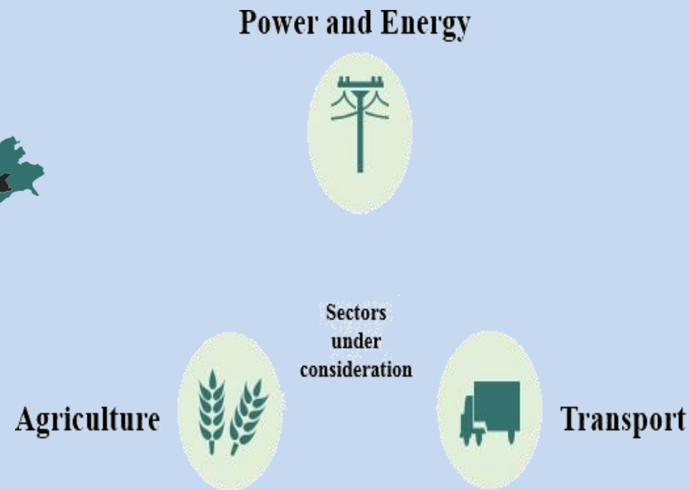
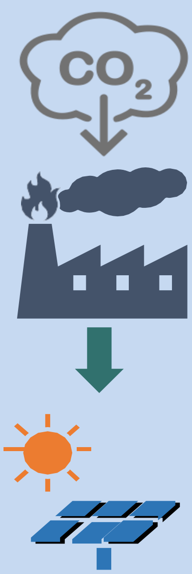


ENABLING STATE LEVEL STRATEGIC ACTIONS FOR INDIA'S NDC

STATE SELECTION REPORT



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1. Introduction

The broad goal of the proposed study is: 1) to identify state-level low carbon growth strategic policy options for selected states to help achieve India’s NDC targets, 2) to suggest market-based solutions and business models that facilitate implementation, and 3) to promote shared learning dialogues through state-level stakeholder consultations/meetings and expert workshops at state and national levels. To achieve this objective, three states were selected for the intensive case study and to come up with the state level strategy and solutions which could be implemented by various other states. It is useful to put our selection of states in the national background.

Climate change is a global challenge posing varied consequences to all nations across the world. It poses an additional challenge to developing countries already struggling to achieve development and uplifting people out of poverty. The gravity of climate challenges has been intensifying over the years and is very much evident in the form of extreme weather events, natural calamities, etc. Prior to the Conference of the Parties (COP21) meeting in Paris 2015, UNFCCC (United Nations Framework Convention on Climate Change) solicited commitments from countries across the globe to support the new international climate agreement. Under this agreement, countries have agreed to publicly outline their NDC (Nationally Determined Contributions) towards a reduction in emissions and follow a low-carbon path for climate-resilient future. Gradually, developing countries have assumed greater responsibilities to meet global climate commitments. India conscious of the need for sustainable development has submitted its NDC within the framework of 8 quantitative and qualitative goals. The NDC Goal 3, is to reduce the emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level. NDC Goal 4 pledges to achieve 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of the transfer of technology and low-cost international finance including from Green Climate Fund (GCF). Past modelling studies by IRADe have shown that these NDC’s targets are achievable albeit with some costs using the figures for technology costs prevalent then and assuming cost reduction trends to continue (Parikh , Parikh , & Ghosh , 2010) (Parikh , Parikh, Ghosh , & Khedkar, Maps India study on poverty and low carbon strategy, 2012). A few modelling studies have also explored India's technology options for exploring emission reduction scenarios (Loulou, Shukla., & Kanudia, 1997) (Rana & Shukla, 2001) (Parikh & Ghosh, 2009).

India, the second biggest country in the world by size of the population (Census, 2011), is facing highly complex economic and social challenges. Despite being the fastest growing economy, it has a significant proportion of poor people. They are dependent on most vulnerable sectors viz. agriculture and services. They are severely hit from the impacts of climate change. Given the climate risks, India is taking various steps towards climate mitigation as well as adaptation. In recent years, the Central Government of India has developed a range of policies, plans, and targets to meet India's NDC commitment while supporting the country's long-term development agenda. India has one of the most ambitious targets of 175 GW renewable power generation capacity by 2022. The renewable target set by the central government has been allocated to the state governments for implementation.

India follows multi-level climate governance where states play an important role in climate action planning and especially in the production of renewable energies. The newly emerging literature about climate policy in India laid a strong focus on the national level plans (Atteridge , Shrivastava , Pahuja , & Upadhyay , 2012). This is because India has been following a strongly centralized federal system and a traditionally dominant decisive role of the national government. However, the recent experiences point to the importance of actions at the subnational regions (states) in the formulation and implementation of climate policies (Jörgensen , April 2012). The International subnational climate research also gives evidence of the pivotal role subnational states play in climate policy-making and implementation.

In India's system of governance, sectoral policy decisions lie either solely with the central government or the state government and sometimes jointly with both. Therefore, several policies formulated by the central government require state-specific actions. Recent experience has shown that not all states are able to attain the goals set by the central government due to state specific limitations. Therefore, states need to design their policies that are compatible with their priorities and resources. (Ghoshal & Bhattacharyya, April 2008), estimated State level carbon dioxide emissions of India from 1980-2000 and found that coal is the most important source of CO_2 in all the states. They observed an inverted U-shape relationship between per capita gross state domestic product and CO_2 emissions. Thus it is essential to consider state-level policies if India is to achieve its NDC targets.

India is a vast country comprising of 29 states with each state varying socially, economically, and demographically and the endowment of natural resources. Impact of climate change may vary across states, sectors, locations, and populations. Given the time and resource constraints, this study proposes to consider three selected states of India for intensive study.

The states are selected in such a fashion that they are representative of other Indian states. To be representative, we propose to select one relatively well developed and fast-growing state, one relatively poor state but a developing state and one Himalayan or north eastern state. In selecting the state from each category, we considered the three main sectors whose contribution to emissions are substantial, namely, electricity, transport, and agriculture.

To formulate a strategy to reduce the overall emission intensity of the economy, understanding of existing intensities and trends of GHG emissions from different sectors is critical. Electricity generation is one of the significant contributors to CO2 emissions. It contributed 48 percent of total CO2 emission followed by 9.9 percent by the transport sector in the year 2010 (Garg, Shukla, Kankal , & Mahapatra, 2017). The past trends indicate that the growth of emissions from these sectors has been very high. Power sector contributed 34 percent to national CO2 emission growth during 2005–2013 followed by road transport, which contributed 14 percent (ibid). In 2013 of the total fossil fuel based electricity generation mix, 71.1 percent came from coal, 7.5 percent from natural gas, and 0.24 percent from diesel (CEA, 2014), Coal is responsible for high emission from power generation sector. Coal-fired units are the largest CO2 emitters. More than 66 percent of the total coal consumption in India is by power generation sector only. The transport sector consists of road transport, railways, aviation, and water transport. Emissions in transport sector depend on the consumption an array of fuels, such as diesel, petrol, coal, aviation turbine fuel (ATF), kerosene, light diesel oil(LDO), fuel oil (FO), compressed natural gas (CNG) and liquefied petroleum gas (LPG). Of the total commercial energy consumed by the transport sector diesel takes the lion's share followed by petrol and ATF. The low share of public transport facility in intra-city transport and a high share of road transport in freight transport are the crucial factors leading to increasing transport sector emissions. Irrigation through pump sets are energy intensive approximately 6 percent of India's GHG emission is attributed to groundwater irrigation (Shah, 2009). In 138.11 million operational holdings estimated by Input Survey 2011-12 in the country, 38 percent of holdings are using pump sets (diesel/electric) for irrigation, and merely 2.5 percent use sprinklers. In India, 30 million and 22 million operational holdings by major agricultural holding size group are using a diesel engine, and electric engine pump sets respectively for irrigation.

Power, agriculture, and transport are vital developmental sectors that are likely to grow and contribute to India's future Greenhouse Gas (GHG) emissions. These sectors are also critical from the climate perspective are considered for a detailed study on select states to come up with effective state-level action plans consistent with national NDC targets.

This Report is organized as follows: section 2 is a comparison of Indian states for each sector to select the three representative state for detailed study. Section 3 provides detailed accounts of sectoral emissions profiles of selected states. Section 4 provides a profile of selected states, and finally, section 5 presents the study's way forward.

2. Interstate comparison methodology

The broad objective is to identify socio-economic and emissions profile of states which could be considered as representative for other states to implement the low carbon pathways. For inter-state comparison analysis, we consider state-wise statistics related to the level of economic indicators, GHG emissions, sectoral energy requirement, and pro-activeness of the state government to implement low carbon growth pathway. The schematic diagram presented in figure 1 explain the inter-state comparison methodology adopted for this study.

