

Sustainable Development, Energy and Climate Change

India continues to undertake and effectively implement a large number of actions relating to energy, environment and climate, in particular, covering renewable energy, energy efficiency, sustainable agriculture, sustainable habitat, water, forestry, Himalayan ecosystem, and knowledge and capacity building. These actions reflect India's commitment to meet (and reconcile) the goals of climate change, sustainable development and energy access. India also expects the international community to be ambitious and fulfil its commitments in accordance with the principles of equity and common but differentiated responsibilities.

SUSTAINABLE DEVELOPMENT GOALS

5.1 The UN Sustainable Development Goals (SDGs) adopted by the international community in September, 2015 comprehensively covers social, economic and environmental dimensions and build on the Millennium Development Goals (MDGs). Notably, the SDGs constitute a universal agreement to end poverty in all its forms and dimensions, including extreme poverty. There are 17 SDGs which have 169 targets to be achieved by 2030. India played an important role in shaping the SDGs.

5.2 Several of the Government's programmes would directly contribute to advancement of the SDG agenda. A noteworthy example is the Pradhan Mantri Jan Dhan Yojana (PMJDY) which is the world's largest financial inclusion programme. While targeting economic growth, infrastructure development and industrialisation, the country's fight against poverty has become fundamentally focussed on social inclusion and empowerment of the poor. Reinforcing India's commitment to the national development agenda and SDGs, the country's Parliament has organized several forums to develop policy and perspectives on elimination of poverty, promoting gender

equality and addressing climate change. India is one of the countries that has volunteered to take part in the Voluntary National Reviews (VNRs) at the High-Level Political Forum (HLPF) 2017. India presented its 1st VNR on implementation of SDGs on 19th July, 2017 in the HLPF at United Nations, New York. The VNR report is based on an analysis of progress under various programmes and initiatives in the country. The VNR report focused on 7 SDGs: 1 (No Poverty); 2 (Zero Hunger); 3 (Good Health and Well-Being); 5 (Gender Equality); 9 (Industry, Innovation and Infrastructure), 14 (Life below Water) and 17 (Partnerships for the Goals).

National SDG Indicators and Baseline

5.3 In the light of the global SDG indicators endorsed by the UN Statistical Commission, the draft national SDG indicators are being developed by Ministry of Statistics & Programme Implementation with inputs from Central Ministries and various other stakeholders and are now at an advanced stage of finalization. Going forward, a monitoring and reporting system will be set up to regularly take stock of the implementation process and generate credible information and evidence on progress of the

SDGs with the base year as 2016. The National Institution for Transforming India (NITI) Aayog's role will be to collect, validate and document best practices in implementation of SDGs for wider dissemination. On a regular basis, progress on SDGs will be tracked through an integrated dashboard.

URBAN INDIA AND SUSTAINABLE DEVELOPMENT

5.4 The SDG 11 states: "make cities inclusive, safe, resilient and sustainable". India is now embarking on a fast rural to urban transition. As cities are the centres of economic activity, how cities deliver on a number of basic services will determine the path and progress of sustainable development. In other words, one of the defining parameters for delivering India's sustainable development agenda will be the development path chosen by urban India.

5.5 According to World Economic and Social Survey, 2013, achieving the sustainability of cities entails integration of four pillars - social development, economic development, environmental management, and effective urban governance. According to the UN World Cities Report 2016, by 2030, India is expected to be home to seven mega-cities with population above 10 million. According to Census 2011, 377.1 million Indians comprising 31.16 per cent of the country's population live in urban areas. India's urban population is projected to grow to about 600 million by 2031. Many Indian cities are now struggling with multiple problems of poverty, inadequate provision of urban services, congestion, air pollution, sizeable slum population, lack of safety measures, and challenges in terms of garbage removal, sewage system, sanitation, affordable housing, and public transport. Government of India has undertaken several measures to improve sustainability of cities, which include the Smart Cities Mission, National Urban Housing & Habitat Policy (2007), Swachh Bharat Mission (Urban), and management of Municipal Solid Waste (MSW) etc. Yet, many challenges

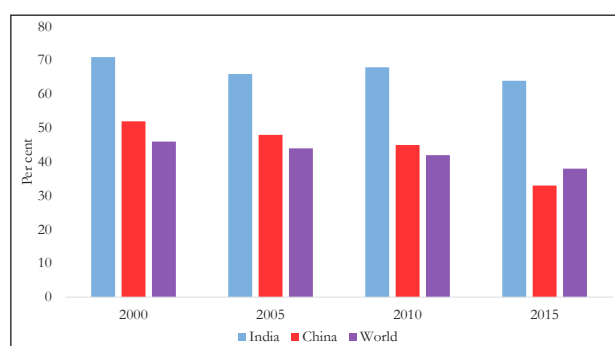
remain. According to the High Powered Expert Committee appointed by the Ministry of Housing and Urban Affairs, about ₹39 lakh crore (at 2009-10 prices) was required for creation of urban infrastructure over the next 20 years. Out of this, about ₹17 lakh crore (44 per cent) was needed for roads and ₹8 lakh crore (20 per cent) for services such as water supply, sewerage, solid waste management and storm water drains. In addition, the requirement for operation and maintenance was separately estimated to be ₹20 lakh crore. Raising resources of this magnitude is going to be a daunting challenge. Besides the average cost recovery is less than 50 per cent in most of the Urban Local Bodies (ULBs). The way forward is to encourage the ULBs to raise resources through various innovative financial instruments such as municipal bonds, PPPs, credit risk guarantees, etc. Example of one such instrument that has been experimented in India worth highlighting is that of municipal bonds. In July, 2015, the Securities and Exchange Board of India (SEBI) notified a new regulatory framework - Issue and Listing of Debt Securities by Municipalities Regulations - for issuing municipal bonds in India. The new regulations allowed for municipal bodies or a corporate municipal entity to issue municipal bonds through private placement or public issue. Municipal bonds can be one among the options for the massive investment requirement in the urban infrastructure. However, the ULBs and the state governments have to bring operational efficiency and financial viability in urban projects.

