Being Cool: Investment Opportunities and Policy Imperatives to Combat Global Warming

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Various studies have found that a steady rise in temperatures across India can significantly compromise biological, social, and labour productivity over the long-term, and perhaps by the end of this decade. Further, such heat-related stress upon both population and economy has increased corresponding cooling demands. In this regard, a recent World Bank report attempts to identify opportunities in certain cooling sectors for private investment, such as in respect of: (i) space cooling in buildings, (ii) cold chain and refrigeration, (iii) passenger transport air-conditioning, and (iv) refrigerants.

Nevertheless, such opportunities need to be balanced with the country's international obligations in connection with hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), respectively, including under the Montreal Protocol. While

HCFCs with ozone depletion potential are poised to be phased out in India by the year 2030, the country recently approved the ratification of the Kigali Amendment pursuant to which the focus will now shift to reducing HFCs.

Although HFCs do not deplete the ozone layer (like HCFCs do), they are potent greenhouse gases which contribute significantly to global warming and exacerbate climate change. Further, the HFC phase down schedule under the Kigali Amendment is expected to achieve a reduction in carbon dioxide emissions as well with the aim of avoiding a global temperature rise of up to 0.5 degree Celsius by the year 2100.

However, these mitigation strategies remain in adequate for the purpose of reducing global temperatures. Emissions from short-lived climate pollutants (SLCPs) need to be addressed too, and quickly. Innovative investment opportunities, such as through seaweed start-ups that focus on improving bovine feed for the purpose of reducing agricultural methane emissions, could be explored further in the future.

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Introduction

A recent[2] report on investment opportunities in India's 'cooling sector' by the International Bank for Reconstruction and Development (the "**World Bank**," and such report, the "**World Bank Report**")[3] finds India experiencing higher temperatures with every subsequent year. This trend includes the possibility that more than 200 million people across the country will be annually exposed to crippling heat waves by the end of the decade. At this rate, according to a 2020 case study by the McKinsey Global Institute (the "**McKinsey Study**"),[4] India could soon witness the kind of heat that breaches human survival requirements.[5]

Rising heat can jeopardize economic productivity too, and significantly so – according to the McKinsey Study.[6] Three-quarters of India's workforce are engaged in heat-exposed labour, which, in turn, not only contributes to nearly half of the country's GDP but also drives a third of GDP growth. Particularly vulnerable sectors include agriculture and mining, as well as those with poor access to air conditioning ("**AC**") such as manufacturing and transport. Accordingly, the World Bank Report warns that by 2030, almost 35 million Indians might lose their jobs on

[2] Press Release dated November 30, 2022, available at: https://www.worldbank.org/en/news/pressrelease/2022/11/30/a-greener-cooling-pathway-can-create-a-1-6-trillion-investment-opportunity-in-india-saysworld-bank-report (the "**WB Press Release**").

[3] *See* 'Climate Investment Opportunities in India's Cooling Sector,' available at: https://www.dropbox.com/s/s01drnsy2xp76dk/Climate%20Investment%20Opportunities%20in%20India%27s%20Cooling%20Sector.pdf?dl=0. The study was conducted by the World Bank in partnership with environmental and climate-solution consulting groups, Iora Ecological Solutions, Energe-se, Tessol and Vertiver.

[4] *See* "Climate risk and response: Physical hazards and socioeconomic impacts – Will India get too hot to work?," Case Study, November 2020, McKinsey Global Institute; available at: https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/will%20india%20get%20too%20hot%20to%20work/will-india-get%20too-hot-to-work-vf.pdf

[5] *See* p. 9 of the McKinsey Study:

"We find that India could become one of the first places in the world to experience heat waves that cross the survivability limit for a healthy human being sitting in the shade."

The human body must maintain a relatively stable core temperature of approximately 37 degrees Celsius to function properly. Pushing the core temperature out of equilibrium only a few degrees in either direction results in rapid negative consequences. *See* Gaither D. Bynum *et al.*, "Induced hyperthermia in sedated humans and the concept of a critical thermal maximum," American Journal of Physiology, November 1978, Volume 235, Number 5. *Alsosee* P. A. Hancock and IoannisVasmatzidis, "Human occupational performance limits under stress: The thermal environment as a prototypical example," Ergonomics, 1998, Volume 41, Number 8. Performance under heat stress declines rapidly: the core temperature needs to rise only 0.06 degree to compromise task performance requiring vigilance, 0.2 degree to compromise multitasking ability, 0.9 degree to compromise neuromuscular coordination, 1.3 degrees to affect simple mental performance, 3 degrees to induce dangerous heat stroke, and 5 degrees to cause death.

