Towards a Net Zero Future: Policy, Technology and Financial Needs

(The India story and beyond)

In the past few years India has made significant climate announcements on the international stage regarding its climate ambition. At COP 26, the Prime Minister announced Panchamrit principles and a target to reach Net-Zero by 2070. These targets were subsequently built into India's updated NDC and have the following targets:

1. To achieve 50% of India's cumulative electric power installed capacity from non-fossil sources by 2030

2. Reduce the emission intensity of GDP by 45% below 2005 levels by 2030

3. Put forward and further propagate a healthy and sustainable way of living based on the traditions and values of conservation and moderation, including through a mass movement for LiFE – Lifestyle for Environment as a key to combating climate change.

India's climate goals are embedded in the principles of Common But Differentiated Responsibility and Respective Capabilities. Additionally, these goals are also designed in a manner to address the country's developmental needs of poverty alleviation, access to clean & affordable electricity, energy security, improved connectivity, livelihoods etc. With the aim to work towards the net zero target, the Union Budget for 2023-24 was geared for 'green growth' that is in line with the government's stance on economic growth/development that also incorporates larger climate considerations.

India's emissions grew at a CAGR of 4.90% from 1585.51 Mt CO2e in 2005 to 2952.87 Mt CO2e in 2018. Energy sector has been the major contributor to India's total economy-wide emissions across the reference period accounting for 83% of the emissions in 2018. Within the energy sector, public electricity generation, industries and transport are the top three categories in terms of energy emissions (as per trend from 2005 to 2018). In 2005, the share of the Energy

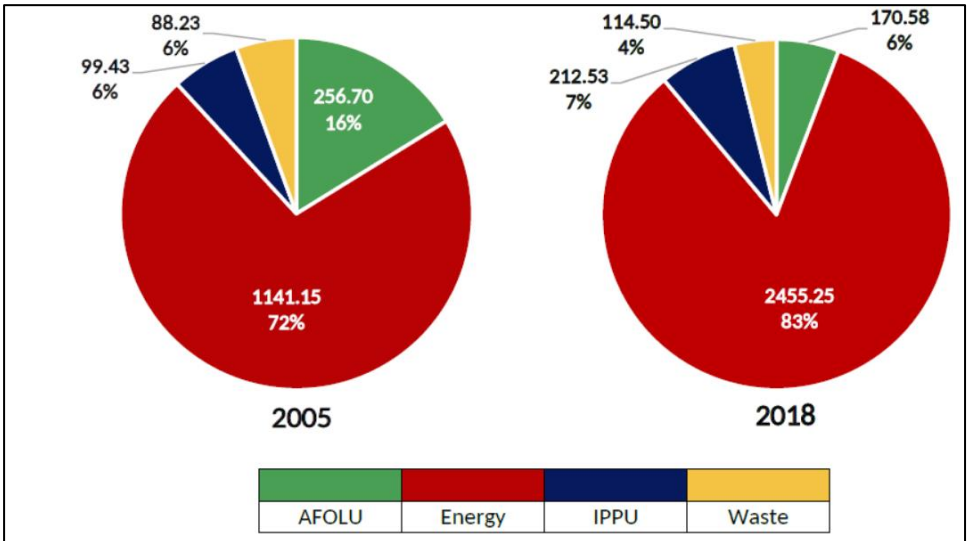

Figure 1: Sector-wise Contribution (Mt CO_2e) and Percentage Share in Net Economy-wide GHG Emissions of India

Source: GHG Platform India

sector in India's economy-wide GHG emissions was ~72%, while the Agriculture, Forestry and Other Land Use (AFOLU) sector accounted for 16%. Both Industrial Processes and Product Use (IPPU) and Waste sectors accounted for 6% each of economy-wide emissions in 2005. In 2018, the share of emissions from the Energy sector increased to ~83% and IPPU's sectoral share increased by 1% during the reference period.

The net zero target provides the country an opportunity to reduce emissions, adopt low carbon technologies and develop in a resilient and sustainable green manner. The Long-Term Low Emissions Development Strategy (LT-LEDS) by India outlines sector-specific action areas, targeting the power, industry, transport, building, and urban sectors. However, clear policy guidance and implementation means to achieve these sectoral targets beyond the existing policies and programmes, emissions pathways, are crucial for materializing the net-zero vision by 2070. This brief aims to explore a few key sectors (electricity, industry & transport) that need to be taken into consideration for India to achieve the target by 2070.

