health-climate linkages in the 2021 United Nations General Debate, and 86 percent of nationally determined contributions documents referring to health, the world has yet to witness a significant translation of these pledges to implementation.[17,18,19]

U.S.-India bilateral and multilateral efforts will have to address several climate-health constraints, enablers, and co-benefits. With respect to barriers, lack of evidence and data, challenging political economies, fragmented and siloed functioning, limited technical expertise, inadequate policy frameworks, and restricted development finance are the major challenges. The key enablers constitute customized climate-health methodologies and frameworks, availability of global best practices, novel financial tools, technical advisory groups, leapfrogging pathways, and research, development, and deployment. The co-benefits of a robust climate and health action for both nations include improved air quality**,** enhanced community health resilience, healthier food systems, reduced heat-related illness, lower health care costs, and mental health benefits.

9.3 THE CURRENT STATE OF U.S.-INDIA CLIMATE AND HEALTH AFFAIRS

9.3.1 United States

With its dominant influence on international policy and standards, the United States is poised to take the lead on health care decarbonization.[20,21] The United States hosts the world's leading medical and technological research institutions, which must spur health innovation in sustainable health technologies, climate-smart infrastructure, and green practices. The United States should set a precedent for Global North nations to follow suit. Other countries such as the United Kingdom, Netherlands, and Australia are already working extensively to deliver net zero health care.[22]

In 2022, the White House and the Department of Health and Human Services launched the Health Sector Climate Pledge, where over 139 private-sector health care organizations voluntarily committed to climate resilience and emissions reduction by agreeing to 1) reduce 50 percent emissions by 2030, achieve net zero by 2050, and publicly report data, 2) develop an inventory of supply chain emissions (Scope 3), and 3) create climate resilience action plans.[23]

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[17] Marina Romanello et al., "The 2022 report of the *Lancet* Countdown on health and climate change: health at the mercy of fossil fuels," The Lancet, November 5, 2022, https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(22)01540-9/fulltext.

[18] Oommen C. Kurian, "Climate and human health: Need to turn promises into actions," ORF, November 18, 2022, https://www.orfonline.org/expert-speak/climate-and-human-health.

[19] Marina Romanello et al., "The 2022 report of the *Lancet* Countdown on health and climate change: health at the mercy of fossil fuels."

[20] National Academy of Medicine, "Action Collaborative on Decarbonizing the U.S. Health Sector," National Academy of Medicine, September 2021, https://nam.edu/wp-content/uploads/2024/08/Climate-Collaborative-one-pager-8.17.24.pdf.

[21] U.S. Department of Health and Human Services, "Climate Change and Health Equity Strategy Supplement," U.S. Department of Health and Human Services, December 2023, https://www.hhs.gov/sites/default/files/hhs-climate-change-health-equity-strategy-supplement.pdf.

[22] NHS England, "Delivering a 'Net Zero' National Health Service," NHS England, July 2022, https://www.england.nhs.uk/greenernhs/publication/delivering-a-net-zero-national-health-service.

[23] U.S. Department of Health and Human Services, "Health Sector Commitments to Emissions Reduction and Resilience," U.S. Department of Health and Human Services, accessed on October 30, 2024, https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-sector-pledge/index.html.

The Inflation Reduction Act (IRA), signed into law in August 2022, included $369 billion in a combination of financial incentives for investments to reduce pollution, expand clean energy production, and address health inequities.[24,25] IRA provides significant tax credits for renewable energy, including incentivizing a majority of hospitals to invest in zero-emissions electricity generation facilities and storage technologies, alternative fuels, clean vehicles, and energy-saving building updates. The act also provides funding to the U.S. Environmental Protection Agency to enhance product declarations of GHG emissions, which facilitates emissions reduction at the supply chain management level.[26]

9.3.2 India

India is home to a dynamic health sector, with a strong pharmaceutical industry, advanced medical research institutions, varied medical tourism options, and growing digital health technologies.[27] These must be leveraged to develop climate-resilient health care solutions that are affordable, accessible, and scalable not only in India but also across the Global South. As a leading country of considerable size, India is strategically pivotal for the scaling of climate-resilient health care. Among the Global South, other countries most affected by, and leading climate-health efforts, include Bangladesh, the Philippines, and Fiji.[28]