ACCESS TO SUSTAINABLE ENERGY

5.6 Access to affordable, reliable, sustainable and modern energy is the *sine qua non* of achieving all the SDGs due to its deep inter-linkages with all the other goals. Its importance in achieving economic prosperity is straightforward. However, it is also directly and indirectly linked to other sustainable development objectives such as good health and well-being, gender equality, industry, innovation and infrastructure, sustainable cities and communities. To understand this, consider an example of the linkage between access

to energy and gender equality. This happens through various channels. In India, the burden of collecting fuel wood and water and cooking falls disproportionately on the female members of households. Although, over the years the country has made considerable progress in providing access to households to clean cooking options, the proportion of population without access to clean cooking was around 64 per cent in 2015 compared to a World average of 38 per cent and 33 per cent for China in the same year (OECD/IEA, 2017) (Figure 1).

Figure 1: Share of population without access to clean cooking



Source: World Energy Outlook Special Report: Energy Access Outlook 2017, OECD/IEA, 2017

5.7 The adverse impacts of indoor air pollution also fall disproportionately on women and children who are directly involved in cooking or spend a major portion of their time indoors. According to a study (Watts et.al., 2017), around 4.3 million people die annually worldwide due to household air pollution resulting from the burning of solid fuels. Not only does using inefficient fuels like firewood and dung cakes cause health hazards, they require a considerable amount of time to be devoted for their collection. One of the estimates of the amount of time spent on collecting firewood in India suggests that on an average, women spend around 374 hours every year for collection of firewood (Global Alliance for Clean Cookstoves, 2014). Thus access to

modern energy sources can reduce the amount of time spent on collection of firewood thereby leading to a positive impact on girls' education and employment. According to Lawson (2008), reduction in gender gap in India by half over the period 2008-2017 and then by half again over 2018-2027 would result in a per capita income that would be higher by around 13 per cent in the year 2030, compared to a baseline scenario.

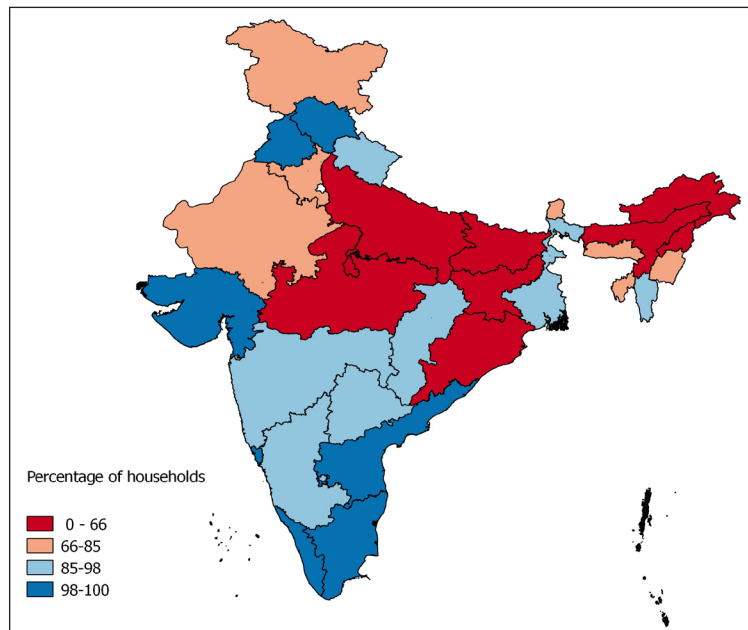
5.8 As reported in the previous edition of the Economic Survey, Government of India had launched "Pradhan Mantri Ujjwala Yojana" (PMUY) in May, 2016 and upgraded it to provide 80 million LPG connections by 2020 to BPL households. Complementing the above scheme, Government has come out with other initiatives namely "Ujjwala Plus" which will address the cooking needs of deprived people who are not covered under the Socio-Economic Caste Census (SECC) 2011. During 2016-17, 3.25 crore new LPG connections were released that includes 2 crore connections released under PMUY. In addition, Government of India is committed to provide 24X7 reliable and quality power supply to all its consumers by 2019. The Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) scheme was launched in 2015 to achieve 100 per cent village electrification and Saubhagya scheme launched on 25th September, 2017, to provide energy access to all by last mile connectivity and electricity connections to all remaining un-electrified households in rural and urban areas to achieve universal household electrification in the country. Out of 18.1 crore rural households in the country, 14.2 crore (78%) rural households have been electrified¹. There are also considerable variations among the different states (Figure 2). Kerala, Tamil Nadu, Andhra Pradesh, Goa, Gujarat and Punjab have achieved 100 per cent electrification of households. In contrast, Bihar, Jharkhand and Nagaland have achieved less than 50 per cent.