Figure 2: India's Long-Term Goal to Reach Net Zero

Source: Vasudha Foundation

I. Electricity

As per the latest estimates available (2018) the energy sector accounts for about 83% of the country's total emissions. As indicated by the figure the emissions from this sector have more than doubled from 2005 (~1141 Mt CO_2e) to 2018 (~2455Mt CO_2e). Within the sector, public electricity generation accounts for 45% of emissions followed by industries (26%) and transport (12%).

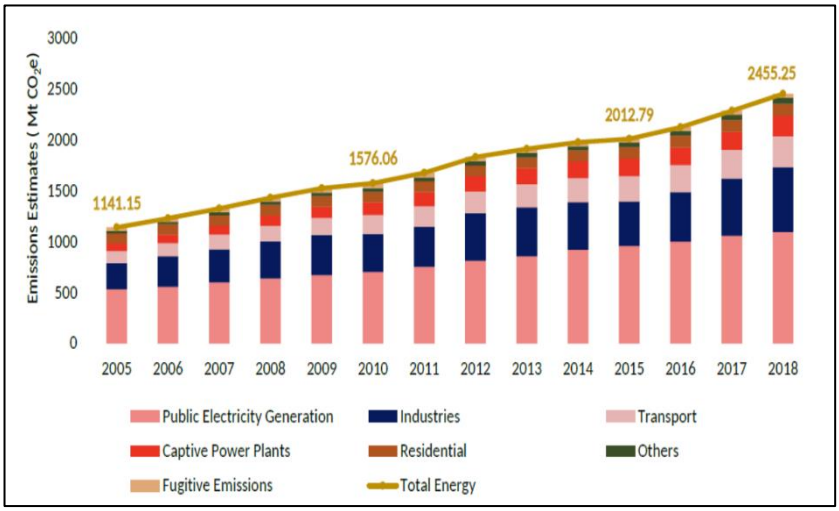

Figure 3: GHG Emissions Estimates of Energy Sector - India (2005 to 2018)

Source: GHG Platform India

India is the third largest energy consumer in the world after China and United States of America (23 EJ of final energy consumption). The energy consumption is only bound to grow over the next few years and decades, given the rapid rate of development and urbanisation that is being witnessed by the country. However, it should be noted that India's per capita energy consumption is well below the global average. Per capita electricity consumption for 2021-22 was 1255 kWh, which is around one-third of the global average.

About 59% of India's primary energy supply is met through coal, oil accounts for 28%, 8% through gas and only 2% through renewables. In terms of installed capacity, Coal accounts for 51% (210.4 GW), followed by solar at 16%. In its updated NDC, India aims to achieve 50% of India's cumulative electric power installed capacity from non-fossil sources by 2030. This is significant in the context of energy security of the country and is also intrinsically tied to the development of the country.

Therefore, a transition in the electricity sector is imperative on the path to achieve net zero. It must be noted that India is already taking steps at the policy level to enable a transition to a net zero future. Decarbonisation of the electricity sector requires policy and technological interventions. Table 1 gives an overview of the current policy landscape that is geared towards a transition in the energy sector.

Table 1: Current Policy Landscape

Policy/ Scheme/ Program	**Target/ Description**
Production Linked Incentive Scheme	India is promoting manufacture of clean energy technologies at scale. Existing Production-Linked Incentive (PLI) schemes support solar, energy storage systems and electric vehicle technologies.

Unnat Jyoti by Affordable LED for All (UJALA) program	Addressing energy efficiency requirements through demand side management initiatives. This scheme targeted the replacement of old wasteful lamps with modern, efficient, longer lasting LED lamps.
Energy Conservation (Amendment Bill) 2022	Addresses several measures on energy conservation and decarbonisation that includes setting up a carbon credit trading system, Energy Conservation and Sustainable Building Code, inclusion of vehicles and industry under the energy consumption standards

A successful transition in the electricity sector will not only require an enabling policy environment but also access to affordable technology. Over the few past years renewable energy tariffs have significantly decreased. The success achieved in solar makes the case for continued use of renewable energy.