India is addressing climate change and human health under the Prime Minister's Council on Climate Change and the National Programme on Climate Change and Human Health (NPCCHH) under the National Health Mission umbrella of the Ministry of Health and Family Welfare.[29] Since 2019, the NPCCHH has functioned at the local, state, and district levels through established structures and systems that provide domain expertise. Its main objectives include: 1) building awareness and capacity, 2) conducting vulnerability mapping and assessments, 3) enhancing surveillance and data collection, 4) developing adaptation and mitigation strategies, and 5) supporting research and development. It carries immense scope to deliver climate and health action based on in-

[24] Celynne Balatbat et al., "How Health Care Organizations Can Use the Inflation Reduction Act to Reduce Costs, Enhance Resilience, and Lower Their Environmental Footprint," National Academy of Medicine, November 29, 2023, https://doi.org/10.31478/202311h.

[25] "Inflation Reduction Act of 2022," H.R. 5376, 117th Congress of the United States of America, August 16, 2022, https://www.congress.gov/bill/117th-congress/house-bill/5376.

[26] Celynne Balatbat et al., "How Health Care Organizations Can Use the Inflation Reduction Act to Reduce Costs, Enhance Resilience, and Lower Their Environmental Footprint."

[27] Navyaa Bansal "Indian Healthcare Sector Report 2024," Wright., August 1, 2024, https://www.wrightresearch.in/encyclopedia/indian-healthcare-sector-report-2024/.

[28] Ministry of Environment and Forests, Government of the People's Republic of Bangladesh, "Climate Change and Health in Bangladesh," Ministry of Environment and Forests, Government of the People's Republic of Bangladesh, 2015, https://iucn.org/sites/default/files/import/downloads/health.pdf, World Health Organization, "Climate And Health Country Profile — 2015 Bangladesh," World Health Organization, https://cdn.who.int/media/docs/default-source/searo/wsh-och-searo/banc-h-profile.pdf?sfvrsn=8b172763_2; World Health Organization, "Climate And Health Country Profile — 2015 Philippines," World Health Organization,, January 31, 2023, https://iris.who.int/bitstream/handle/10665/208868/WHO_FWC_PHE_EPE_15.14_eng.pdf?sequence=; Rais Akhtar, *Climate Change and Human Health Scenarios: International Case Studies*, Springer Nature, 2023, https://doi.org/10.1007/978-3-031-38878-1.

[29] Government of India Ministry of Health & Family Welfare, "National Programme on Climate Change & Human Health (NPCCHH)," National Centre for Disease Control, accessed on October 30, 2024, https://ncdc.mohfw.gov.in/national-programme-on-climate-change-human-health; Government of India Ministry of Health & Family Welfare, "National Action Plan for Climate Change & Human Health," Government of India Ministry of Health & Family Welfare, October 23, 2018, https://ncdc.mohfw.gov.in/wp-content/uploads/2024/04/27505481411548674558.pdf.

stitutional strengthening through capacity building, technical assistance, financing, and partnerships.[30]

In 2024, multilateral momentum in the climate and health arena is translating to the national scene with the ecosystem rapidly developing in India. Through a galaxy of players, this movement is also witnessing the operationalization of "One Health"—a collaborative, multi-sectoral, and transdisciplinary approach that recognizes the interconnectedness of human, animal, and environmental health—in India.[31]

9.4 THE UNITED STATES, INDIA, AND THE WORLD

The United States and India are members of and participate in various multilaterals, such as the United Nations, the International Monetary Fund, Multilateral Development Banks, the Group of Twenty, and the Coalition for Disaster Resilient Infrastructure, and mini-laterals, such as the Quadrilateral Security Dialogue and the Indian Ocean Rim Association. These position the U.S. and India as global leaders and provide them the platform to lead emerging areas such as the climate-health agenda.