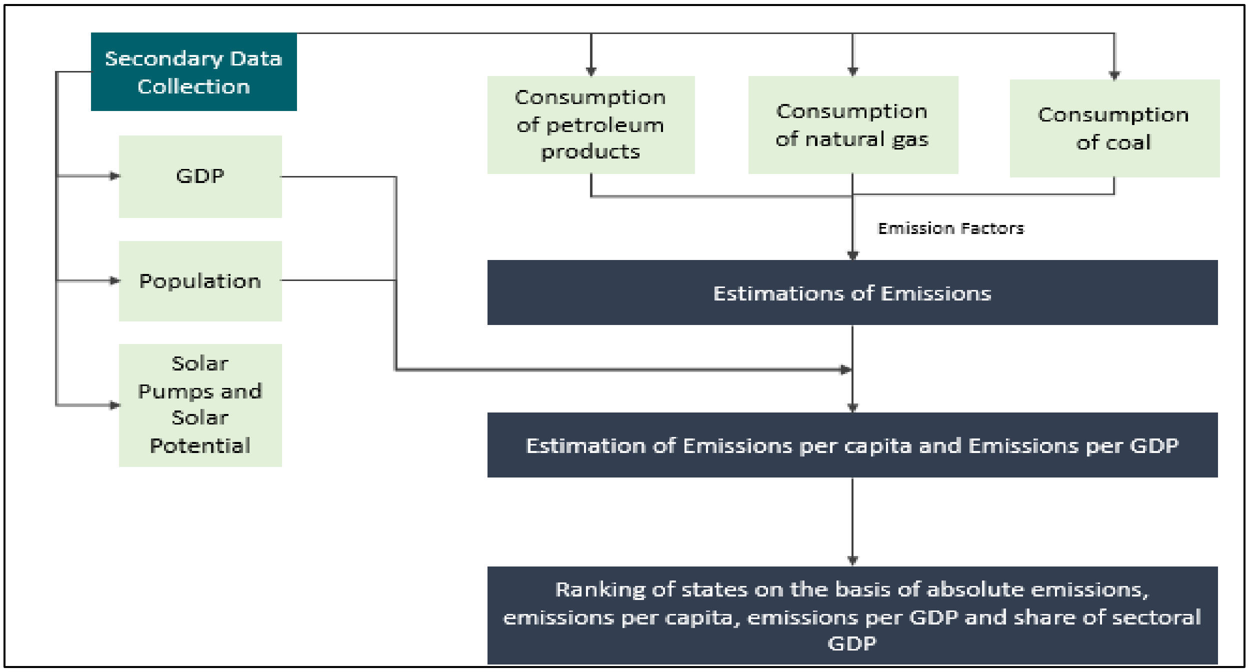

Figure 1: Schematic diagram of the state selection methodology

Considering the development priorities, geographical constraints, and size of the economy, states are clustered into two groups 1) North eastern and Himalayan states and 2) other major states. This classification is primarily done considering the geographic landscape and availability of resources in the Himalayan states. Further, based on the GDP per capita criteria, other major states have been divided into two groups: 1) 'High-Income states' -States with the GDP per capita higher than 1 lakh and low-income states and 2) States with per capita income less than 1 lakh. Finally, states have been divided into three groups 1) Himalayan and Northeastern states, 2) High-income states and 3) Low-income states.

Three states, one from the Northeastern and Himalayan clustered and two states one each from high income and low-income states groups need to be selected for extensive analysis.

2.1 Economic Indicators

Gross State Domestic Product (GSDP) per capita: is an important indicator of the size of the economy or an estimate of the volume of economic activities taking place in the economy. We have used GSDP 2017-18 at 2011-12 prices provided by MoSPI (Ministry of Statistics and Programme Implementation) and projected population of 2017-18 provided by United Nations Population Estimates division to estimate per capita GSDP. To get a better representative picture the analysis considers only major states of India. States having a small share in total national GDP such as Goa, or centrally administered states such as Chandigarh, Puducherry, etc. are not considered for the analysis.

Sectoral GSDP: State GDP is used to capture the economic structure and energy demand by state. Considering the study objective, for this analysis, we have chosen three sectors or subsectors such as 1) agriculture, forestry, and fishing, 2) electricity, and 3) transport.

Population: Population is an important demographic indicator to estimate demand requirement (Power, energy, water, mobilization, etc.) of a state. This will significantly influence the emission profile of a state. For this analysis, we have considered the projected population for the state.

2.2 GHG Emissions

Total Emissions: total emission of a state depend on many factors such as the structure and size of the economy, population, availability of fuel types, etc. The total emission of the state due to the consumption of energy sources such as petroleum products, and natural gas is publicly available but state wise consumption of coal is not readily available and needs to be compiled from secondary sources. Therefore, for this analysis, the estimation was done using the estimation methodology discussed in section 2.5.

Emissions per capita: a useful way to compare contribution to emissions across states is to divide the total emissions by state population and examine them on a per capita basis. Population contribute energy consumption and therefore to variation in emissions from a state. A state having high population size and density pattern would require more resource than a state having low population size and density. The emission per capita is calculated as the amount of emission measured in tonnes of CO2 divided by the total population of the state.

Emission Intensity of GDP: reducing emission intensity of GDP is one of the crucial goals of India's NDC targets. Emission intensity reduction at the national level would require corresponding emissions intensity reductions of each state also. This indicator plays an important role in identifying the states, which have high emissions, requires support and immediate action to reduce GDP emission intensity. The emission intensity of GDP of a state is calculated as the number of emissions per unit of economic output or, specifically, tonnes of CO2 per million rupees of a state's gross domestic product (GDP).

2.3 Sectoral Analysis

Power and Energy: Power Sector emissions by states are compiled from published literature and respective government agencies. Emissions from electricity generation for coal, gas, and diesel based thermal power plants were computed based on the total consumption of this feedstock.

For renewable energy Ministry of New and Renewable Energy Resources (MNRE), the government of India has come out with a detailed state-level target to be archived by the year 2022, which is based on states potential and resource endowments for different energy sources.

Agriculture: Within the agriculture sector, this study focuses on the energy requirements for irrigation. The study focusses on total energized pump and potential to convert those pumps into the solar pump. There is currently a high penetration of diesel pump for irrigation. Small and fragmented land holdings in most of the Indian states, fall in water tables in several states and lack of continuous electricity supply are responsible for high penetration of diesel water pumps.

Agricultural residue burning, livestock and rice cultivation are three important activities, which contribute to carbon emission from the agriculture sector. However, accounting for these, emissions are beyond the scope of this study.

Transport: Emissions in transport sector depends on fuel consumption, which in turn depends on the stock and mix of on-road vehicles by mode. The state-wise growth of on-road vehicles and the changing mode wise mix will help in understanding future mobility preference. Supply-side interventions like emission standards, fuel standards, Gas based vehicles, EVs and hybrid vehicles reduce fuel consumption. Demand-side measures like the shift to public transport and the use of non-motorized transport and measures to reduce transport demand reduces fuel consumption. Higher the fuel consumption, higher is the potential for implementation of these measures in the states transport sector to reduce the emissions intensity of GDP. Thus fuel consumption is a key indicator of the sector to understand the present scenario and possible intervention areas for the low carbon strategies.

2.4 Willingness of State government

Above all the techno-economic parameters, the willingness of the state governments is an important consideration for state selection. Political will gives an assurance of support from the government authorities and officials for the data and information. Additionally, the main aim of the study is to promote implementable business models, which can only be achieved with the support from the government and its machinery. Therefore, the willingness of administration in the pilot state is vital for the success of this project. To gauge the state willingness, a detailed dialogue with state-level officials and another stakeholder from the state will be carried out about the study goals and objectives. Post an initial discussion with local stakeholder's extensive state-level stakeholder consultations comprising government officials, academicians, and civil societies will be carried out in each of the selected states to incorporate stakeholders view at the outset of the project.

2.5. Estimation of emission

Emissions from fuel combustions are estimated by multiplying the amount of fuel used with a fuel-specific emission factor. For each type of fuel, the emissions are the product of three terms, the amount of fuel consumed, the fraction of the fuel that is oxidized, and a factor for the carbon content of the fuel. Specific formulae for estimation of emission from consumption of petroleum products, natural gas, and coal are as given in equation 1, 2, and three respectively. The data for different types of fuel consumption and sources of the data are provided in detail in Annexure A. Emission factors for different fuel types are gathered from various published research sources and discussed in Annexure B.

$$E_{pp_i} = \sum_1^j C_{ji} * F_{NCV_j} * F_{CO2_j} \ldots\ldots\ldots\ldots \text{(1)}$$

Where,

E_{pp_i} is the total absolute emissions from the consumption of petroleum products in the ith state (tCO_2)

C_{ji} is the consumption of the jth petroleum product in the ith state (Kt)

F_{NCV_j} is the factor for converting consumption of jth petroleum product into energy consumption (Tj/Kt)

F_{CO2_j} is the factor for converting energy consumption of jth petroleum product into emissions (tCO_2/TJ)

$$E_{ng_i} = C_i * F_{NCV} * F_{CO2} \ldots\ldots\ldots\ldots \text{(2)}$$

Where,

E_{ng_i} is the total absolute emissions from the consumption of natural gas in the ith state (tCO_2)

C_i is the consumption of natural gas in the ith state (MMSCM)[1]

F_{NCV} is the factor for converting consumption of natural gas into energy consumption (Tj/MMSCM)

F_{CO2} is the factor for converting energy consumption of natural gas into emissions (tCO_2/TJ)

$$E_{c_i} = C_i * F_{NCV} * F_{CO2} \ldots\ldots\ldots\ldots \text{(3)}$$

Where,

E_{c_i} is the total absolute emissions from the consumption of coal in the ith state (tCO_2)

C_i is the consumption of coal in the ith state (Kt)

F_{NCV} is the factor for converting consumption of coal into energy consumption (Tj/Kt)

F_{CO2} is the factor for converting energy consumption of coal into emissions (tCO_2/TJ)

[1] The coal consumption is considered only for the generation of power which indicates the exclusion of coal consumption in other sectors such as industries. Although the proposed methodology excludes a major chunk of nearly 30% of the total coal consumption but as per the scope of project, the methodology gives the appropriate picture of the states.