These policy interventions mostly cater to improving energy efficiency, energy conservation and incentivising domestic manufacturing of technology for renewable energy. This will need to be augmented with technologies:

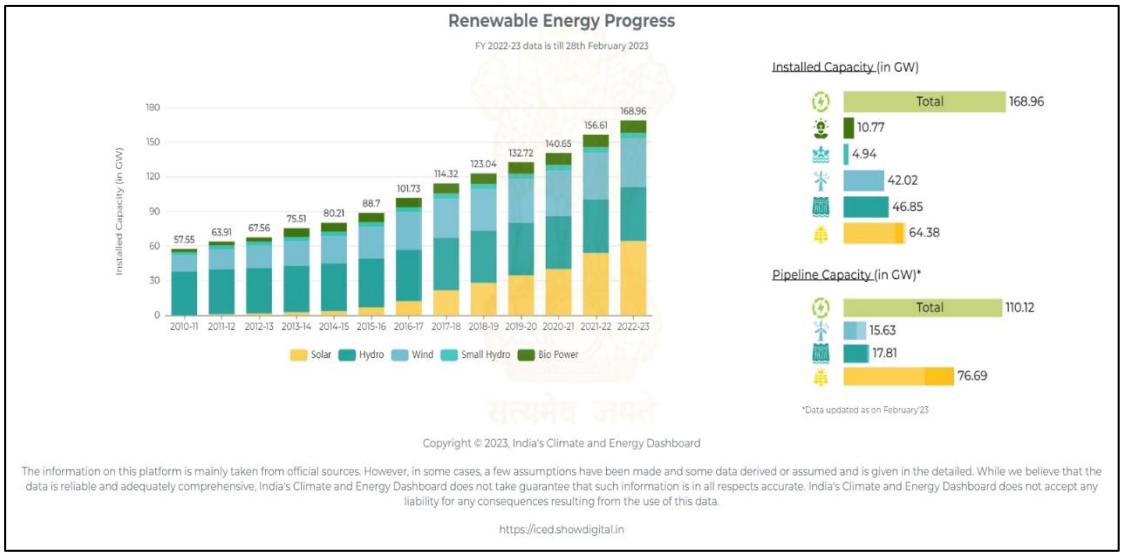

Figure 4: India's Renewable Energy Progress

Source: Vasudha Foundation

1. Integration of RE into existing GRID/ Intermittency of RE: Providing affordable and reliable electricity is one of the major developmental priorities for the country. India recently achieved near universal access to electricity. Maintaining this status through the transition is imperative. This will require the promotion of decentralised solutions like rooftop solar PV, solar feeders for agriculture and mini- and micro-grids.

2. Wind Energy [1]-With a 7600-kilometer coastline, India has an immense opportunity of harnessing offshore wind energy. Creation of a domestic manufacturing ecosystem for large-scale wind turbine and components projects may reduce costs and increase adoption of the new technologies.

[1] IEA (2022), *Direct Air Capture 2022*, IEA, Paris, https://www.iea.org/reports/direct-air-capture-2022

3. Smart Grids (SG)[1]- SG with an interactive technology that provides real-time information on power generation and transmission. This includes decentralized generation systems through large plants and small consumers and businesses, digital substations for real-time monitoring of power consumption and generation, smart meters in distribution, systems for consumers to locally generate and contribute excess energy. SG also includes microgrid solutions, and advanced circuit breakers to improve grid resilience and reliability.

4. Carbon capture, utilization and storage (CCUS) - CCUS Technology to capture carbon emissions at the Coal power plant level and utilize/store for hydrogen generation or biofuel generation.

5. Direct air capture (DAC) - DAC technology with geological CO2 storage has relatively small land and water footprint, and high degree of assurance in both the permanence of the storage and the quantification of CO2 removed. The two leading DAC technologies are– solid DAC (S-DAC) and liquid DAC (L-DAC). Innovation to support renewable energy options for high-temperature industrial heat would maximize the carbon removal potential of L-DAC plants. Innovation in CO2 use opportunities, including synthetic fuels, could drive down costs and provide a market for DAC. Further research and innovation are needed to support cost reductions and faster commercialisation, and build a potentially large market for air-captured CO2.

II. Industry:

As per latest emissions data available, the industrial sector accounts for about 7% of India's total emissions (2018). These emissions are categorised as Industrial Processes and Product Use (IPPU). The mineral industry is the major contributor to emissions in this sector. The cement production accounts for 55.15% of emissions within the mineral industry. This is followed by the production of iron and steel that contributes 11.12% of the total. Emissions from both these sectors have steadily increased for the 2005-2018 period as indicated in the adjoining figure.