[6] *See* p. 10 of the McKinsey Study:

"We further estimate that the effective number of outdoor working hours lost will increase approximately 15 percent by 2030, resulting in approximately 2.5-4.5 percent, or $150-250 billion, risk to GDP."

account of heat-related stress.[2] More specifically, while the McKinsey Study found that lost labour from rising heat and humidity could risk up to 4.5% of India's GDP by the end of the decade, a *Nature* study[3] from December 2021 found that countries with large populations in South and East Asia witnessed the most number of lost work hours, with India facing the largest impact on heavy labour on account of heat exposure: in excess of 100 billion hours lost per year.

Investing in India's Cooling Sector

Unsurprisingly, as temperatures rise, so will demands for cooling.[4] India's long-term food and public health security (including in respect of transporting fresh produce and pharmaceutical products) will depend upon the country's access to a reliable cold chain network. Accordingly, harnessing available programs, such as the "Make in India" or the "Production Linked Incentive" schemes, can help boost investments, promote manufacturing, and create jobs across the cooling value chain. Further, investments in both adaptive technology and infrastructure may reduce the direct consequences of heat.

[2] Wet-bulb temperature is an indicator that combines air temperature and relative humidity. It provides a more accurate measure of heat stress on the human body than does air temperature alone. Over the past 30 years, maximum wet-bulb temperatures across India have steadily climbed, driven by an increase in humidity. High wetbulb temperatures are more dangerous to human beings than extreme air temperatures. Wet-bulb temperature is technically defined as the minimum temperature to which a parcel of air can be cooled by evaporation at a constant pressure. As wet-bulb temperatures increase, the ability of human beings to exert effort or perform work decreases due to two factors: firstly, the need to take breaks to avoid the physiological consequences of core temperature rise, and secondly, the body "self-limiting" or instinctively fatiguing, to prevent overheating. *See* TordKjellstrom et al., "Estimating population heat exposure and impacts on working people in conjunction with climate change," International Journal of Biometeorology, March 2018, Volume 62, Number 3.

[3] Parsons, L.A., Shindell, D., Tigchelaar, M. *et al.* Increased labour losses and decreased adaptation potential in a warmer world. *Nat Commun* 12, 7286 (2021).

[4] *See* p. 36 of the World Bank Report:

"India, with its predominantly tropical climate, is experiencing escalating temperatures along with population growth and rapid urbanization, contributing to a steep increase in cooling demand for which India will require massive cooling infrastructure across sectors."

In 2019, the Indian Government launched the India Cooling Action Plan ("**ICAP**").[5] However, challenges in its implementation remain.[6] Accordingly, the World Bank Report identifies

[5] The Ministry of Environment, Forests, and Climate Change released the India Cooling Action Plan ("**ICAP**") in March 2019. Built over a 20-year timeline, ICAP is a multi-stakeholder-driven framework that identifies diverse sustainable cooling needs and issues recommendations across key sectors, including space cooling in buildings, agriculture and pharmaceutical cold chains, refrigeration, passenger transportation, and refrigerants transition. It also lists actions across sectors to help reduce India's cooling demand. *See* Radhika Lalit and Ankit Kalanki, How India is solving its cooling challenge, Rocky Mountain Institute, 2019; India Cooling Action Plan, Government of India, Department of Environment, Forests, and Climate Change, 2018.

[6] The World Bank commissioned the World Bank Report to develop an actionable roadmap comprising policy, investment, and knowledge guidelines to help guide the implementation of ICAP.

opportunities for concessional financing[7] and private sector investment in four sectors: (i) space cooling in buildings, (ii) cold chain and refrigeration, (iii) passenger transport air-conditioning, and (iv) refrigerants.[8]

Space Cooling

With 10 million new homes required to be built every year to keep pace with domestic demand in India, the World Bank Report identifies significant opportunities to introduce natural cooling techniques into climate-responsive construction. Further, the World Bank Report estimates the market potential in space cooling to reach USD1.5 trillion by the year 2040. Within this market, green buildings[9] themselves have an investment potential of approximately USD1.25 trillion and USD228 billion, for purposes of residential and commercial use, respectively. Effective land use is also crucial. In this regard, urban centres, in particular, may require private sector participation.[10]

Cold Chain and Refrigeration

The World Bank Report estimates that investment opportunities in India's cold chain and refrigeration sector will be almost USD30 billion by 2038. Other estimates suggest that investments worth about USD12 billion will be required for the purpose of developing physical infrastructure, along with transport-related elements, with regard to the agriculture cold chain alone – the biggest requirement attributable to building modern packhouses (about USD8.5 billion).