The total absolute emissions of the state are simply the addition of absolute emissions from the consumption of different energy sources in a particular state. Equation 4 is used to calculate the emissions intensity of GDP of the particular state.

$$E_{T_i} = E_{pp_i} + E_{ng_i} + E_{c_i} \dots\dots\dots\dots\dots\dots\dots (4)$$

Where, E_{T_i} is the total absolute emissions from the i^{th} state and

$$EI_i = \frac{E_{T_i}}{GDP_i}$$

Where,

EI_i is the emission intensity of GDP of the ith state (tCO_2 per GDP)

GDP_i is the GDP of the ith state.

3. Analysis

The four yardsticks- economic indicators, GHG emissions, sectoral analysis and willingness of state government- form the basic grid of our analysis of states. Selection of state from a group of states (high income, low income, and Himalayan/North-eastern), is based on these four yardsticks. The state selection process involved two stages. In the first stage, a detailed comparative analysis on three quantitative indicators (economic indicators, GHG emissions, sectoral analysis) for the states in a group and three states are identified from each group for further consideration. In the second stage, state level consultations are carried out with the officials from three identified states to get a sectoral perspective of the issues that hinder and policies required for the implementation of low carbon measures.

3.1. Economic Indicators

Gujarat, Haryana, Maharashtra, Tamil Nadu, Karnataka, Telangana, Kerala, Punjab, and Andhra Pradesh are the major non-Himalayan states having higher per capita income. These states have higher per capita income higher than the country average. In the group of higher income states, Gujarat has the highest per capita income almost 1.5 times of Andhra Pradesh, which has the least per capita income in the group.

Chhattisgarh and Bihar respectively have the highest and lowest per capita income in the below income group of states. Rajasthan, Odisha and West Bengal, and Madhya Pradesh are the other states in this group. (Figure 2).

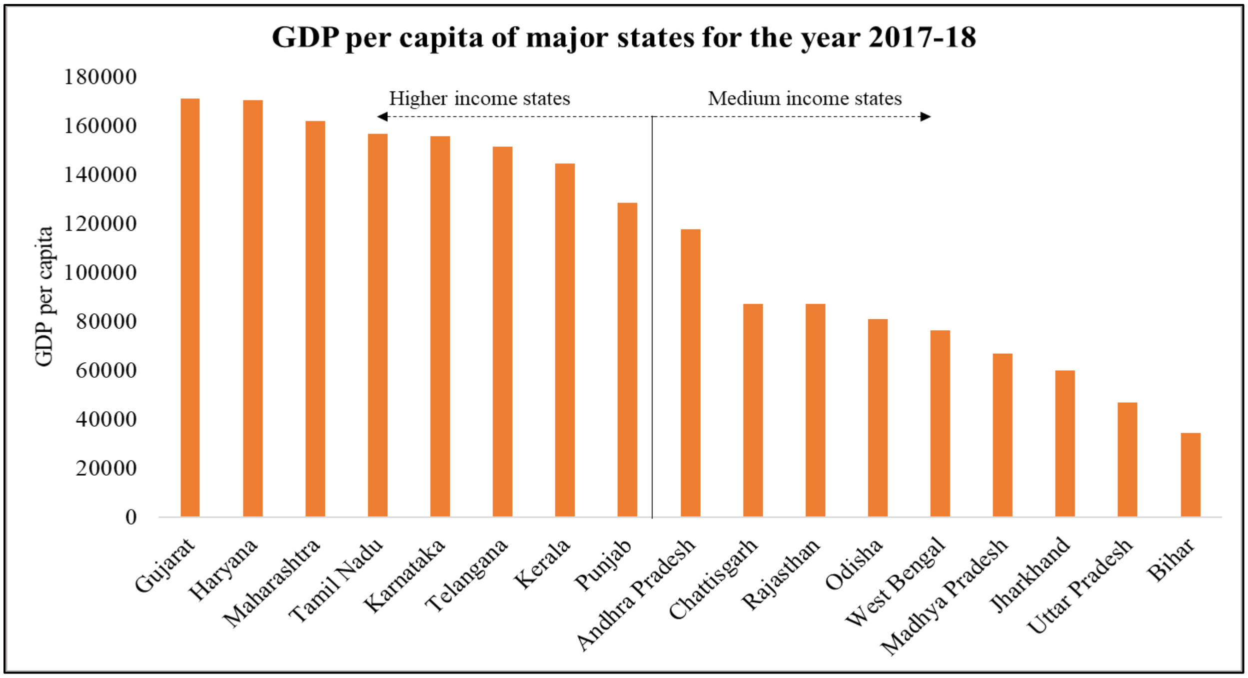

Figure 2: GSDP per capita of major states

Sikkim, Uttarakhand and Himachal Pradesh are the highest per capita income states in the group of Himalayan/North-eastern states. Assam is the most crucial state in this group by the size of its economy. Higher per capita income in other states in this group is due to their low population base (Figure 3).

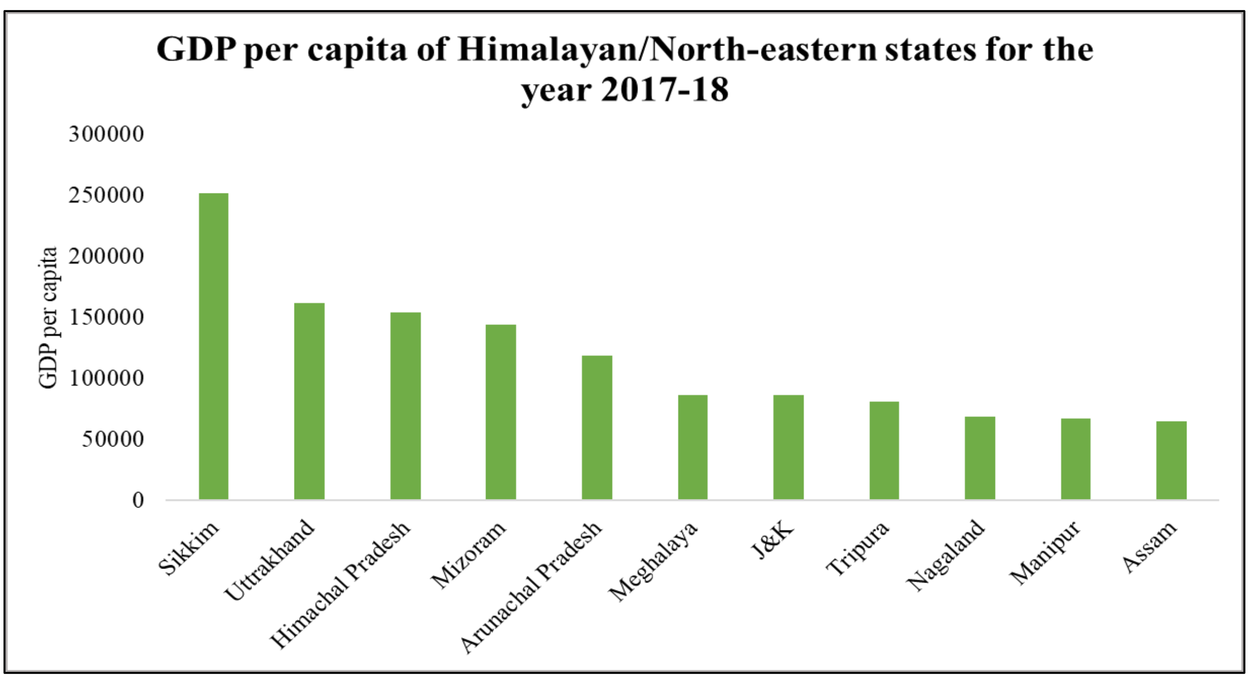

Figure 3: GSDP per capita of Himalayan/North eastern states

3.2. GHG emissions across states of India

(India: Second Biennial Update Report to the United Nations Framework Convention on Climate Change, 2018) highlights that India's total annual GHG emissions have increased from 2,136.8 million tonnes (Mt) of CO2e in 2010 to 2,607.5 Mt of CO2e in 2014. The report further notes that due to proactive and sustained actions on climate change mitigation, the emission intensity of India's Gross Domestic Product (GDP) has reduced by 21% throughout 2005-2014. In 2016-17, primary energy supply added up to 817.37 million tonnes of oil equivalent (MTOE). The energy intensity (at 2011-12 prices) decreased from 0.2732 Mega joule per rupee (MJ/₹) in 2011-12 to 0.2401 (MJ/₹) in 2016-17.

In India, GHG inventories are estimated at the national level whereas, this analysis uses emissions at the subnational/state level. The state-level emissions include those from direct fuel use across all sectors, including residential, commercial, industrial, and transportation, as well as primary fuels consumed for electricity generation. The calculation presented here considered the consumption of all three fossil fuels namely petroleum products, coal, and natural gas. For coal consumption, the analysis considered coal consumption in the power sector only. Emissions from coal consumed in other activities are not included in this analysis. In 2017-18, power sector accounted for approximately 66 percent of the total coal consumption in the country; this means the emission due to 34 percent of total coal consumption in the country is not accounted for here. However, this is not a major drawback as all major coal-based emission reduction interventions are in power sector only.

The physical size of a state, as well as the available fuels, types of economic activities, climate, population size and density, all, play a role in determining the level of total emissions. Also, each state's energy system reflects circumstances specific to that state. For example, some states have abundant hydroelectric supplies, and others contain abundant coal resources.

State wise emission is estimated from the fossil fuel usage patterns in a particular state. Figure 4 portrays the state wise absolute emissions in 2017-18 for major Indian states excluding Himalayan/North Indian states. Uttar Pradesh with 169 Million tons of CO2 equivalent is the largest emitter state. The distribution of emissions across states is quite uneven. Merely 10 states account for more than 3/4th of total emissions. Uttar Pradesh alone contribute to 12 percent of the country total emission; it is closely followed by Maharashtra 11 percent, Madhya Pradesh, and Gujarat both accounts for 8 percent each. Few studies are available for India that estimate state wise GHG emissions. State level studies are mostly sector specific. One of such studies, (T.V. Ramachandra, 2012) compute state wise carbon footprint analysis to find that Maharashtra was the largest emitter followed by Uttar Pradesh and Gujarat.