1 Saubhagya Portal of Rural Electrification Corporation, retrieved on 16 January, 2018.

5.9 Not only has the government focussed on providing reliable electricity to the common man but also has strived to ensure that the additions are from sustainable sources. As on 30th November, 2017, the total installed capacity of electricity in India was 330860.6 MW out of which 18 per cent was from renewable energy sources. As Figure 3 shows the share of renewables in the total installed capacity has been increasing over the years and the current share is around 3 times what it was in the

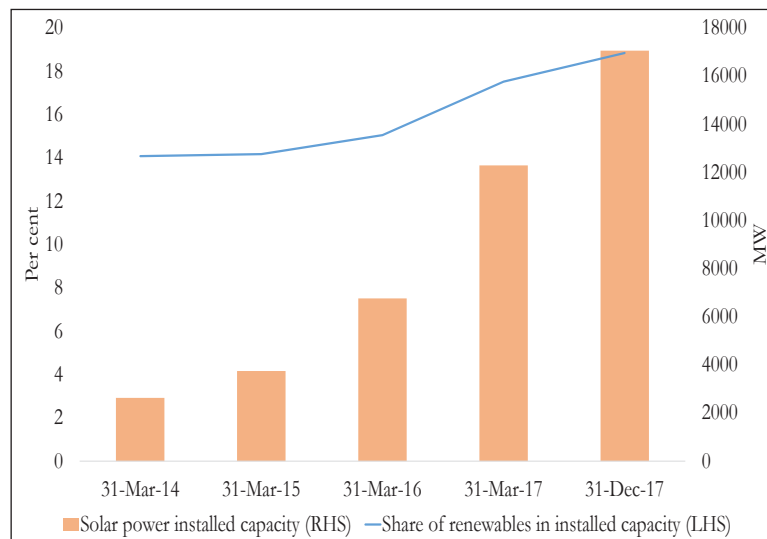
year 2007. Figure 3 also shows the progress made in the installation of solar power in the recent years. Between March, 2016 and December, 2017, the installed capacity of solar power increased from around 6.8 GW to 17 GW. In recent years, India has been witnessing falling solar tariffs. While this has a positive impact on the cost of procuring power, it has also initiated certain discussions about renegotiation of already signed power purchase agreements (PPAs) by certain states (Box: 5.1).

Figure 2 : Percentage of rural households electrified



Source: Saubhagya Portal of Rural Electrification Corporation

Figure 3 : Progress of Renewables in India



Source: Ministry of New and Renewable Energy

Box 5.1 : Discussions around Renegotiation of PPAs by certain states

PPA is a contract between purchaser of electricity and electricity generator setting out the terms and price for supplying electricity. Earlier, tariffs were fixed by state electricity regulatory commissions based on which PPAs were made with power generators. In the case of renewable energy, state electricity regulatory commissions set the Feed-in Tariffs for the purchase of electricity from these sources. PPAs were signed based on these pre-determined prices for a number of years. One of the key objectives of the Electricity Act, 2003 is promotion of competition in the electricity sector. Section 63 of the Act specifies that notwithstanding anything contained in section 62, the Appropriate Commission shall adopt the tariff if such tariff has been determined through transparent process of bidding in accordance with the guidelines issued by the Central Government. A tariff order shall, unless amended or revoked, continue to be in force for such period as may be specified in the tariff order. The revised tariff policy was published in January, 2016.

The recent auctions for solar power procurement have led to discovery of very low tariffs (Figure). Auctions for wind based power were first held by Solar Energy Corporation of India in February, 2017 which realised a tariff of ₹ 3.46/unit. This is much lower than the lowest feed-in tariff for wind at ₹ 4.16/unit. Second wind auctions were conducted in October, 2017 where the tariffs again touched a historic low level of ₹ 2.64/KWh. The discovery of very low tariffs through the auctioning process, though a welcome news, possibly contributed to some demands for renegotiation of the already signed PPAs. Some discoms have hinted at the possibility of renegotiating the PPAs signed by them at tariffs higher than those in the recent bids. According to CRISIL (2017), renegotiating the tariffs could result in risk for investments worth ₹ 48000 crore.

Figure: Solar Tariffs



Renegotiation of PPAs are likely to face tough resistance from the developers and may result in legal battles. This introduces uncertainty for the sector and banks which are already facing the issue of NPAs, may become apprehensive of lending to the sector in the future. There are cases where the developers have already made huge investments into renewable energy projects based on the expected stream of revenue. One of the principal expectation from the Government is the enforcement of PPAs. This is especially crucial considering the government's ambitious target of achieving 175 GW of renewable energy by 2022.