[7] Concessional finance is below market rate finance provided by major financial institutions, such as development banks and multilateral funds, to developing countries to accelerate development objectives. The term 'concessional finance' does not represent a single mechanism or type of financial support but comprises a range of below market rate products used to accelerate a climate or development objective.

[8] According to ICAP, cooling demand across India is projected to rise at a rate of 15-20% annually, and aggregated cooling demand will grow to around eight times by 2037-38 (compared to a 2017-18 baseline). Space cooling for buildings has the largest current and projected cooling demand, refrigerant demand, energy consumption, and associated GHG emissions as compared to other sectors. Accordingly, the World Bank Report focuses on ICAP's thematic cross-sectoral areas including space cooling in buildings, cold chain and refrigeration, transport airconditioning, and refrigerants.

[9] Generally speaking, a 'green building' involves the planning, design, construction, and operations of a building with certain key considerations, including those related to energy use, water use, indoor environmental quality, material section, and the building's effects on the concerned site and surrounds. The Indian Green Building Council (IGBC) offers services in this regard, which include developing new green building rating and training programs along with certification services. Certain government agencies have issued recognitions to IGBC's green rating systems. See https://igbc.in/igbc/.

[10] Guidelines for implementation of local and city-wide urban cooling measures, such as cool roofs and nature-based solutions, can support urban planning frameworks while integrating effective responses to heat-related stress.

Passenger Transport Air-conditioning

The World Bank Report estimates the market potential and investment opportunity in passenger transport to be USD8 billion. Further, the AC market for Indian passenger cars is predicted to cross USD1 billion by next year. According to ICAP, refrigerant demand for the mobile airconditioning sector (comprising passenger cars, buses, and railways) is expected to quadruple by 2037-38.

Refrigerants

Refrigerant demand is expected to grow more than six times over two decades. In 2015, the AC sector had the largest market share among all such sectors, estimated at more than three-fifths of aggregate refrigerant consumption in India. However, along with market share, the country's commercial refrigeration sector was the highest consumer of hydrochlorofluorocarbons ("**HCFCs**") as well. HCFCs are chemical compounds commonly used in the foam, refrigeration, and air-conditioning sectors that deplete the ozone layer and contribute to climate change. By global consensus, it is essential to phase out the use of HCFCs across industries. Currently, the most common alternatives to HCFCs are hydrofluorocarbons ("**HFCs**"), which do not deplete the earth's ozone layer but are nevertheless powerful greenhouse gases ("**GHGs**") having high 'Global Warming Potential' ("**GWP**"),[11]and thus contribute significantly to climate change.

HCFCs and HFCs

Having implemented the first stage of the phaseout management plan related to HCFCs under the Montreal Protocol on Substances that Deplete the Ozone Layer (the "**Montreal Protocol**"),[12] India is now implementing the second. While HCFCs with ozone depletion potential will be phased out in India by 2030, the country recently approved the ratification of the Kigali Amendment[13] to the Montreal Protocol (such amendment, the "**Kigali**

[11] GWP is defined as the cumulative radiative forcing, both direct and indirect effects, over a specified time horizon resulting from the emission of a unit mass of gas related to some reference gas. GWP has been developed as a metric to compare (relative to another gas) the ability of each GHG to trap heat in the atmosphere. Carbon dioxide was chosen as the reference gas to be consistent with the guidelines of the Intergovernmental Panel on Climate Change ("**IPCC**").

[12] The Montreal Protocol was adopted on September 16, 1987, and entered into force in 1989. It is a multilateral environmental agreement. The phase-out plan under the Montreal Protocol includes both the production and consumption of ozone depleting substances ("**ODS**").

[13] Recognizing the growth in use of HFCs, especially in the refrigeration and air-conditioning sectors, the parties to the Montreal Protocol agreed, at the 28th meeting of the parties held in October 2016 at Kigali, Rwanda, to add HFCs to the list of controlled substances, and further, approved a timeline for the gradual reduction of HFCs by 8085% by the late 2040s.

Amendment"),[14] pursuant to which the focus will now shift to phasing down HFCs.[15]

While the air-conditioner remains the most effective tool for combating heat, widespread expansion of installed air-conditioning runs the risk of increasing GHG emissions and exacerbating climate change. The World Bank Report predicts a rise in demand for refrigerant based vapor compression technologies to meet cooling requirements of buildings in India. However, the domestic refrigerant sector aims to transition away from HFCs – given India's commitment to the Montreal Protocol.

[14] *See* "Cabinet approves Ratification of Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer for phase down of Hydrofluorocarbons – National strategy for phase down of Hydrofluorocarbons after required consultation with all the industry stakeholders by 2023," PIB, August 18, 2021 (the "**Kigali Press Release**"); available at: https://pib.gov.in/PressReleasePage.aspx?PRID=1746946

[15] HFCs are factory-made chemicals used primarily in air-conditioning, refrigeration, and insulating foams. HFCs are among the fastest growing GHGs in much of the world, increasing at a rate of 10-15% per year.