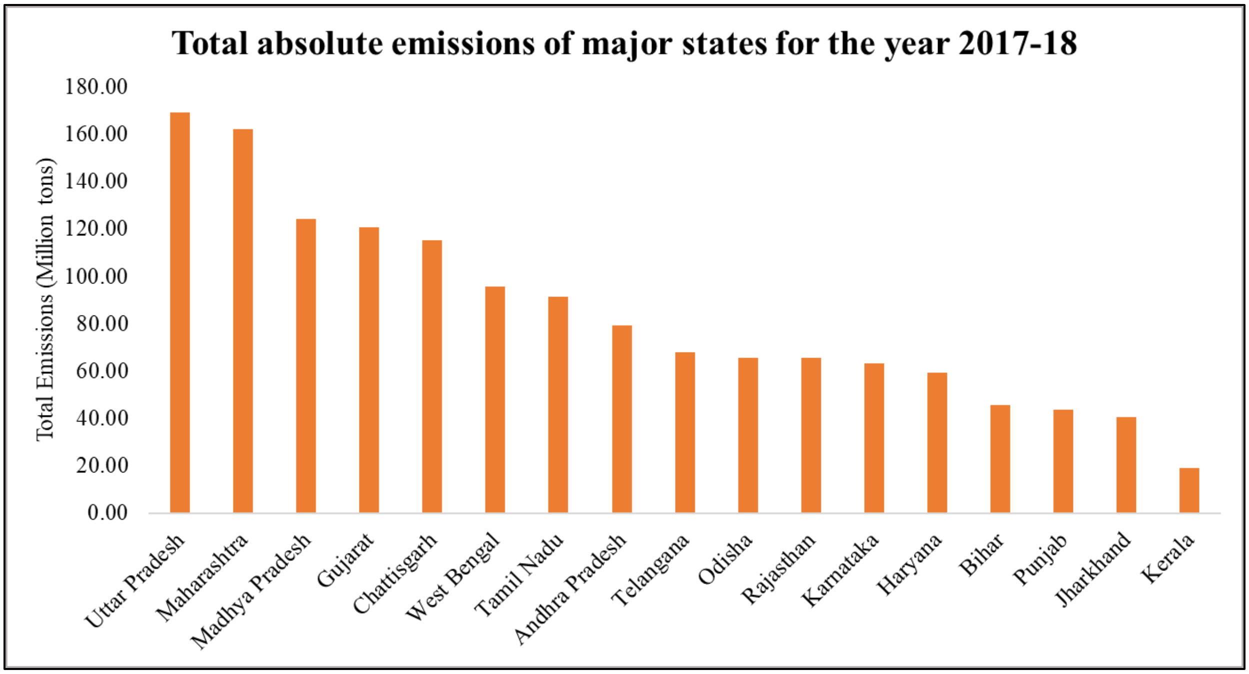

Figure 4: Total absolute emissions by major states

States exhibit very different emissions profiles because of varying consumption of fuel types. Coal is the largest source of emissions in the major states followed by petroleum products. Fuel wise emission pattern shows that coal accounts for 61 percent of the emission and petroleum products 38 percent in the year 2017-18. Many of these states are dominated by coal emissions from the power sector and petroleum emissions from the transportation sector. Alternative fuel based public or private transport infrastructure in the states are completely missing though the share of renewable in power generation mix of many of these states are gradually increasing

In contrast to major Indian states fuel, wise emission pattern of Himalayan/North Indian states is quite the opposite to major states. Coal merely accounts for 3.5 percent of total emissions from this group of states. Petroleum products contribute 70 percent of total emissions followed by 26.5 percent by natural gas. These states hardly have coal-based power plants; therefore; coal consumption in these states is almost negligible. These 11 states' total contribution to the country's emissions is merely 2.5 percent. Assam having the largest population and size of the economy is the biggest emitter in this group followed by Himachal Pradesh and Uttrakhand (Figure 5).

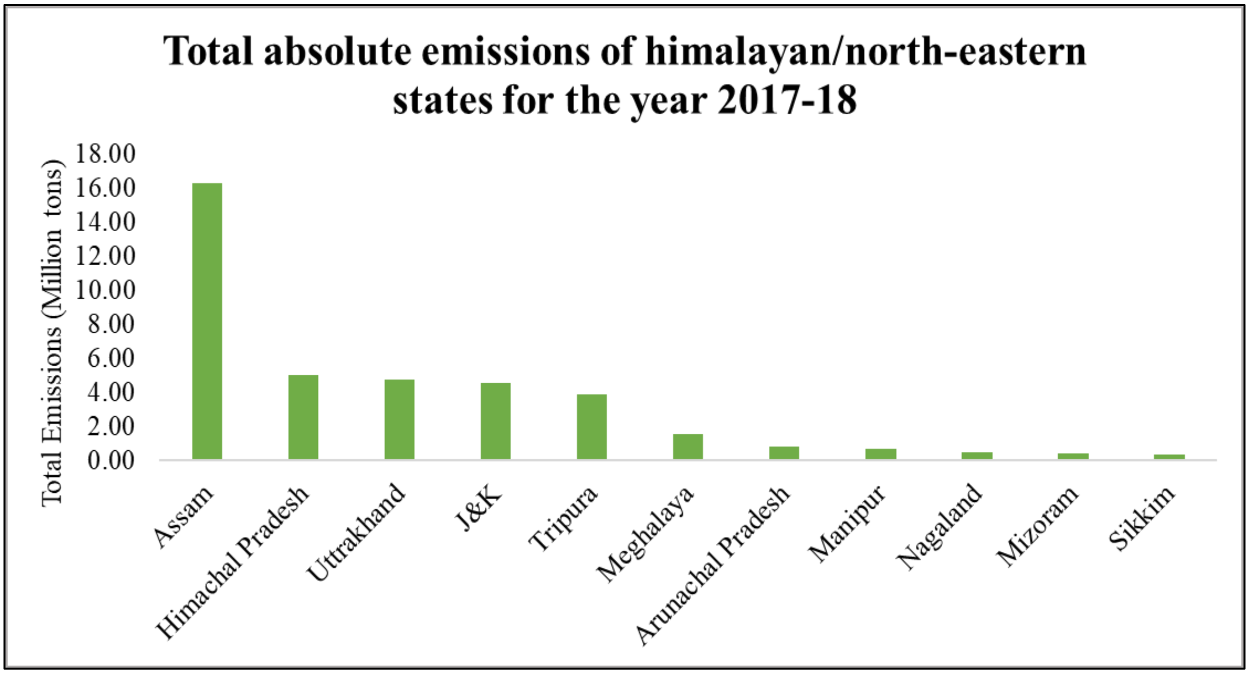

Figure 5: Absolute emission of Himalayan/north eastern states in 2017-18

3.2.1 Per Capita emissions

To bring in population more directly in the discussion we have reported the per capita emissions by states in figure 6 and seven respectively for major Indian states and Himalayan/North eastern states. In the case of Uttar Pradesh, the aggregate emission is high but so is population. Hence, per capita emission is low. Chhattisgarh is the biggest emitter followed by Haryana where the per capita emission is less than ½ of Chhattisgarh. A further probe in Chhattisgarh fuel wise emission pattern shows that Coal accounts for more than 90 percent of emission. Since many pit head power plants generate electricity in Chhattisgarh for transmitting to other states, this is understandable. In the case of Haryana and Telangana aggregate emission for Haryana and Telangana are low but their populations are also lower. Hence, their per capita emissions are high.

The analysis of state-level total absolute emission pattern shows that the size of the population of a state is one of the indicators of the quantum of emissions. States with small population sizes generally have low emission levels. However, this hypothesis is not always true for states like Chhattisgarh which has a much lower population base is the fifth largest emitter state whereas Bihar even having a large population base is emitting much less than even the many smaller states. Size and nature of the economy, availability of fuel types, etc. are important parameters that determine per capita level of emissions.