Making the term of future PPAs shorter may not be desirable as it could only increase the cost of capital without much gains. Affordable financing holds the key for financing sustainable energy projects. Risk mitigating instruments such as payment guarantee fund or a foreign exchange fund available to developers could be a way forward.

The Government, so far, has played an active role in promoting the adoption of renewable energy resources by offering various incentives, such as generation-based incentives, capital and interest subsidies, VGF, and concessional finance. Renewable energy has been placed under the priority sector lending and the bank loan for solar roof-top systems is to be treated as a part of home loan/home improvement loan with subsequent tax benefits. Currently, the levelised tariff is approaching grid parity. There is a case for revisiting the subsidies and incentives being given to the renewable energy sector.

5.10 Also important is the efficient and effective use of energy resources. As a move in the direction of efficient energy use, the Ministry of Finance has issued guidelines for mandatory installation of energy efficient appliances in all Central Government buildings across India. Buildings Energy Efficiency Programme was launched in May, 2017 which is being implemented by Energy Efficiency Services Limited (EESL). Under this scheme, EESL is likely to retrofit about one crore LED lights, 15 lakh energy efficient ceiling fans, and 1.5 lakh energy efficient ACs in more than 10,000 government and private buildings by the year 2020².

INTERNATIONAL SOLAR ALLIANCE (ISA) ENTERED INTO FORCE

5.11 ISA, which was launched by Shri Narendra Modi, Hon'ble Prime Minister of India and Mr. François Hollande, former President of France on 30th November, 2015 in Paris, entered into force on 6th December, 2017. As per Article XIII (1), the ISA Framework Agreement (FA) has entered into force on 6th December, 2017, on the thirtieth day after the date of deposit of the fifteenth instrument of ratification, acceptance or approval. With ISA FA's entry into force, ISA has become a *de jure* treaty-based International Intergovernmental Organization. ISA is the first International intergovernmental treaty-based organization headquartered in India (Gurugram, Haryana). As on date, 46 countries have signed and out of these, 19 countries have ratified the ISA Framework Agreement (Figure 4).

5.12 ISA is a coalition of solar resource rich countries lying fully or partially between the Tropics of Cancer and Capricorn and aims to specifically address energy needs by harnessing solar energy. The Paris Declaration establishing ISA states that the countries share the collective ambition to undertake innovative and concerted efforts for reducing the cost of finance and cost of technology for immediate deployment of solar generation assets. This will help pave

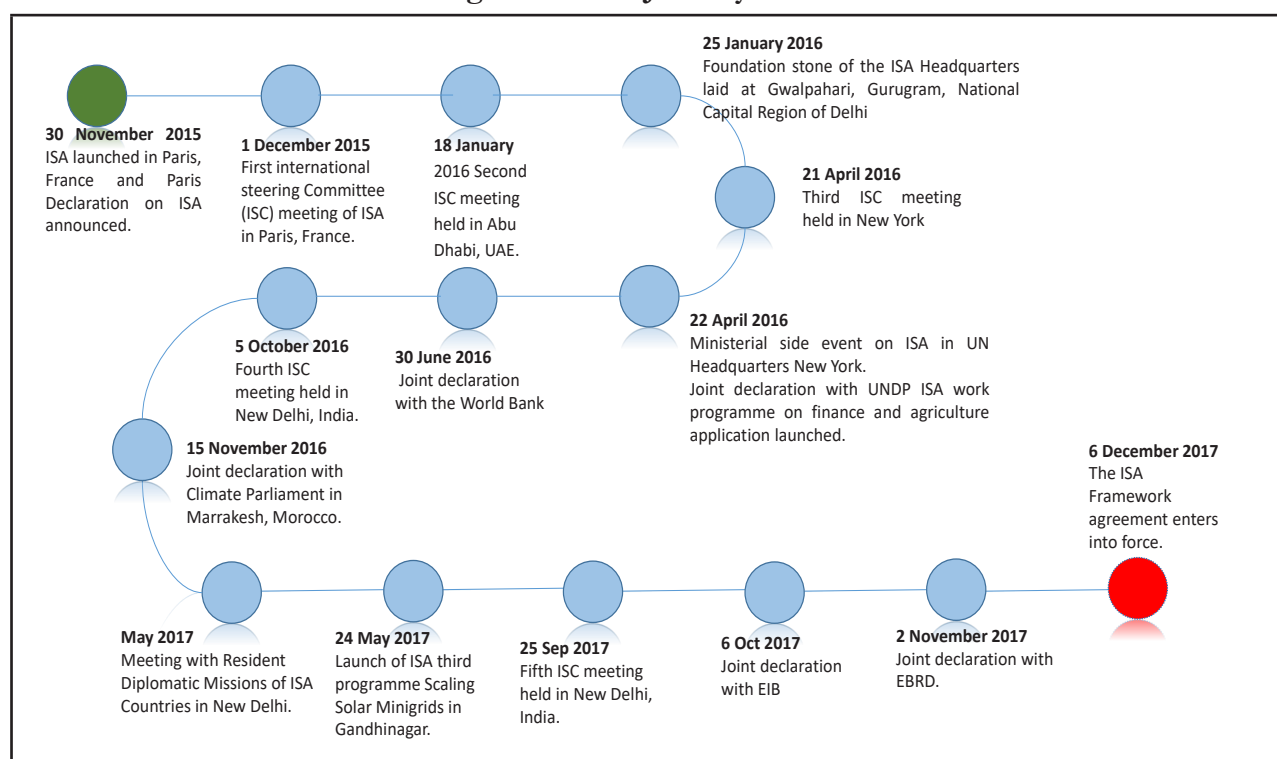
the way for future solar generation, storage and good technologies for each prospective member country's individual needs by mobilizing more than US \$ 1 trillion dollars in investments that will be required by 2030.