The Montreal Protocol

By the mid-1980s, scientific understanding related to atmospheric ozone depletion had crystallized, along with a consensus about adverse consequences on human health and the global environment on account of such depletion.[16] Accordingly, the Vienna Convention for the Protection of the Ozone Layer was negotiated. However, this treaty, in essence, is a framework convention. Thus, despite laying out principles as agreed upon by participants, it does not require countries to take concrete actions with respect to controlling emissions for the purpose of protecting the ozone layer.[17]

On the other hand, the Montreal Protocol regulates the production and consumption of several man-made chemicals that deplete the earth's stratospheric ozone layer when released into the atmosphere. Such chemicals are referred to as ozone depleting substances ("**ODS**"). The Montreal Protocol contemplates a staggered phasedown of ODS with different timetables for developed and developing countries, respectively. Although developing and developed countries have equal but differentiated responsibilities, both groups have binding, time-targeted, and measurable commitments.[18]

[16] Prior to 1989, most air-conditioning units used a class of coolants called hydrochlorofluorocarbons ("**HCFCs**"). After it was discovered that HCFCs deplete the ozone layer, global consensus gave rise to the 1987 Montreal Protocol, which required manufacturers to switch to alternative, non-ozone-degenerative coolants. Among the most popular classes of alternative coolants are HFCs. Although they do not deplete the ozone layer, they are extremely powerful GHGs. For example, releasing one tonne of HFC-410a into the atmosphere is the equivalent of releasing 2,088 tonnes of carbon dioxide. *See* Mohit Sharma, Vaibhav Chaturvedi, and Pallav Purohit, "Long-term carbon dioxide and hydrofluorocarbon emissions from commercial space cooling and refrigeration in India: A detailed analysis within an integrated assessment modelling framework," Climatic Change, August 2017, Volume 143, Number 3–4.

[17] It is an instrument for harmonizing policies and strategies on research. *See* "Decision VC I/3: Relationship between the Vienna Convention and the Montreal Protocol," available at: https://ozone.unep.org/treaties/viennaconvention/meetings/first-conference-parties/decisions/decision-vc-i3-relationship-between-vienna-conventionand-montreal-protocol

[18] The Montreal Protocol includes provisions related to Control Measures (Article 2), Calculation of control levels (Article 3), Control of trade with non-Parties (Article 4), Special situation of developing countries (Article 5), Reporting of data (Article 7), Non-compliance (Article 8), Technical assistance (Article 10), along with provisions related to other topics. The substances controlled by the Montreal Protocol are listed in its Annex A (CFCs, halons), Annex B (other fully halogenated CFCs, carbon tetrachloride, methyl chloroform), Annex C (HCFCs), Annex E (methyl bromide), and Annex F (HFCs).

The Kigali Amendment

The parties to the Montreal Protocol meet once a year to make decisions aimed towards successful implementation of the protocol, including in respect of adjusting or amending such protocol.[19] In 2016, for instance, the Kigali Amendment called for the phase-down of HFCs.[20]

India and the Kigali Amendment

The union cabinet press release announcing India's ratification of the Kigali Amendment in 2021 (the "**Kigali Press Release**")[21] expressed optimism about the scope for domestic manufacturing of equipment, along with alternative non-HFC and low-GWP chemicals for the purpose of enabling a national transition consistent with India's obligations under the Kigali Amendment. In addition, the Kigali Press Release spoke about opportunities to promote domestic innovation in respect of alternative refrigerants and related technologies.[22] In terms of the HFC phasedown schedule under the Kigali Amendment, along with gains in energy efficiency, it is expected to achieve a reduction in carbon dioxide ("**CO2**") emissions with the aim of avoiding a global temperature rise of up to 0.5 degree Celsius by the turn of the century.

SLCPs

Unfortunately, India's aggressive CO2 mitigation initiatives and allied pivot towards renewable energy, although essential, are not enough.[23] Fast reductions of short-lived climate pollutants ("**SLCPs**")[24] are equally crucial, especially over the short-term.[30] Reducing SLCPs can (i) avoid

[19] Such separate adjustments and amendments to the Montreal Protocol were adopted by the meetings of the parties in 1990 (London), 1992 (Copenhagen), 1995 (Vienna), 1997 (Montreal), 1999 (Beijing), 2007 (Montreal), 2016 (Kigali), and 2018 (Quito).