Beyond national and bilateral initiatives, both countries must unlock international institutions and multilateral momentum around climate and health.[32,33,34] In 2021, at the United Nations Framework Convention on Climate Change (UNFCCC) COP26 in Glasgow, Scotland, the World Health Organization (WHO) instituted the Alliance for Transformative Action on Climate and Health.[35] COP28 in Dubai, United Arab Emirates, in 2023 hosted the first-ever "Health Day" in the history of the UNFCCC. This culminated in the endorsement of the UAE Declaration on Climate and Health by 120 countries, the launch of several climate- and health-focused initiatives by international organizations, and the pledging of $1 billion to climate-proof health systems.[36,37,38] In May 2022 and September 2023, under the G7 German and G20 Indian presiden-

[30] Government of India Ministry of Health & Family Welfare, "National Action Plan for Climate Change & Human Health," 7.
[31] Rafael Ruiz de Castañeda et al., "One Health and planetary health research: leveraging differences to grow together," The Lancet Planetary Health, February 2023, https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(23)00002-5/fulltext.
[32] The World Bank, "World Bank Climate and Health Program: Putting Health at the Center of Climate Investment and Action, The World Bank, April 2024, https://documents1.worldbank.org/curated/en/099545304092419245/pdf/IDU15cb9fac213ad51444318ef7146f6988dfa2e.pdf.
[33] Asian Development Bank, "COP28 Launch of ADB-led Climate and Health Initiative and Roundtable Discussion in the Context of G20 Supported by the Incoming Brazilian Presidency," Asian Development Bank, December 3, 2023, https://www.adb.org/climatebank/cop28/launch-adb-led-climate-health-initiative-roundtable-discussion-context-g20.
[34] "Quantifying the Impact of Climate Change on Human Health," World Economic Forum and Oliver Wyman, January 2024, https://www3.weforum.org/docs/WEF_Quantifying_the_Impact_of_Climate_Change_on_Human_Health_2024.pdf.
[35] World Health Organization, "Alliance for Transformative Action on Climate and Health (ATACH)," World Health Organization, accessed on October 30, 2024, https://www.who.int/initiatives/alliance-for-transformative-action-on-climate-and-health.
[36] UAE Consensus, "COP28 UAE Declaration on Climate and Health," COP28 UAE, December 2023, https://www.cop28.com/en/cop28-uae-declaration-on-climate-and-health.
[37] UAE Consensus, "Guiding Principles for Financing Climate and Health Solutions," COP28 UAE, December 2023, https://www.cop28.com/en/guiding-principles.
[38] Asian Development Bank, "COP 28 Launch of ADB-led Climate and Health Initiative and Roundtable Discussion in the Context of G20 Supported by the Incoming Brazilian Presidency," COP28 UAE, December 3, 2023, https://www.adb.org/climatebank/cop28/launch-adb-led-climate-health-initiative-roundtable-discussion-context-g20.

cies respectively, heads of state asserted their collective resolve for climate-resilient and low-carbon health systems.[39,40]

9.5 UPCOMING GLOBAL CLIMATE LEADERSHIP IN THE UNITED STATES AND INDIA

In 2025, the United States takes over the G20 presidency, during which it should continue to prioritize and scale multilateral and bilateral climate-health action, especially with champion and demonstrator countries such as India, and focus on cross-sector operationalization.

While the United States has never hosted the UNFCCC COP, India has been a host in 2002 and recently made a bid to host COP33 in 2028.[41] Given this runway, both nations are well placed to prepare and position themselves as global leaders in climate and health action during potential upcoming COP presidencies.[42]

9.6 RECOMMENDATIONS FOR U.S.-INDIA CLIMATE AND HEALTH BILATERAL RELATIONS

We propose three specific recommendations for unlocking the climate and health intersection through the U.S.-India partnership. These are divided into one each for different stages of the engagement lifecycle—upstream, midstream, and downstream—based on the WHO health systems building blocks that include service delivery, health workforce, health information systems, access to essential medicines, financing, and leadership and governance.[43,44] This will help in laying out and understanding the flow of bilateral efforts from strategy to operations, focusing the proposed recommendations on larger ecosystem shaping and specific activity level work.