5.13 Government of India has made a provision of ₹100 crore as one-time fund for ISA Fund corpus. In addition, a recurring expenditure grant of ₹15 crore per annum for the period 2016-17 to 2020-21 has also been committed by India for meeting ISA's day to day expenditure and meeting cost of outreach events etc. On the request of the ISA, the Government of India has earmarked around US \$ 2 billion Line of Credit (LoC) to the African countries for implementation of solar and related projects out of its total US \$ 10 billion LoC under the Indian Development and Economic Assistance Scheme. Also as a founding member of the ISA, Government of France through the *Agence Française de Développement*, has also offered €300 million for solar projects across ISA member countries. ISA will similarly persuade other countries to contribute to the cause of solar deployment globally.

5.14 Presently ISA has three programmes Scaling Solar Applications for Agricultural Use, Affordable Finance at Scale and Scaling Solar Mini-grids. In addition, ISA plans to launch two more programmes on Scaling Solar Rooftops, and Scaling E-Mobility & Storage. Strategic and financial partnerships have been entered into with the UNDP, the World Bank, EIB, EBRD and the Climate Parliament to further the mandate of ISA. The United Nations including its organs are ISA's strategic partners. ISA is also developing "Common Risk Mitigating Mechanism" (CRMM) for de-risking and reducing the financial cost of solar projects. An international expert group has been working on the blue print of the mechanism. Another major initiative of ISA includes establishment of Digital Infopedia which serves as a platform to interact, connect, communicate and collaborate with one another. ISA also plans to administer global awards for solar R&D, applications and innovative financing. The State

2 <http://pib.nic.in/newsite/mbErel.aspx?relid=169896>.

Figure 4: ISA's Journey so far...



Government of Haryana has agreed to institute Kalpana Chawla Solar Award for the women Solar Scientists doing extraordinary work across the 121 ISA prospective member countries. The Haryana Government has been a trendsetter in this regard and has granted ₹10 crore to institute the award.

5.15 ISA is a trillion-dollar opportunity in solar. Economy and industry in turn can benefit from the business opportunities available across 121 ISA member countries.

INDIA AND CLIMATE CHANGE

5.16 India's climate ranges from continental to coastal, from extremes of heat to extremes of cold, from extreme aridity and negligible rainfall to excessive humidity and torrential rainfall. The rainfall in India shows great variation, unequal seasonal and geographical distribution and frequent departures from the normal. Temperature variations are also notable in the Indian sub-continent. The annual mean, maximum and minimum temperatures during the period 1901-2010 for India, show a significant increasing

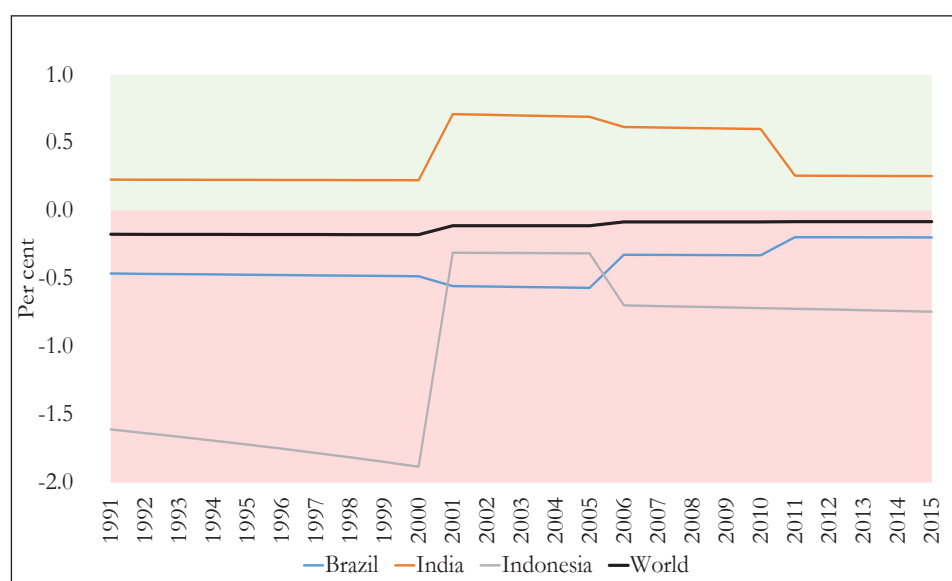
trend of 0.60°C, 1.0°C and 0.18°C per hundred years, respectively. For the 1981-2010 period, the mean, maximum and minimum temperatures increased almost at an equal rate of around 0.2°C per decade, which is much higher than the trends for the period 1901-2010. Daily rainfall observations during the period 1901-2004 indicate that the frequency of extreme rainfall events (rain rate > 100 mm/day) has a significant positive trend of 6 per cent per decade. Hence, it is no surprise that India takes the challenge of climate change seriously. India has always engaged constructively at the multilateral level under the United Nations Framework Convention on Climate Change (UNFCCC) and India is now actively engaged in the efforts towards developing guidelines for effective implementation of the Paris Agreement on climate change.