[20] At the 28th meeting of the parties to the Montreal Protocol held in Kigali between October 10 and 15, 2016, such parties adopted a further amendment to the Montreal Protocol in accordance with the procedure laid down in paragraph 4 of article 9 of the 1985 Vienna Convention for the Protection of the Ozone Layer.

[21] The Kigali Amendment entered into force on January 1, 2019, subject to certain exceptions and qualifications. 146 countries are parties to such amendment as of date.

[22] See the Kigali Press Release.

[23] Achieving 'net-zero' CO2 emissions is essential towards global decarbonization goals. However, decarbonization alone, and on its own, will *not* keep the planet from exceeding the 1.5 °C limit, and thereby facing a climate catastrophe. Even the most aggressive decarbonization efforts will not have a discernible cooling effect until midcentury, when it can avoid 0.1°C. Recent science and mitigation reports prepared by the IPCC, such as the Sixth Assessment Report of the IPCC (AR6), confirm the need for a dual strategy to slow down both near-term and longterm warming.

[24] Since SLCPs have atmospheric lifetimes ranging from only a few days to a decade and a half (compared to CO2 which can persist in the atmosphere for millennia), these super pollutants are considered 'short-lived'.

four times more warming by the year 2050, and slow down warming one to two decades earlier (relative to what cutting down on CO2 emissions alone can achieve); (ii) decrease the current rate of global warming by half; and (iii) provide global benefits for climate, crops, and health which is valued at almost USD6 trillion annually, starting from the year 2030. Apart from HFCs, such SLCPs include, among other things, methane.[31]

[30] Reducing SLCPS is the best, and likely the only, strategy that will avoid near-term warming fast enough to prevent the world economy from losing control of the climate system. See Dreyfus G. B., Xu Y., Shindell D. T., Zaelke D., & Ramanathan V. (2022) Mitigation climate disruption in time: A self-consistent approach for avoiding both nearterm and long-term global warming, PROC. NAT'L. ACAD. SCI. 119(22).

[31] SLCPs include methane, tropospheric ozone, black carbon, and HFCs. Methane is a powerful GHG with a 100year GWP – *i.e.*, 21 times that of CO2. Approximately 60% of methane is emitted to the atmosphere through human activities (anthropogenic emissions) such as oil and gas systems, agriculture, landfills, wastewater treatment,

and emissions from coal mines. Methane has contributed to about one-third of current anthropogenic GHG-driven warming. See *Methane matters*. Nat. Geosci. 14, 875 (2021), available at: https://www.nature.com/articles/s41561-021-00875-1#citeas

Methane

India did not sign the Global Methane Pledge[25] at the 26th United Nations Climate Change Conference (COP26)[26] despite being one of the largest methane emitters in the world.[27] Methane has more than 80 times the warming power of CO2 over the first 20 years after it reaches the atmosphere. Even though CO2 has a longer-lasting effect, methane sets the pace for warming in the near term. At least a fourth of today's global warming is driven by anthropogenic methane emissions (*i.e.*, those stemming from human actions).[28]

Most Indian methane emissions can be traced back to agriculture (about 75%).[29]In turn, the largest source of agricultural methane is enteric fermentation, generated in the digestive tracts of ruminant livestock. The fact that India has the largest cattle population in the world further complicates the issue.[30]

[25] The Global Methane Pledge, launched in 2021, aims to keep alive the 1.5 degrees Celsius goal. Over 100 countries have committed to reducing global methane emissions by at least 30% by 2030 from 2020 levels. This reduction could eliminate over 0.2˚C warming by 2050.

[26] Held at Glasgow in 2021.

[27] *See*https://www.iea.org/reports/global-methane-tracker-2022/the-global-methane-pledge

[28] *See* "Methane: A crucial opportunity in the climate fight," Environmental Defense Fund (EDF), available at: https://www.edf.org/climate/methane-crucial-opportunity-climatefight#:~:text=Methane%20has%20more%20than%2080,by%20methane%20from%20human%20actions.

[29] The two predominant sources of methane emissions in India are enteric fermentation and paddy cultivation. These emissions result from the agricultural activities of small, marginal, and medium farmers across India. India's methane emissions in 2016 (excluding land use, land-use change and forestry (LULUCF) activities) were 409 million tonnes of CO2 equivalent, of which 73.96% was from the agriculture sector, 14.46% from the waste sector, 10.62% from the energy sector, and 0.96% from industrial processes and the product use sector.