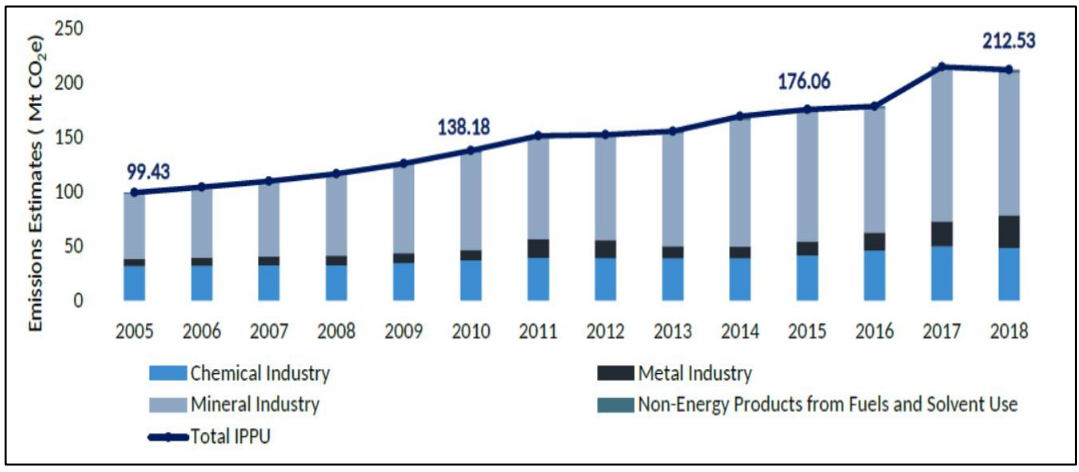

Figure 5: GHG Emissions Estimates of IPPU Sector - India (2005 to 2018)

Source: GHG Platform India

Decarbonisation in the industrial sectors requires action to be taken in the spheres of improving energy efficiency, switching to renewable energy/ alternative fuel sources, circularity of materials (across the value chain and low-carbon technologies in hard to abate sectors like cement, iron and steel production and fertiliser industries.

Current Policy Landscape	
Policy/ Scheme	**Target/ Description**
National Hydrogen Mission	The mission is expected to generate a production capacity of five million tonnes of green hydrogen per annum. Phase I of the Mission is focused on demand generation, while Phase II aims at accelerated production of green hydrogen.
National Biofuel Policy	Indicative 2025 target of 20% blending of ethanol in petrol, with an annual savings potential of INR 300 billion of foreign exchange.
Perform, Achieve and Trade (PAT)	is a regulatory instrument to reduce Specific Energy Consumption in energy intensive industries, with an associated market-based mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded.

The Technology needs to be considered in this sector:

1. Green Hydrogen[1] - The National Green Hydrogen Mission and the financial allocation made for the same in the Union Budget is an important step. Achieving green hydrogen produced solely by renewable energy sources in the long run is critical towards a net-zero path. With the creation of demand and infrastructure, green hydrogen will eventually enter the market and utilize existing storage, transmission and distribution infrastructure. Technological breakthroughs and system-level integration to achieve solutions for round-the-clock (RTC) green electricity is required.

2. Direct reduced iron (DRI) processes for steel production don't require coke and typically use hydrogen and carbon monoxide, derived from methane or coal. Plants that use methane-derived gas and renewable electricity for DRI emit 61% less CO2 than coke-based ones. Plants that use only hydrogen for DRI could reduce emissions by 97% to 50 kilograms or less per tonne of steel.

3. LC3 Technology in cement production i.e. Limestone calcined clay cement (LC3) can be adopted in up to half of the clinkers. It uses the strategy of replacing some of the clinker – the combination of lime, sand and clay before it's mixed with other materials to create cement – with more sustainable materials like blast-furnace slag and ash from coal-fired power stations, while fossil fuels are gradually phasing out as part of net-zero plans.

III. Transport

The transport sector contributes to about 10% of India's GDP. The automotive industry sector is a key driver of economic growth in India. It contributes nearly 6.4% of India's GDP (2021). It accounts for more than one-third of the manufacturing GDP in India and provides direct or indirect employment to around 3.7 crore people in the country. The transport sector makes up 12.38% of the total economy wide emissions in India (2018).