5.17 Domestically, India has launched various policies and set up institutional mechanisms to advance its actions. Government of India is implementing the National Action Plan on Climate Change, which includes eight national missions covering solar, energy efficiency, agriculture, water, sustainable habitat, forestry, Himalayan

ecosystem and knowledge, apart from various other initiatives. These actions reflect its commitment to address climate change. Key initiatives and progress in various areas include:

- As part of the mission on strategic knowledge on climate change, India has established 8 Global Technology Watch Groups in the areas of Renewable Energy Technology, Advance Coal Technology, Enhanced Energy Efficiency, Green Forest, Sustainable Habitat, Water, Sustainable Agriculture and Manufacturing.
- The broad policy initiatives of the central government are supplemented by actions at the sub-national levels. 32 States and Union Territories have put in place the State Action Plans on Climate Change attempting to mainstream climate change concerns in their planning process.
- Climate Change Action Programme, launched in 2014 with an objective of building and supporting capacity at central & state levels, strengthening scientific & analytical capacity for climate change assessment, establishing appropriate institutional framework and implementing climate related actions has been extended for the period 2017-18 to 2019-20 with a budget outlay of ₹132.4 crore.
- National Adaptation Fund on Climate Change established in 2015 to support concrete adaptation activities which are not covered under on-going activities through the schemes of State and Central Government, continues till 31st March 2020 with financial implication of ₹364 crore.
- India is one of the few countries where, despite ongoing development, forest and tree cover has increased transforming country's forests into a net sink owing to national policies aimed at conservation and sustainable management of forests. India's growth in the forest cover has been in the positive territory while that for Indonesia and Brazil, which are countries with substantial forest cover, the growth has been in the negative territory during the same period (Figure 5).

Figure 5: Annual change in forest cover (per cent)



Source: World Development Indicators, World Bank

- Pradhan Mantri Krishi Sinchayee Yojana has been formulated with the vision of extending the coverage of irrigation and improving water use efficiency.
- Second Phase of Science Express Climate Action Special train with the aim to create awareness among various sections of society, especially students, on the science of climate change, the observed and anticipated impacts, and different possible responses as to how climate change can be combated.
- Zero Effect, Zero Defect is a policy initiative to enhance energy efficiency and resources efficiency in Medium & Small Industries.
- The National Mission for Clean Ganga seeks to rejuvenate the river along its length of more than 2,500 km.
- Indian financial market also moved in the direction of greener actions. SEBI issued the circular on the disclosure requirements for Issuance and Listing of Green Debt Securities on 30th May, 2017. The utilisation of the proceeds shall be verified by the report of an external auditor, to verify the internal tracking method and the allocation of funds towards the project(s) and/or asset(s), from the proceeds of Green Debt Securities.
- In the Union Budget 2017, government indicated to increase the coverage under the Pradhan Mantri Fasal Bima Yojana (PMFBY) from 30 per cent to 40 per cent in 2017-18 and 50 per cent in 2018-19.
- In February, 2017, India launched the world's first interoperable Quick Response (QR) code

acceptance solution. It is a sticker pasted on the teller counter wall of the merchant and can be generated dynamically on merchant itself, removing the need to even print. By providing the Bharat QR option, India is taking the right step in the direction of greener and sustainable future.

CURRENT MULTILATERAL NEGOTIATIONS ON CLIMATE CHANGE

5.18 Currently, the multilateral climate change negotiations are primarily focused on framing the rules and regulations for implementing the Paris Agreement. The task of finalizing the rules for implementing the Paris Agreement began in Marrakech, Morocco in 2016 (COP 22). Parties agreed that they would complete and finalize the rulebook by December, 2018 (COP 24). At COP 23, the Parties advanced the work programme under Paris Agreement.