[30] *See*LOK SABHA UNSTARRED QUESTION NO. 2478, "Emission on Methane," asked by Smt. MANEKA SANJAY GANDHI, answered on December 13, 2021 by the MINISTER OF STATE IN THE MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE, SHRI ASHWINI KUMAR CHOUBEY; available at: http://164.100.24.220/loksabhaquestions/annex/177/AU2478.pdf

Seaweed Start-ups

However, a key method for reducing agricultural methane emissions is by manipulating microbial processes in bovine feed and gut through the introduction of seaweed-extract additives.[31]Accordingly, seaweed start-ups across the world[39] are now raising capital to expand

[31] *See* Lauren Kramer, "Aquaculture pioneer Josh Goldman's Asparagopsis venture aims to reduce methane emissions in terrestrial farming," Global Seafood Alliance, October 14, 2019, available at: https://www.globalseafood.org/advocate/beefing-up-seaweed-production-to-green-up-beef/; Kinley, Robert D., de Nys, Rocky, Vucko, Matthew J., Machado, Lorenna, and Tomkins, Nigel W. (2016) *The red macroalgae Asparagopsistaxiformis is a potent natural antimethanogenic that reduces methane production during in vitro fermentation with rumen fluid.* Animal Production Science, 56 (3). pp. 282-289, available at: https://researchonline.jcu.edu.au/43225/; Judith

operations.[40] According to global estimates, the commercial seaweed market was valued at over USD40 billion in 2020.[41] Participants in this market remain involved in a number of strategic initiatives, including with respect to mergers and acquisitions, geographical expansion, scaling up production capacity, and partnerships.[42] Most money raised so far has been in pre-seed and seed rounds. Although corporate and venture capital ("**VC**") investments dominate this space, traditional VCs are yet to meaningfully discover the seaweed industry relative to other options and sectors in the market. While Europe leads in terms of having the largest number of seaweed start-ups, both in terms of the number of deals and the amount of money invested, North American start-ups are able to attract capital more easily, consistent with trends across industry. Nevertheless, a majority of companies that raise funds are vertically integrated to some extent: thus, most seaweed producers also process their own 'crops' into finished products.

India and Seaweed

In India too, a seaweed-based additive substance with regard to cattle-feed was developed around two years ago, and its commercial production subsequently approved.[43] Moreover, as

Lewis Mernit, "How Eating Seaweed Can Help Cows to Belch Less Methane," Yale School of the Environment, July 2, 2018, available at: https://e360.yale.edu/features/how-eating-seaweed-can-help-cows-to-belch-less-methane; James Temple, "Seaweed could make cows burp less methane and cut their carbon hoofprint," MIT Technology Review, November 23, 2018 ("A diet supplemented with red algae could lessen the huge amounts of greenhouse gases emitted by cows and sheep, if we can just figure out how to grow enough"), available at: https://www.technologyreview.com/2018/11/23/1826/how-seaweed-could-shrink-livestocks-global-carbonhoofprint/.

[39] *See* "Seaweed startups in 2021: an ecosystem emerges," Phyconomy, available at: https://phyconomy.net/state-ofthe-industry-2022/startups/. Phyconomy is a new project to track the emerging economy of seaweed.

[40] Last year, Symbrosia Inc., a US-based Hawaiian seaweed start-up that developed 'SeaGraze' – a seaweed additive made with the tropical seaweed *Asparagopsistaxiformis* – to reduce methane emissions in cattle belches, raised a further USD 7 million in new funding. In 2017, seaweed first made headlines when research showed that adding *Asparagopsistaxiformi* to cattle-feed helped reduce methane emissions in cow burps up to 50%. Several companies started developing sea plants in the hopes of reducing the climate impacts of cattle production. *See* State of the Seaweed Industry 2022, Phyconomy, available at: https://phyconomy.net/state-of-the-industry-2022/

[41] *See* "Commercial Seaweed Market," Global Market Insights, Report ID: GMI1658, July 2021, available at: https://www.gminsights.com/industry-analysis/commercial-seaweed-market. However, according to a different report, the global commercial seaweed market was valued at about USD 14 billion in 2020. *See* "Commercial Seaweed Market," Fortune Business Insights, Report ID FBI100077, July 2021, available at: https://www.fortunebusinessinsights.com/industry-reports/commercial-seaweed-market-100077

[42] *See* "In 2021, seaweed investment deals doubled," Phyconomy, available at: https://phyconomy.net/state-of-theindustry-2022/investments/.

[43] *See* NimeshKhakhariya, "Seaweed feed to reduce methane emission in bovine," November 20, 2020, Times of India, available at: https://timesofindia.indiatimes.com/city/rajkot/seaweed-feed-to-reduce-methane-emission-inbovine/articleshow/79309067.cms; *also see* "Seaweed Based New Animal Feed Additive Formulations for Improving Productivity and Health," Central Salt & Marine Chemicals Research Institute, Council of Scientific & Industrial Research, updated on May 27, 2021, available at: https://www.csmcri.res.in/node/8131. Around the same time, FutureFeed, an Australian company, secured new funding from five separate investors using the same seaweed-

part of its 'Blue Revolution',[44] India aspires to expand seaweed production to at least 1 million tons a year by 2025.[45] The country's extensive coastline (almost 8,000 km), open waterways (14,500 km), and diverse ecosystems sustain thousands of seaweed species, each with substantial commercial value. In addition, collected seaweed can be used to create biofuels, the use of which is now being actively promoted in India.