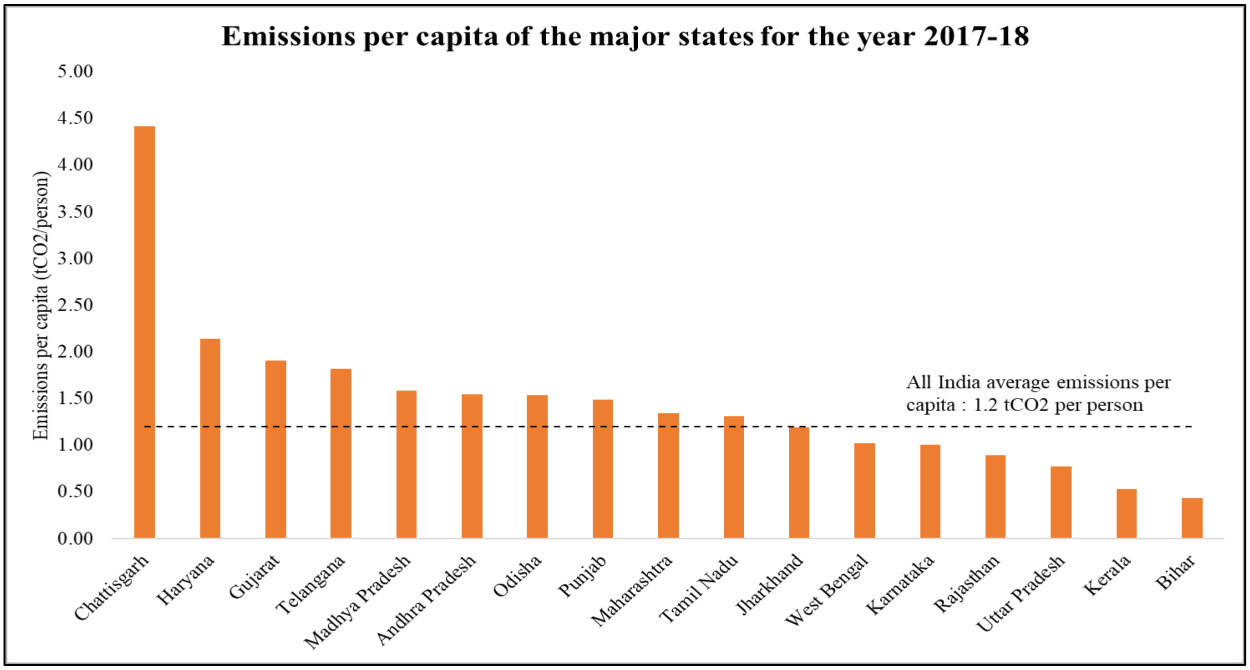

Figure 6: Per capita emission of major states in 2017-18

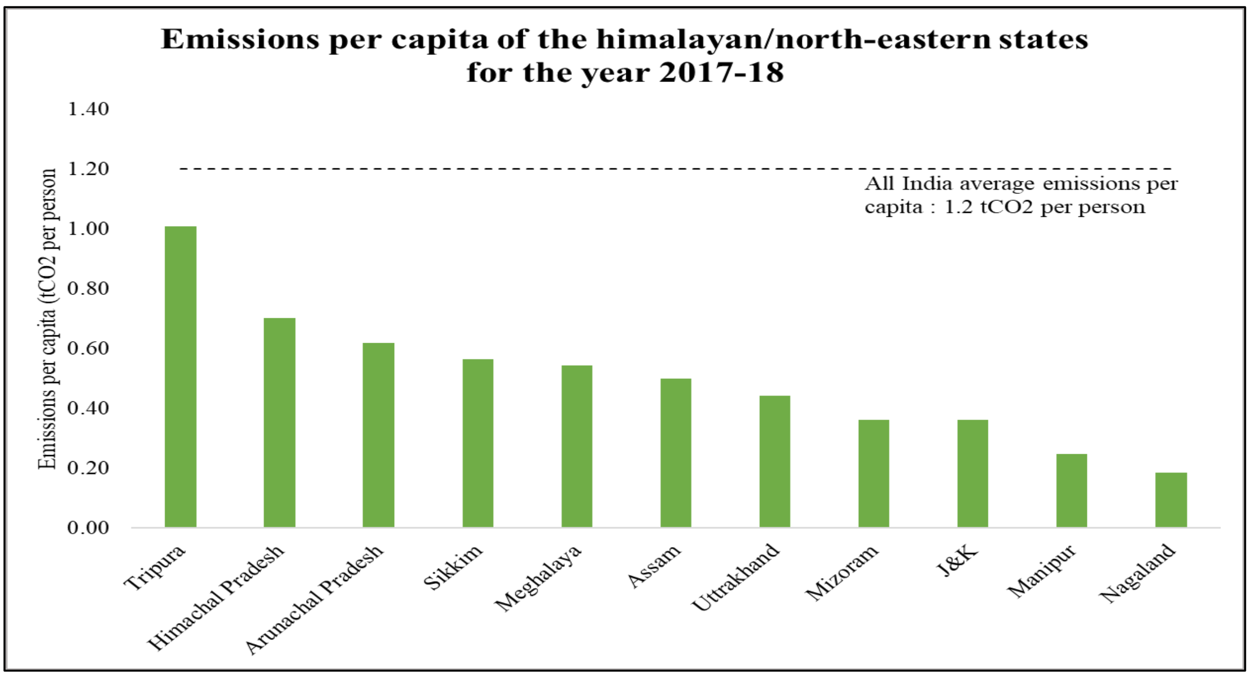

Figure 7: Per capita emission of Himalayan/north eastern states in 2017-18

In the Himalayan/North eastern states, Tripura has the highest per capita emission followed by Himachal Pradesh and Arunachal Pradesh. These small states though have small absolute emissions but due to small population base, per capita emissions are high in these state. Assam even being the largest emitter in this group is having low per capita emissions because of its large population base.

3.2.2 Emission intensity of GDP

India made a voluntary pledge in 2010 to reduce the emission intensity of its GDP by 20-25% from 2005 levels by 2020 (excluding emissions from agriculture). Later in 2015, India submitted its Nationally Determined Contributions (NDCs) under the Paris Agreement, wherein India voluntarily pushed up its target of reducing emission intensity of its GDP by 33 - 35% from 2005 levels by 2030.

Emission intensity (measured in tonnes CO2 per lakh of GDP) is the level of emissions per unit of GDP, is an important indicator of the emitting potential of a state. The comparison of the emission intensity of Indian states in 2017-18 shows the level of dependence of economic activities on fossil fuels for its energy requirements. National emissions intensity reduction should also correspondingly result in emissions intensity reduction of States also. Ranking in terms of emissions intensity shows states that have higher potential for reduction. Emissions intensity of GDP varies widely across states for both categories of major Indian states and Himalayan/North eastern states (figure 8 and 9).

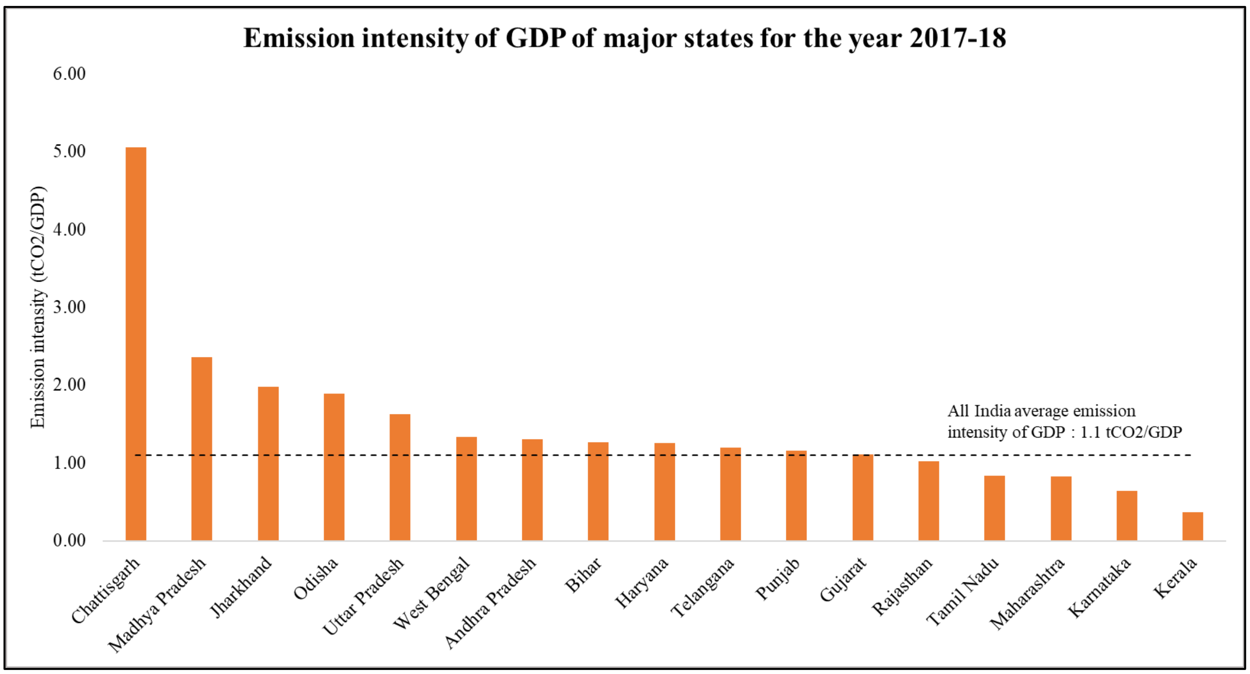

Figure 8: Emission intensity of GDP for major states in 2017-18

In the group of major Indian states, Chhattisgarh has the highest emission intensity of GDP followed by Madhya Pradesh, Jharkhand, Odisha, and West Bengal, etc. All these states have their emission intensity way above the national average. Gujarat and Rajasthan emission intensity is close to the national average whereas Tamil Nadu, Maharashtra, Karnataka emission intensity or way below the national average. This is consistent with the environmental Kuznets curve where emissions increase as economies grow until a level is reached after which emissions do not grow as fast as growth occurs. This is because the economies that are less developed are less urbanized, rely more on primary sectors like agriculture, mining & quarrying, manufacture of primary industrial products like Metals, etc. which can be more energy intensive. This is the case with states like Chhattisgarh, Madhya Pradesh, Jharkhand, Odisha, West Bengal, and Rajasthan. while developed economies are typically more urbanized, have a significant services sector and specialize in the manufacture of industrial products which is the case with states like Gujarat, Tamil Nadu, Maharashtra, and Karnataka. This state wise emission intensity of Indian states clearly follows a Kuznets curve kind of relationship, but the link between GDP and CO2 depends on the level of development, i.e., high GDP does not necessarily imply high emission growth, but it depends on the nature of industries in the state, which is an important determinant for the emission intensity of a state. Since the nature of industries is different in different stages of development hence the low carbon strategy too has to be different for the states in different stages of development.