Current Policy Landscape	
Policy/ Scheme	**Target/ Description**
National Biofuel Policy	Indicative 2025 target of 20% blending of ethanol in petrol
Faster Adoption and Manufacturing of Hybrid and Electric Vehicles	(Currently in its 2nd phase) Aims to generate demand by way of supporting 7000 e-Buses, 5 lakh e-3 Wheelers, 55000 e-4 Wheeler Passenger Cars (including Strong Hybrid) and 10 lakh e-2 Wheelers.
Bharat Stage VI	Aimed at improving fuel efficiency through emission standard regulation. Leapfrogging from Bharat Stage IV emissions standards for vehicles directly to Bharat Stage VI emission standards.
Vehicle Scrappage Policy	Mandatory scrappage of old, polluting vehicles subject to fitness and emissions tests and replacement of end-of-life vehicles (ELVs) to address fuel efficiency issues and emissions reductions

Technology Needs:

1. Low-carbon fuels (bio-based fuels, sustainable fuels) with engines for hybrid electric vehicles can reduce carbon and other pollutant emissions of vehicles now, while enabling a faster transition to net-zero-carbon emissions for on-road transportation in the future. Fuels produced from the same biomass—such as forestry and agricultural by-products, algae, discarded cooking oil, and even manure—could eventually meet 100% of future demand for air, marine, and rail fuel. Research focused on identifying and understanding fuel components known as blendstocks, which can be combined with affordable petroleum-based fuels to improve vehicles' carbon footprint and engine performance[2].

2. Hydrogen and fuel cells can reduce emissions in heavy-duty vehicles wherein vehicles produce only heat and clean water, no pollutants. Fuel cells convert a fuel's chemical energy to electrical energy and can be two to three times more efficient than internal combustion engines[3].

3. Long range battery technology allows vehicles to travel great distances on a single charge, especially beneficial for trucking companies. Long-Range Li-Ion Batteries for Electric Vehicles involves material and manufacturing development for a new type of

[2] On the Road to a Net-Zero-Carbon Transportation Future, Bioenergy Technologies Office, June 2022, https://www.energy.gov/eere/bioenergy/articles/road-net-zero-carbon-transportation-future
[3] Hydrogen's Role in Transportation, Vehicle Technologies Office, Feb 2022, https://www.energy.gov/eere/vehicles/articles/hydrogens-role-transportation

Li-Ion battery material, a silicon-coated paper. Silicon-based batteries are advantageous due to silicon's ability to store large amounts of energy[4].

Financing Net-zero

While efforts to enhance many existing technologies and research to innovate new technologies to achieve net-zero targets are rigorous and underway, the crucial question is how can we leverage these technologies into practice for effective sectoral policy and strategy-making, impact and implementation. Efforts must be laid by countries to enhance mitigation measures and pathways followed, in turn, leading to a periodic target review process. The lack of transparency around India's plans to use carbon dioxide removal technologies is also a critical limitation of the new LTS.

Efforts must be laid by countries to enhance mitigation measures and pathways followed, in turn, leading to a periodic target review process. India could clarify the emissions scope of the target, better quantify its mitigation measures and pathways, and also develop a target review process. The lack of transparency around India's plans to use carbon dioxide removal technologies is also a critical limitation of the new LTS.

The Long-Term Low Emissions Development Strategy (LT-LEDS) by India outlines sector-specific action areas, targeting the power, industry, transport, building, and urban sectors. However, clear policy guidance and implementation means to achieve these sectoral targets beyond the existing policies and programmes, emissions pathways, are crucial for materializing the net-zero vision by 2070. Policies, initiatives and efforts to realize India's Net zero target by 2070 should largely be focused on the Energy sector and its major emission categories. Detailed medium-term decarbonisation plan with sector-specific priorities and policy frameworks that account for interdependencies across sectors and provide demand signals to attract investment is necessary.

According to the Centre for Energy Finance (CEEW-CEF), India may require an investment of over USD 10 trillion to achieve its net-zero target by 20701. To reach net zero emissions by 2070, the IEA estimates that $160 billion per year is needed, on average, across India's energy economy between now and 2030. That's three times today's investment levels. Research and Innovation in formulating and expanding innovative financing mechanisms domestically in larger capacity like green financing through climate/green bond market, fiscal incentives for investors, risk reducing mechanisms, etc. is important to boost self-reliance in terms of financial requirements for net zero agenda. This also indicates the need for developing a standard Green Taxonomy with classification system for investment projects that are environmentally sustainable and a real-time dashboard showcasing climate impact to avoid green washing and streamline fundings effectively.