Foreign entities have already invested in early-mover Indian companies engaged in the local seaweed industry.[46] Further, by sanctioning 100% FDI through the automatic route in both pisciculture and aquaculture, the Indian government is aiming to attract more foreign investors, even as domestic seaweed farming and aquapark investments continue to grow, especially in states such as Tamil Nadu and Gujarat.

Suggestions and Conclusion

The World Bank Report suggests that with a steady rise in temperatures across India on account of climate change and a corresponding demand for cooling, the use of alternative, innovative, and energy-efficient technologies can produce investment opportunities aggregating USD1.6 trillion by the year 2040.[47] A supportive policy environment can boost further investment in India's cooling sector, including via insights from the World Bank Report that might be used to improve upon ICAP – including in terms of its implementation. While India's HFC/HCFC phaseout plans and corresponding obligations under the Montreal Protocol (along with the Kigali Amendment) may continue in tandem, the country's present initiatives towards

based technology. *See* https://www.future-feed.com; Jack Ellis, "CSIRO, Woolworths unveil FutureFeed, a seaweed supplement that cuts cow methane by 80%," AgFunder News, August 20, 2020, available at: https://agfundernews.com/futurefeed-gets-9-3m-from-csiro-woolworths-others-for-seaweed-supplement-that-cutscow-methane-by-80.

[44] *See* 'Blue Revolution', Department of Fisheries, at: https://dof.gov.in/blue-revolution

[45] *See* https://www.investindia.gov.in/team-india-blogs/seaweed-india

[46] For instance, *see* Nell Lewis, "An Indian startup could revolutionize ocean farming with its 'sea combine harvester'," CNN Business, October 6, 2022, available at: https://edition.cnn.com/2022/01/05/business/indiasea6-energy-seaweed-harvester-spc-intl/index.html. Pursuant to a joint news release dated August 17, 2022, it was announced that

(i) BASF Venture Capital GmbH, the corporate venture company of BASF SE, Germany, and (ii) Aqua-Spark, a Dutch investment fund focusing on the global aquaculture industry, were investing in Sea6 Energy Pvt. Ltd. ("**Sea6 Energy**," an Indian seaweed company founded in 2020 and located in Bangalore) as part of a Series B round. Other existing investors in Sea6 Energy included Tata Capital Innovations Fund. With such investment, Sea6 Energy completed its Series B transaction of INR 1402 million (about USD 18.5 million) in total. *See* "BASF Venture Capital and Aqua-Spark invest in Sea6 Energy," Joint News Release, August 17, 2022, available at: https://www.basf.com/global/en/media/news-releases/2022/08/p-22-312.html.

[47]See the WB Press Release

decarbonization and renewable energy can be considerably strengthened through informed policy decisions with respect to reducing SLCPs as well (*e.g.*, methane).

Given India's ambitious plans related to climate and promoting the ease of doing business, respectively, both domestic and foreign entities could explore relatively *avant-garde* options with respect to global warming including through investing in methane capture/reduction technologies. While certain causes of warming are universal, the source, nature, and extent of emissions, along with allied investment strategies differ from region to region (and/or across cultures and countries). Accordingly, seaweed start-ups that aim to scale up production with the goal of mitigating agricultural methane emissions are an illustration of a localized solution which could be replicated elsewhere and/or in other contexts.

For instance, given that the waste sector constitutes the second largest source of methane emissions in India (about 15%), municipal authorities, private landfill owners, and project developers could finance landfill gas ("**LFG**")[32] management systems.[33] Developing LFGs to energy[34] requires financial investments that are often beyond the reach of local governments or landfill owners alone. Obtaining financing typically requires a range of public and private actors to

[32] Landfills and dumpsites contain a significant amount of biodegradable waste, including food scraps and agricultural refuse. When these organic materials break down in municipal landfills, various gases known collectively as landfill gas (LFG) are produced and either build up within such landfills or get discharge into the atmosphere. Managing LFGs is a growing challenge around the world. LFG is a by-product of decomposing waste and a significant source of methane.

[33] *See* Markgraf, Claire and Kaza, Silpa. 2016. Financing Landfill Gas Projects in Developing Countries. Urban Development Series Knowledge Papers, no. 23; World Bank, Washington, DC.