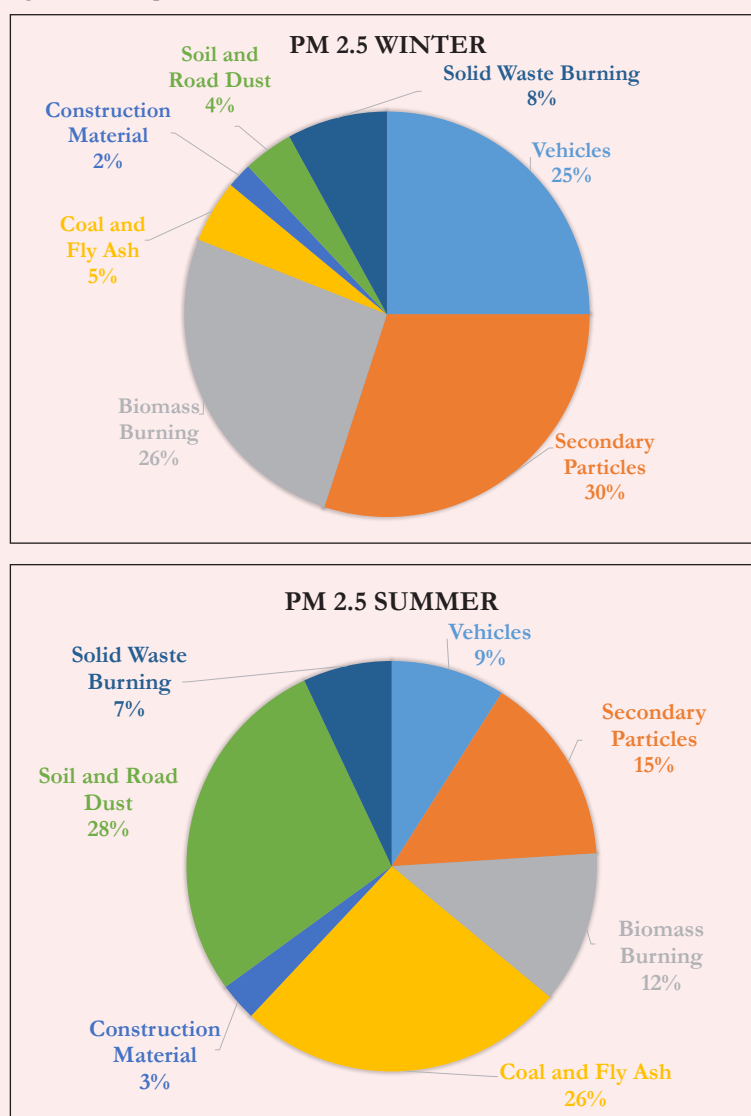
5.19 Key takeaways for India from COP 23 have been that the agenda of pre-2020 climate change commitments and implementation has found a significant place in COP 23 outcome in the form of a decision with steps for future action on pre 2020 action and ambition. This decision emphasizes that enhanced pre-2020 actions can lay a solid foundation for enhanced post-2020 ambition. India has been able to preserve differentiation in informal notes/texts on various elements of Paris Agreement work programme including nationally determined contributions, adaptation communication, transparency framework, global stocktake, compliance, technology framework, finance and capacity building prepared for further work on rules, modalities and guidelines for Paris Agreement.

Box 5.2 : Air Pollution in Delhi -- Possible Solutions.

In recent years, the National Capital Delhi and adjoining areas have experienced alarmingly poor air quality starting winter. The farmers mainly from Northern India set their paddy fields on fire after harvesting. The resultant smoke, however, gets carried by winds all the way to Delhi and beyond, adding to the existing suspended particulate matter (SPM) and noxious substances that clogs lungs and leaves behind a near eclipsed sun.

In fact, a number of reasons cause the massive spike in suspended particulate matter (PM 2.5, being the most dangerous) during winter in this part. In 2016, it surpassed $1,000\mu\text{g}/\text{m}^3$ making Delhi one of the unhealthiest cities in the world in terms of air pollution (IIT Mumbai, 2016 and others). Generally, also, the annual average PM 2.5 levels remain about 3 times higher than the prescribed standards. A combination of reasons, among which crop burning in the adjoining states plays a major role, piling on top of one another, in a dense urban concentration of a massive and growing capital city renders this region in a serious hazardous state. The solution? Addressing each source problem, systematically, one-by-one, coordinating across agencies and governments, and with sustained civic engagement (TERI, 2016)—as Mexico City has been doing since 1980s ('Proaire' package). London's Great Smog in 1952 spurred similar action and the Clean Air Act of 1956.

IIT Kanpur reported results earlier from a two-season study (summer and winter 2015)--whose approximate attributions to source, are noted in the diagrammatic representation below.



Source: IIT Kanpur, 2015

It is imperative to address the proximate 4 top reasons for Delhi's worsening air quality, especially in winter, about 30-40 per cent of which comes from outside the NCR region (crop residues, biomass, industries and power plants) (TERI, 2016 and CPCB 2017):