U.S.-India Climate Health Action Pact (Upstream)

We recommend that the United States and India design and deliver a 10-year pact that initiates and mainstreams high-level bilateral climate and health relations between both

[39] "G7 Leaders' Communiqué," G7 Germany 2022, June 28, 2022, https://www.g7germany.de/resource/blob/974430/2062292/fbdb2c7e996205aee402386aae057c5e/2022-07-14-leaders-communique-data.pdf.

[40] Indian G20 Presidency, "G20 New Delhi Leaders' Declaration," Ministry of External Affairs Government of India, September 9-10, 2023, https://www.mea.gov.in/Images/CPV/G20-New-Delhi-Leaders-Declaration.pdf.

[41] Jayashree Nandi, "Modi pitches India as host of COP33 in 2028," *Hindustan Times*, December 02, 2023, https://www.hindustantimes.com/india-news/modi-pitches-india-as-host-of-cop33-in-2028-101701455363982.html.

[42] United Nations Framework Convention on Climate Change, "Conference of the Parties (COP)," United Nations Framework Convention on Climate Change, accessed on October 30, 2024, https://unfccc.int/process/bodies/supreme-bodies/conference-of-the-parties-cop.

[43] U.S. Department of Health and Human Services, "Developing a Climate Resilience Plan for Healthcare Organizations: Key Considerations," U.S. Department of Health and Human Services, accessed on October 30, 2024, https://www.hhs.gov/climate-change-health-equity-environmental-justice/ climate-change-health-equity/climate-resilience-plan/index.html.

[44] Karen Hacker et al., "CDC's Approach to Social Determinants of Health," JPHMP Direct, October 7, 2022, https://jphmpdirect.com/cdcs-approach-to-social-determinants-of-health.

countries.[45,46,47] A long-term partnership on health action will carry forward multilateral momentum to shape bilateral engagement on this emerging cross-sectoral agenda. This can be bilaterally achieved, as is demonstrated through first mover countries nationally, by involving respective ministries, steering committees, centres of excellence, reorienting national and state budgets by embedding a climate-health focus (20 percent health budget to climate and 15 percent of the climate budget to health), steering and unlocking finance through public sector banks and mobilizing multilateral resources and activities.[48]

Biannual ministerial meetings and high-level leadership involvement in building a climate-first health system will ensure that strategic policy dialogues and frameworks exist and are combined with effective oversight, coalition-building, regulation, attention to system design, and accountability. As the climate and health agenda is prioritized by the United States and India at key multilateral and bilateral forums, the Global North and Global South under their respective leadership, must advance adaptation, resilience, and mitigation operational pathways.

U.S.-India Climate and Health Adaptation and Resilience (CHAR) Fund (Midstream)
This paper recommends that the United States and India establish catalytic and blended finance for climate-health adaptation and resilience through a U.S.-India Climate and Health Adaptation and Resilience (CHAR) Fund.[49] The CHAR Fund would leverage resources to develop and scale climate and health bold bets, provide risk capital, and facilitate market creation for the climate-health ecosystem.[50] This would be undertaken through an independent public-private partnership entity (40 percent public, 40 percent private, and 20 percent philanthropic) led by bilateral institutions such as the National Institution for Transforming India, the U.S. Council of Economic Advisers, the U.S. Agency for International Development, and the U.S.-India Business Council.

This initiative would support a yearly cohort of entrepreneurs and develop climate and health innovation pipelines across four key verticals—process, product, service, and technology. The fund would aim to transform emerging climate-health solutions from start-up to growth stage and accelerate mature solutions for broader scalability across various sub-themes including extreme weather events, climate-ready human resources, and sustainable supply chains. The CHAR Fund would be expected to create significant effect through climate and health adaptation and resilience across the urban and rural environments in both countries and beyond.