[34] While diverting organic waste entirely from landfills would obviate the need to manage corresponding emissions, a second-best solution is the capture and combustion of LFG before it is released into the atmosphere. Flaring (burning) or converting methane gas into an alternative energy source both reduce harmful emissions and have the potential to generate revenue for local governments or other landfill owners. Though there are many technologies available for LFG collection and combustion, the challenges involved in financing these systems continues to present a major obstacle to mitigating emissions from waste.

agree on how to incentivize development, equitably assign risk, divide potential project revenue, and support ongoing operations. Further, the profitability of LFG systems is subject to market volatility in natural gas, electricity, and carbon, as well as other factors such as regional variation in the cost of maintenance, availability of skilled labour, and ability to obtain spare parts. Consequently, LFG is a largely untapped municipal asset.

Nevertheless, a mixture of both innovative and traditional infrastructure-finance methods including through municipal infrastructure bonds, public-private partnerships, and leveraged government incentives can be, and have been, used to build effective LFG management systems around the world. In India too, the Ministry of New and Renewable Energy has launched a program to support the setting up of 'waste to energy' projects for generation of biogas from urban, industrial, and agricultural residue. This program provides central financial assistance to developers of such projects.[35] Large municipal waste dumpsites in India have, in fact, been turned into significant sources of green automotive fuel, converting LFG into compressed biogas.[36]

Paddy is another sector that could be tapped into. Along with bovine enteric fermentation, paddy cultivation is a major source of agricultural methane emissions in India. Accordingly, large investments are needed across rice value chains to transform the sector. To achieve this goal, governments can leverage public finance to attract private investment, over and above existing initiatives such as the Gobardhan Scheme,[37] direct seeded rice,[38] crop diversification program,[39]

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[35] *See* 'Waste to Energy (WTE) Schemes,' MNRE, available at: https://mnre.gov.in/waste-to-energy/schemes

[36] *See, e.g.*, "Telangana: India's Largest Landfill Based Biogas Plant Inaugurated In Hyderabad," India Infra Hub, October 29, 2021, available at: https://indiainfrahub.com/2021/waste-management/telangana-indias-largestlandfill-based-biogas-plant-inaugurated-in-hyderabad/

[37] The Indian Government is taking a number of initiatives to reduce methane emissions. Through initiatives like 'The Gobar (Galvanizing Organic Bio-Agro Resources) – Dhan' scheme (the "**Gobardhan Scheme**") and the New National Biogas and Organic Manure Programme, cattle waste utilization is being incentivized, in addition to the promotion of clean energy in villages. Among other things, the Gobardhan Scheme supports biodegradable waste recovery, conversion of waste into resources, and reduction of GHG emissions.

[38] This system reduces methane emissions because it does not involve raising nurseries, puddling, and transplanting. Unlike transplanted paddy cultivation, standing water is not maintained in this system.

[39] Methane emissions are avoided due to diversion of paddy to alternative crops like pulses, oilseeds, maize, cotton and agroforestry.

and system for rice intensification[40] (in India). For example, the Thai Rice Nationally Appropriate Mitigation Action (NAMA)[41] project[42] uses overseas development assistance to finance a revolving fund for integrating locally adapted best management practices in

[40] The technique has the potential to enhance rice yield from 36-49% with about 22-35% less water than conventional transplanted rice.

[41] The decision-making body of the NAMA Facility is the NAMA Facility Board, currently comprising representatives of donors including: the Germany Federal Ministry for Economic Affairs and Climate Action; UK's Department for Business, Energy and Industrial Strategy; the Danish Ministry of Climate, Energy and Utilities; the Danish Ministry of Foreign Affairs; the European Union; and the Children's Investment Fund Foundation.

[42] Thai Rice NAMA is a joint project funded by NAMA Facility with the Thai government. Thai rice is significant because it is cultivated on almost half of all agricultural land in Thailand, accounting for nearly 55% of Thai emissions from agriculture. Thailand is the world's fourth-largest emitter of rice-related GHG. In irrigated rice production, flooding of paddy fields leads to significant emissions of methane.

combination with laser land levelling[43] to facilitate private sector involvement. In fact, one of the key factors driving the growth of the global laser land leveller industry is the rising demand for water-saving technologies in agriculture owing to climate change.[44]Further, impact investors could include rice in their portfolios and investment strategies.

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[43] Laser levelling is the process of smoothening the land surface ± 2 cm from its average elevation by using laser equipped drag buckets to achieve precision in land level.

[44] *See* "Laser Land Levelers Market by Type, End-user, and Geography - Forecast and Analysis 2022-2026," Technavio, Report, April 2022; available at: https://www.technavio.com/report/laser-land-levelers-marketindustry-size-analysis