A critical aspect is building and maintaining an "enabling and facilitating environment" for technology development, piloting, implementation and upscaling through several policy and strategy level interventions. For advanced and upcoming technologies there is a need for:

[4] The Future of Mobility: Long Range EVs, EverCharge, May 2017, https://evercharge.com/blog/the-future-of-mobility-long-range-evs/

a. Supportive and favourable policies/mandates across all stages for research and innovation, development, testing and adoption/implementation under formal regulatory framework;

b. Low-cost technology and cost-optimization mechanisms, means to enhance feasibility and decentralized adoption and

c. Continued and proactive research and development in new and easy techniques and tools, building connections between existing and new storage, transmission and distribution infrastructure should be strategically planned for.

This kind of supportive environment also crucially should include attractive, profitable and viable mechanisms like carbon markets, production-linked incentives, user-side incentives, cross-subsidies for innovation, domestic production and adoption of clean technologies/energy. Above all, very important is building a network and platform for knowledge sharing, capacity building and training associated with innovation, piloting and adoption of technologies under a formalized regulatory framework.

Opportunity and Potential of India's G20 Presidency

India's G20 presidency is an opportunity to steer the forum towards greater cooperation on catalyzing climate finance. This opportunity holds the best potential to address and advocate the need for development of taxonomies for smooth cross-border capital flow towards the vulnerable countries, particularly in the global south. India can spearhead the climate finance discussion and be a voice for the global south by bringing various stakeholders to the table to discuss issues of climate-smart Multilateral Development Banks (MDBs) reforms, frameworks for climate-related disclosures, comparable and interoperable taxonomies and alignment of global investors with climate pledges. This platform can be used to explore innovative financing ways like Blended Finance and Environmental-Social-Governance (ESG) in renewable energy infrastructure from the private sector, manufacturing of green technology to create green jobs, and transparent sovereign borrowings from Multilateral Finance Institutions (MFIs). As the host country, India can also leverage this opportunity to spearhead bilateral and triangular cooperation with other member states like

Just Transition- 'Leaving no-one behind'

India's path to decarbonisation will impact the communities that are already part of the workforce and value chains of fossil fuel sectors. This would typically lead to loss of jobs leading to an increase in vulnerability of the communities that are involved. Given the diversity of jobs, livelihood opportunities and their interconnectedness with environmental issues, the path to a just transition is more complicated in a country like India. Along with decarbonisation, a just transition pathway should focus on providing basic amenities, reducing vulnerabilities and building long term resilience. This transition must be carried out in a nuanced manner that incorporates region/state-specific concerns and needs along the process. This would ensure minimal adverse implications the Just Transition pathway will have on all the dependent communities and economies.

Indonesia's Just Energy Transition Partnership (JET-P) and drive in the required sovereign and private investments[5].

India has the opportunity to share its clean energy expertise and products with the member countries. India could also play an effective role in supporting the multilateral goals of advancing research and development to produce affordable renewable energy[5].

The platform provides an opportunity for not only fast-tracking India's clean transitions in hard-to-abate industries domestically and becoming a key manufacturer and supplier of alternative fuels like hydrogen, but also affords the role to facilitate international cooperation on energy transitions and shape the global clean energy mandate going forward[4]. Further, India can establish itself as a facilitator of energy diplomacy as exhibited with the International Solar Alliance (ISA) and use its presidency to foster a spirit of collaboration and encourage sharing of knowledge, information and capacities between and within countries[6]. India could lead the discussions to foster and build a consensus among developed and developing countries to endorse and comply with current climate policies, intensify their implementation and propose targets in consonance with the SDGs. In addition, the country should hold concrete discussions on enhancing cooperation between the developed and emerging market economies to support green growth and a circular economy.

Adaptation needs

Given India's diverse geography, large population and development imperatives, a transition to a low- carbon future must also consider the adaptation needs of the country.

The Indian economy is also known to be dependent on climate sensitive sectors. Climate change will have a differential impact on the vulnerable communities. Therefore, there is a need to mainstream climate adaptation into development.

For example, one of the considerations that can be made is to mainstream adaptation into urban planning. This would involve considerations like- increasing green spaces, climate resilient infrastructure (in building/public infrastructure design, construction & operation), efficient water and waste management systems.

[5] https://thegeopolitics.com/pursuit-of-climate-change-under-indias-g20-presidency/

[6] https://economictimes.indiatimes.com/small-biz/sme-sector/leveraging-indias-g-20-presidency-for-a-new-architecture-on-global-supply-chains/articleshow/95159261.cms