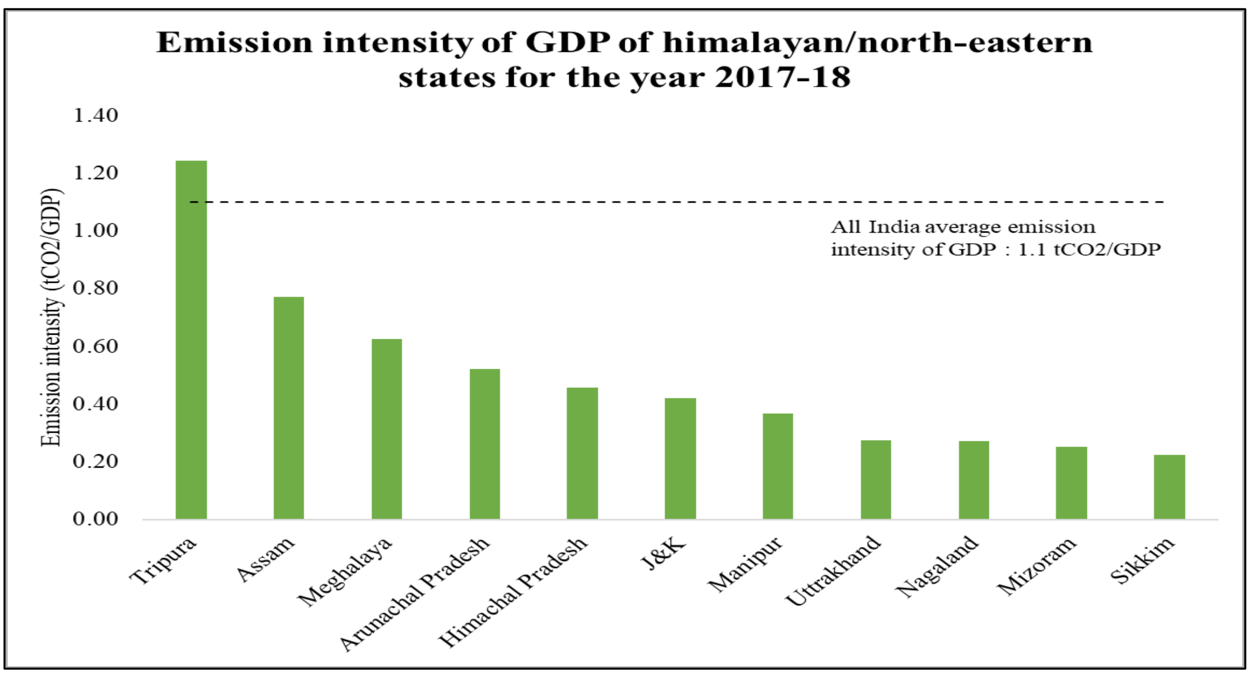

Figure 9: Emission intensity of GDP for Himalayan/north eastern states in 2017-18

The emission intensity of GDP for the Himalayan/North eastern states shows that only Tripura has emission intensity higher than the national average and all other states in the group have emission intensity way below the national average. Natural gas deposits are among the most important feature of Tripura's natural resource base. Natural gas-based thermal power plants have already been set-up at Barmura in Khowai

District and Rokhia in Sepahijala District. The 726.6-MW gas-based thermal power project at Palatana near Udaipur in Gomati District has been started with the help of Oil, and Natural Gas Corporation (ONGC) and another 104-MW gas-based thermal power project at Monarchak in Sepahijala District has been taken-up by NEEPCO. The consumption of natural gas for power production is an important factor behind high emission intensity for the state. Assam one of the biggest state in the group comes at second place in term of emission intensity of GDP. Sikkim a small state has the lowest emission intensity of GDP in the group.

3.3 Sectoral GHG emission

We next estimate state wise sectoral shares of CO_2 emissions for 2017-18 for the three sectors -Power, agriculture, and transport sectors.

3.3.1 Power and Energy

Electricity generation has been the single largest contributor in India's emissions portfolio. Coal consumption in the power sector is approximately 66 percent of total coal consumption in India. India's per capita emissions considering coal consumption only from the power sector in 2014-15 is 894.14 million tons of CO2, which is 61 percent of the total emission. Uttar Pradesh, the largest state by population size, generates the highest power followed by Maharashtra, Chhattisgarh, Madhya Pradesh, Gujarat, etc.

Power sector emission profiles of the states are similar to the power generation status of the states. Figure 10 shows the power generation by major Indian states. Uttar Pradesh the biggest power generator is also the biggest emitting state accounting for 12 percent of total national emission by the power sector. Maharashtra, Madhya Pradesh, Gujarat, and Chhattisgarh are other big emitter states. These five states jointly contribute to almost 1/2 of the total emission by the sector.

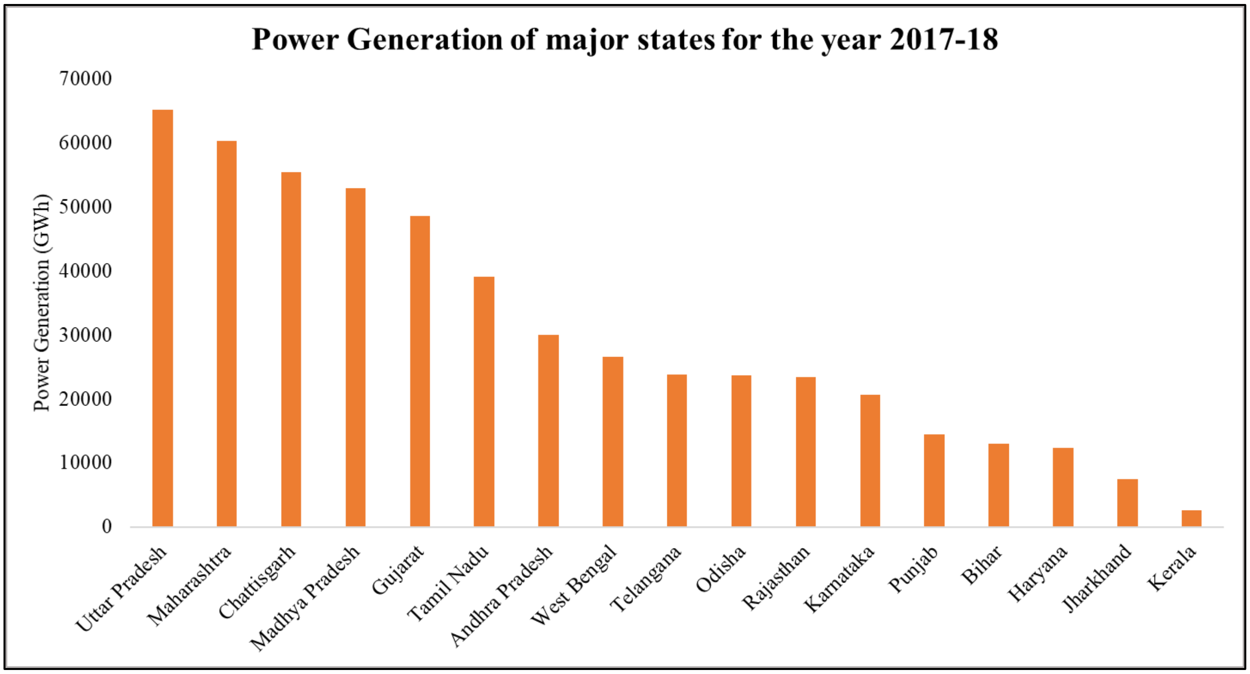

Figure 10: Power generation by major states in 2017-18

Himachal Pradesh is the biggest power generator in the Himalayan/North eastern group of states followed by Jammu and Kashmir and Uttarakhand respectively. However, not all these states are generating power from coal. Therefore, emission from power generation in these states are almost nil.