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[45] National Institutes of Health, "Climate Change and Health Initiative Strategic Framework," National Institutes of Health, February 2022, https://climateandhealth.nih.gov/files/2024-05/nih-climate-change-framework.pdf.
[46] "Ministry of Health and Family Welfare, Government of India, and the Asian Development Bank conclude the Climate and Health Solutions India Conclave with Strategic Insights for Future Action," Ministry of Health and Family Welfare, Government of India, September 27, 2024, https://pib.gov.in/PressReleasePage.aspx?PRID=2059375.
[47] Department of Health and Aged Care, Australian Government, "National Health and Climate Strategy," Department of Health and Aged Care, Australian Government, December 2023, https://www.health.gov.au/sites/default/files/2023-12/national-health-and-climate-strategy.pdf.
[48] Green Deal, "Green Deal: Working together towards sustainable healthcare," Government of the Netherlands, December 2019, https://www.greendealduurzamezorg.nl/files/c-238-green-deal-working-together-towards-sutainable-healthcare.pdf.
[49] U.S. Agency for International Development, "Partnership for Climate Change and Adaptation — India And South Asia," U.S. Agency for International Development, accessed on October 30, 2024, https://www.usaid.gov/india/climate-change-adaptation.
[50] IPE Global, "Leveraging Blended Finance for Climate and Healthcare in India: Bold Equitable Bets to Catalyze Climate Health Opportunities," IPE Global, June 2024, https://www.ipeglobal.com/wp-content/uploads/2024/06/Leveraging-Blended-Finance-for-Climate-and-Healthcare-in-India-Bold-Equitable-Bets-to-Catalyze-Climate-Health-Opportunities.pdf.

U.S.-India Joint Program on Health Sector Decarbonization (Downstream)

We recommend that leading government agencies in both the United States and India, such as the Centers for Disease Control and Prevention and NPCCHH, develop a joint program on decarbonizing the health sector. The program would implement efforts to reduce carbon emissions within health systems and facilities across six key areas—transportation and logistics, renewable energy, built environment decarbonization product innovation and utilization—and waste reduction.[51] It would address the climate health policy and regulatory gap by establishing guidelines and action plans that enable the health sector to meet its interim and net-zero emissions goals. This involves understanding emission footprints, defining targets, activating strategies, building workforce capacity, and measuring progress.[52]

To achieve its goals, the program would require significant changes in health facility operations and delivery mechanisms, including mandatory disclosure of greenhouse gas emissions, installation of energy-efficient systems, and adoption of renewable energy sources like solar power and battery storage. Facilities would be encouraged to meet revised performance standards and adopt sustainable strategies, such as committing to Renewable Energy 100, reducing unnecessary pharmaceutical usage, transiting their fleets to electric, implementing logistical efficiencies, identifying opportunities for product composition changes, substituting high-emissions products, and incentivize green financing.[53] The joint program would ensure that low carbon health infrastructure efforts for health sector mitigation in both countries are cultivated.

9.7 CONCLUSION

The U.S.-India bilateral relationship is strongly placed to drive the emerging and evolving climate and health conversation. This paper highlights the mutual climate and health equation — both the effects of climate change on health and the footprint of the health care sector on climate. However, given the over-indexing of mitigation efforts, the overlooked nature of adaptation and resilience, and the development stages of the United States, India, and other countries, the paper organically focuses slightly on the latter. Together, the United States and India must collectively work to foster country priorities, ecosystem development, cross-sectoral operationalization, catalytic finance, and technical expertise to deliver climate-resilient and low-carbon health for the United States, India, and the world.

[51] Seema Wadhwa et al., "Catalyzing Collective Action to Decarbonize Healthcare: Roadmap for Health Systems and MedTech Suppliers," Kaiser Permanente, May 2023, https://supplier.kp.org/impactspending/wp-content/uploads/sites/2/2023/06/Catalyzing-Collective-Action-to-Decarbonize-Healthcare_FINAL_6-7-23.pdf; Nitya Mohan-Khemka et al., "Climate-Proofing Health Care: Strategies for Resilience," Asian Development Bank Institute, June 2024, https://www.adb.org/sites/default/files/publication/973421/adbi-climate-proofing-health-care-strategies-resilience.pdf.

[52] Emily Hough, Evan D. Gumas, and Shanoor Seervai, "Action to Decarbonize the U.S. Health Care System: Lessons from the U.K.'s National Health Service," The Commonwealth Fund, July 26, 2022, https://doi.org/10.26099/aed1-3n95.

[53] Seema Wadhwa et al.,"Catalyzing Collective Action to Decarbonize Healthcare: Roadmap for Health Systems and MedTech Suppliers."

EMERGING CLIMATE LEADERS BIOGRAPHIES

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