- i. **Crop residue, biomass burning (26-29 per cent).** Some 35 million tons of rice-paddy stubble in 10 million ha, in 3 adjoining states (Punjab, Haryana and Western Uttar Pradesh), burnt in late October, and whose plumes drift eastward, and seasonal load from other sources, including fire-cracker burning during Diwali (banned in 2017 by the Supreme Court, which saw a notable decrease as a contributory factor). Crop residue burning is a practice that came with combine harvesters — machines that harvest, thresh and clean the separated grain at one go. It takes barely an hour and ₹ 1,000-1,500 to cover an acre of paddy using combines. The same job through traditional sickle-harvesting and manual threshing-cum-cleaning requires about 10 men working a full day, and costing ₹ 4,500 or upwards. But combine-harvesting also leaves behind 14-15-inch long stalks in the fields that farmers have to, then, find a way to get rid of. This is to reduce the cost of disposing off the stubble.
 - a. According to a 2014 study by the Indian Agricultural Research Institute (IARI), in 2008-09 the country generated 620 million tonnes of crop residue, of which around 16 per cent was burnt on farms. Of which, 60 per cent was paddy straw, whereas wheat accounted for just 22 per cent. As per estimates, Punjab alone produces 19-20 million tonnes of paddy straw and about 20 million tonnes of wheat straw. About 85-90 per cent of this paddy straw is burnt in the field, and, as the satellite images show, wheat straw is also increasingly being burnt in recent years.
 - b. IARI report also shows that the main reasons for burning crop residues in field include unavailability of labour, high cost in removing the residues and use of combines in rice-wheat cropping system especially in the Indo-Gangetic plains (IGP). Primary crop types whose residues are typically burned include rice, wheat, cotton, maize, millet, sugarcane, jute, rapeseed-mustard and groundnut. Farmers in northwest India dispose a large part of rice straw by burning *in situ*. Wheat crop residue burning is emerging as a major issue in districts where irrigation is not a concern, cropping patterns are intense and mechanised farming options are abundant. Increased irrigation network has resulted in acreage and thus proportionate increase in residue burnings as well.
 - c. The usage of combine harvesting machines appear to be an important reason because it only reaps the grains, leaving stalks or stubble of around 40 cm. Removing the stubble manually or by using specialised machines to do the job is costly. For every 0.4 ha of wheat crop, the cost of renting a combine harvester is just ₹ 800. Once the machine has harvested, the cost of getting the stubble removed is ₹ 3,500/ha. So the value of fodder is discounted because it is more economic for the farmers to just burn by using one Rupee match box and clear the fields.

On December 10, 2015, the National Green Tribunal (NGT) banned crop residue burning in states of Rajasthan, Uttar Pradesh, Haryana and Punjab. Parts of these states constitute the National Capital Territory. Earlier in 2014, the Union government had released the National Policy for Management of Crop Residue, which NGT directed the states to implement. Under this policy each state needs to have an action plan to stop residue burning by involving people at different levels—from communities to panchayats to state governments. It also calls for a mechanism to alert to cases of crop burning. Moreover, crop residue burning is punishable under the Air (Prevention and Control of Pollution) Act, 1981.

- ii. **Vehicular emissions (23-28 per cent) and redistributed road dust (20-27 per cent).** From trucks, buses, cars, three-wheelers and two-wheelers. Diesel particulates have higher share in the vehicular category and are especially dangerous.
- iii. **Massive construction, power plants, industry, other (19-35 per cent).** Dust particles from construction activity, concentrated in and neighbouring NCR areas. This is further compounded by power plants and industrial pollution.
- iv. **Winter temperature inversion, humidity and (absence of) wind.** Falling air temperature and inversion that locks particulates near the ground, compounded by relative absence of wind. The Central Pollution Control Board (CPCB) reported that 2017 saw worse meteorological conditions compared to 2016 during peak pollution episode in early November, although the banning of fire-crackers caused a significant drop in air pollution compared to last year.

A menu of effective actions has been suggested (National Green Tribunal and Supreme Court decisions; TERI, 2016; Indicus Foundation, 2017, and others), some of which have begun:

Short-Term Emergency Plan (when 24-hourly PM_{2.5} exceeds 300-400 µg/m³): Strict enforcement through heavy penalties on agricultural waste burning using satellite based tools detecting fires, and mobile based applications in NCR; and incentive payments to farmers, coordinated across states and NCR.

Medium and Long-Range Actions: Implement congestion pricing for vehicles, expand and improve public buses dramatically to reduce private vehicle use, and for connectivity to and beyond metro. Phase-out old vehicles, accelerate BS-VI (already notified and to be commenced from 2020), and expand modernized bus fleets.

Use technologies to convert agricultural waste into usable concentrated fodder or bio-fuels, develop and implement business models with private sector and communities and incentivize shift to non-paddy crops. In other words, explore the business cases for finding uses for the crop residues such as manure to reduce fertilizer cost, generate power so that economic values could be assigned. One such example is the straw management system for rice and wheat farming. A technology called Happy Seeder machine could be a possible technological solution. It is a machine that sows seeds without the need to remove paddy straw and works well when the straw is spread evenly on the field through the straw management system. The technological solution has to be combined with the economics of it by further incentivizing by the Centre and States and implemented through agricultural cooperatives, local bodies etc.

WAY FORWARD

5.20 The Global Climate Risk Index 2018 has put India amongst the six most vulnerable countries in the world. Given that a sizeable population under poverty live in areas prone to climatic shifts and in occupations that are highly climate-sensitive, future climate change could have significant implications for living standards. At the same time, the effect of climate change will vary significantly depending on the level of exposure and the inherent adaptive capacities of individuals, households, and communities. India's efforts on sustainable development and climate change have ensured several positive outcomes. There are immense financial requirements to fulfil the commitments. Yet, climate change has been given high importance in policy decisions. The Fifteenth Finance Commission Terms of Reference outlined climate change as an important aspect for consideration.

5.21 The obligations of the provision of the long-term climate finance under the multilateral climate regime have not been fulfilled in any meaningful way. To allay such uncertainties on funding in the coming years, it is necessary for developed countries to be compliant on their commitments based on historical responsibilities and the principle of equity and common but differentiated responsibilities. Acting upon their fair share of responsibilities by each nation would provide the pathway of low carbon climate resilient development for our Planet.

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