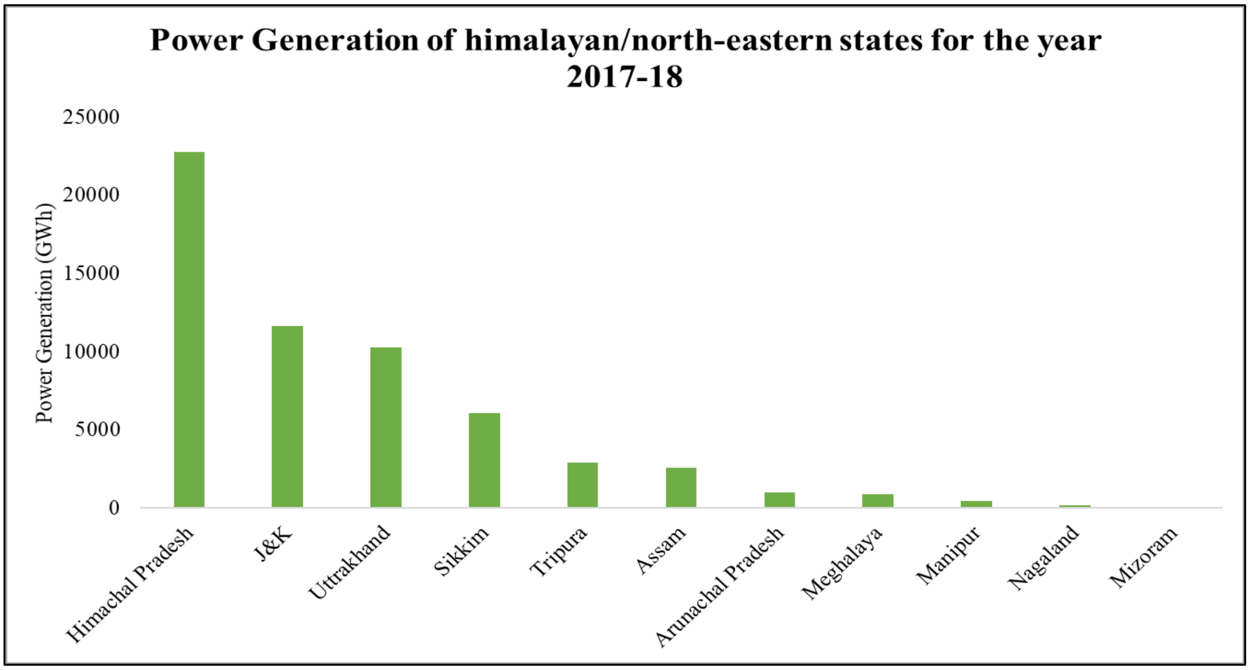

Figure 11: Power generation by Himalayan/north eastern states in 2017-18

Under the National Action Plan on Climate Change in 2008, the government of India had identified the development of solar energy technologies in the country as a National Mission. The mission aims at the development and deployment of solar energy technologies in the country to achieve parity with grid power tariff by 2022. At that time the government had set a target for the deployment of 20 GW of solar power by 2022. However, later this target was revised substantially. The government had set a target to achieve 175 GW renewable deployment by 2022, which comprises 100 GW solar, 60 GW Wind, 5 GW Small hydropower and 10 GW biomass power. To achieve the national target, each region and further each state was given a target to achieve renewable deployment as shown in figure 11. We have classified states based on their proposed renewable deployment targets by 2022 in 1) States having total deployment target above 4 GW- high potential states, 2) States having total deployment target above 1 GW and less than 4 GW - medium potential states, and 3) States having total deployment target below 1 GW -low potential states.

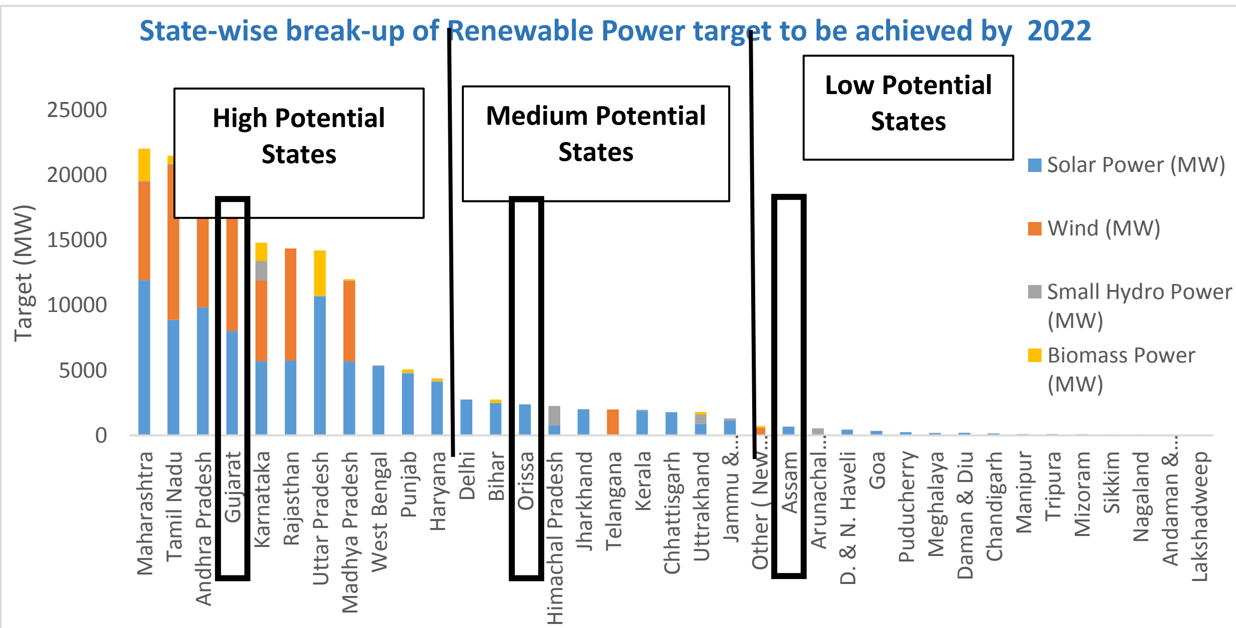

Figure 12: State wise renewable power production capacity target to be achieved by 2022

3.3.2 Agriculture

Agriculture is a very important sector in terms of economic growth and livelihood generation. In the past whenever the agriculture sector has shown good growth the economy has also shown high growth rates. Despite being a very vital sector, it is critically dependent on good rainfall as irrigation coverage has not been adequate. However even in areas with irrigation coverage to farmers mostly uses electric or diesel pump for irrigation. Converting these energized pumps into solar pumps have multiple benefits. Solar pumps for irrigation leads to energy saving and water conservation especially when surplus power from solar pumps are purchased by a third party against payment as it incentivizes farmers for efficient use of both electricity and water.

Figure 13 and Figure 14 show the state wise total number of energized pumps (electric pumps) used by major states and Himalayan/North eastern states of India. Maharashtra has the largest number of energized pump sets, almost 21 percent of the total pump sets in the country. The distribution of energized pumps across the country is quite uneven. The distribution is neither in proportion to the cultivation area in the states nor in proportion to the population of the state. Merely four states Maharashtra, Karnataka, Tamil Nadu, and Telangana account for more than 50 percent of the total energized pumps in the country.

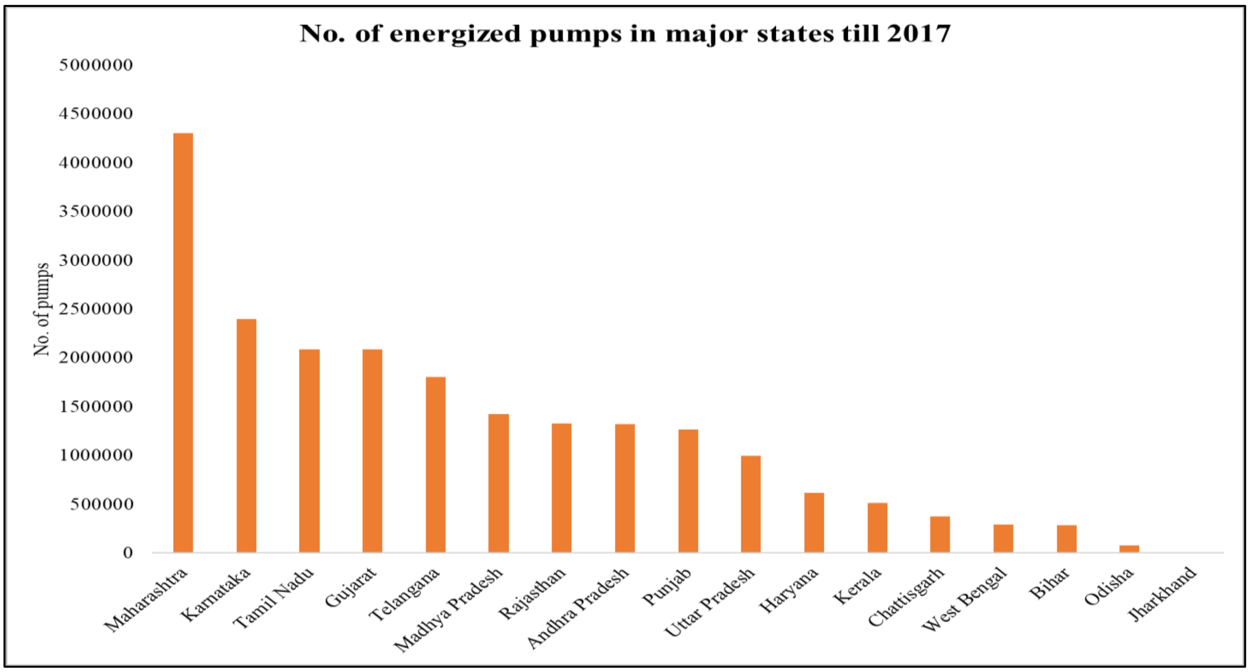

Figure 13: Total number of energized irrigation pumps in major states of India

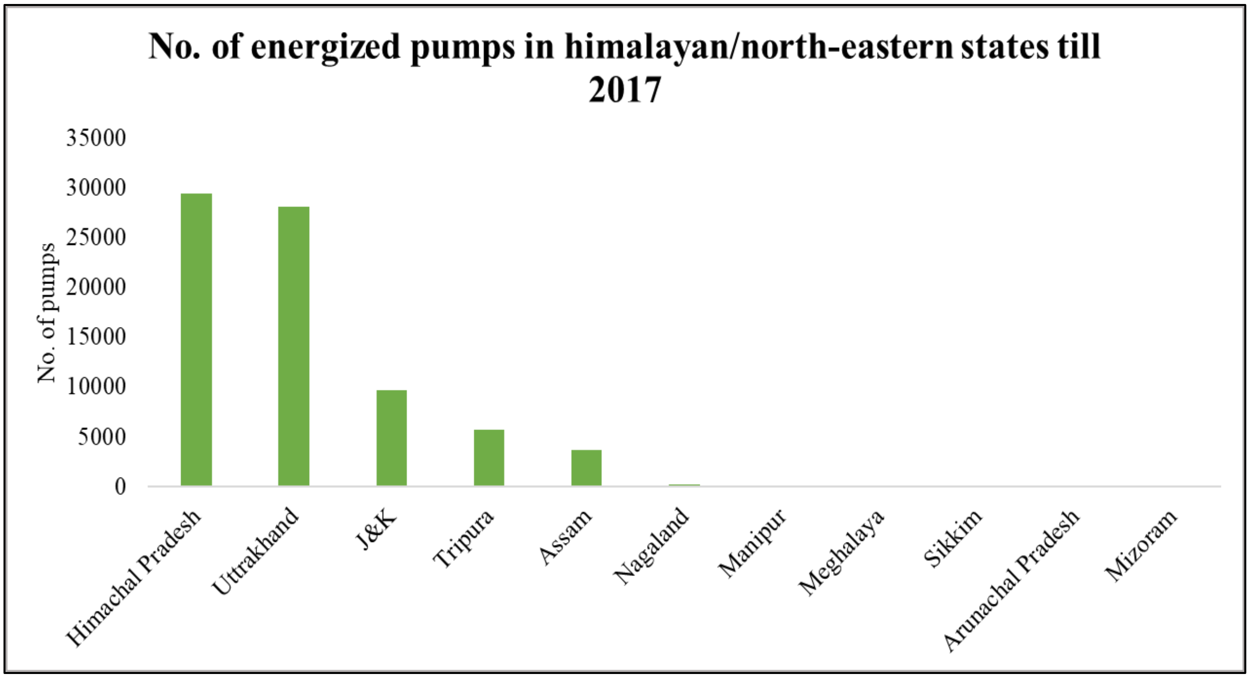

Figure 14: Total number of energized irrigation pumps in Himalayan/North eastern states of India

In north eastern states terrains are either not suitable for irrigation pumps sets or food is produced mainly on rain-fed land. In these states water for irrigation purposes is mostly drawn from surface reservoirs. In the group of Himalayan/North eastern states, Himachal Pradesh has the largest number of energized pumps followed by Uttarakhand and Jammu and Kashmir respectively. Smaller States such as Sikkim, Arunachal Pradesh, and Mizoram do not have even a single energized pump. These states are mostly dependent on the surface reservoirs for irrigation.

Powering irrigation systems with solar energy is a reliable and environmentally sustainable option. Moreover, solar-based irrigation systems can be scaled to meet diverse energy demands. This can contribute to the decoupling of growth in irrigated land areas from fossil fuel use. The factor inhibiting the growth of solar-based irrigation solutions is that it is a capital-intensive technology with front-loaded investments that pay back over time. However, it is competitive on a life-cycle basis. In the recent past, the gradual reduction in solar photovoltaic costs is leading to falling of the solar irrigation system cost. In order to make solar irrigation systems accessible to farmers, central and state governments are also coming up with different schemes to substantially reduce the effective cost of the solar system to the farmers.

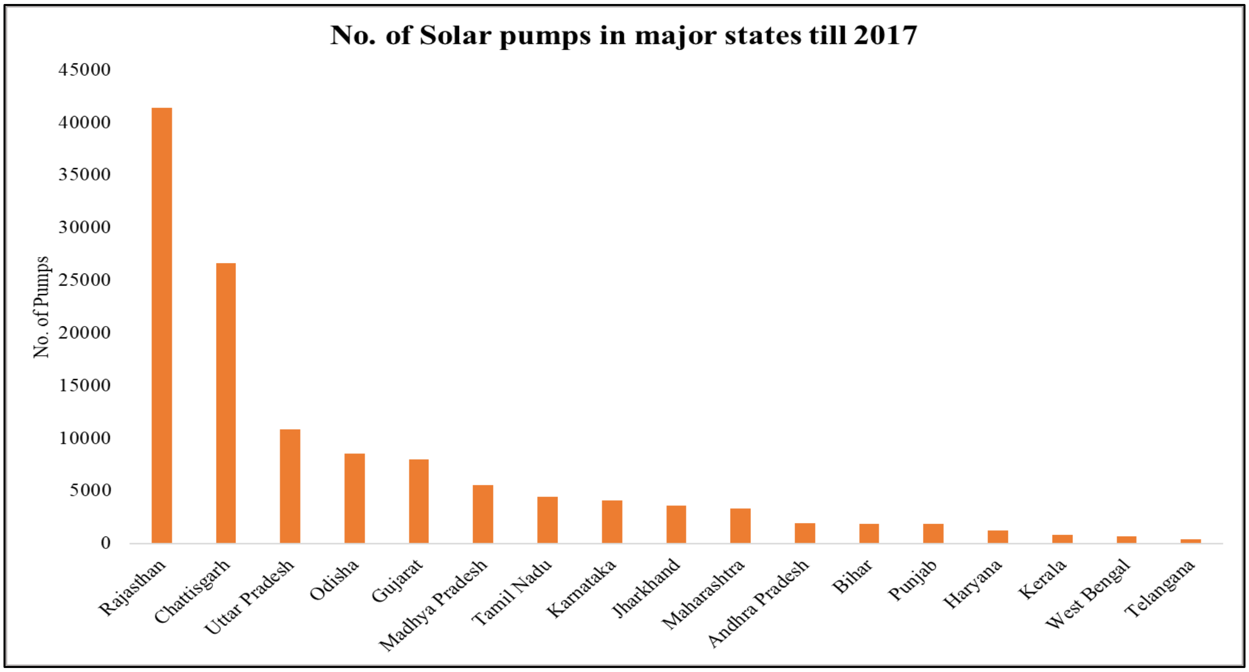

Figure 15: Total number of solar irrigation pumps in major states of India

Rajasthan is leading the solar water pump revolution in India; the state accounts for almost 1/3rd of total installed solar water pumps in the country. The state of Chhattisgarh occupies the second position in the country for a number of the installed solar water pump. Penetration of solar water pumps in states like Odisha, Gujarat, Maharashtra, Madhya Pradesh, and Uttar Pradesh is gradually increasing. in states like Punjab and Haryana which are heavily dependent on groundwater for irrigation the number of installed solar water pumps is still very low. There exist a wide state specific disparities in adoption of the solar water pump.

In the Himalayan/North eastern group of states, Tripura though being a small state in the land area has the highest number of solar water pump followed by Assam and Manipur respectively. Jammu and Kashmir despite having huge solar potential is not able to harness solar energy for irrigation. In 2017, the state had merely 39 solar water pumps.

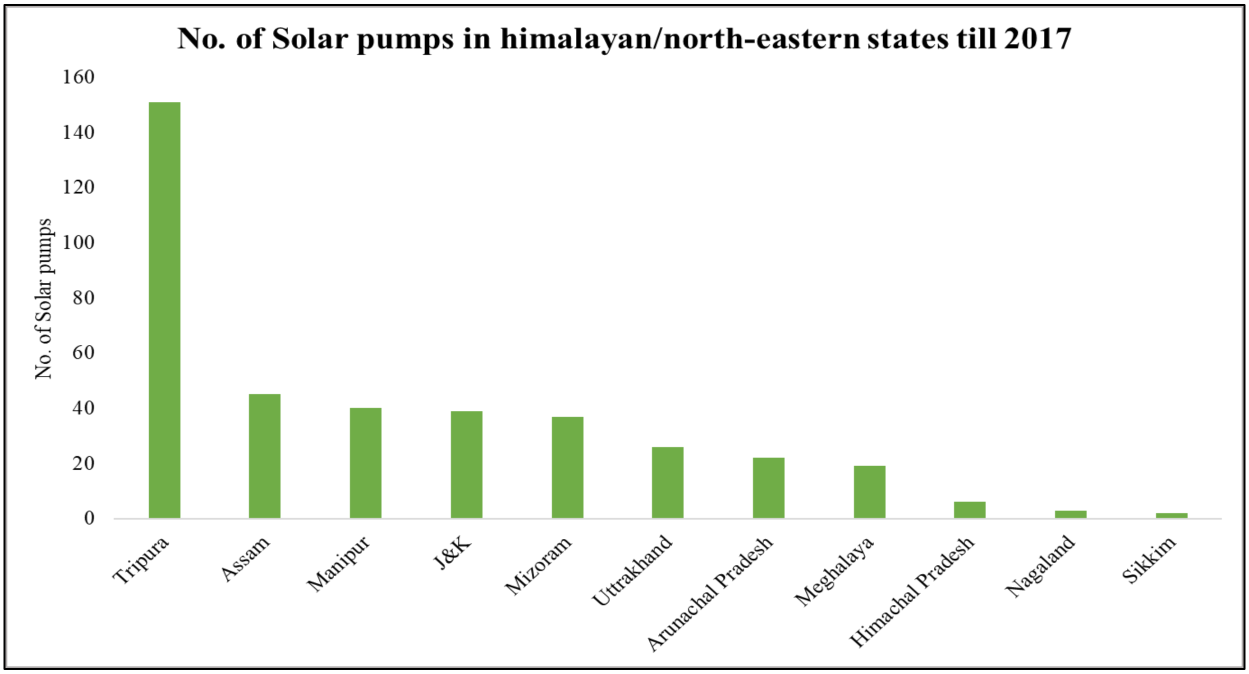

Figure 16: Total number of solar irrigation pumps in Himalayan/North eastern states of India

3.3.3 Transport

In India, the transport sector plays a vital role in connecting all states, cities, and suburbs augmenting inter and intra-regional trade. In 2016-17, it accounted for 4.1 percent of India's Gross Domestic Product (GDP). Of the three major modes (Road, Rail & Air) of transport in India, road transport is the most dominant mode, which contributes around 3.2 percent to the GDP ((Handbook of Statistics on Indian Economy, 2016-17). Both passenger and freight movement depends heavily on road transport, as it carries almost 90% of the country's passenger traffic and 65% of the freight. India's transport sector has seen remarkable growth in the last decade, as the total registered motor vehicles had gone up from 21 million in 1991 to 230 million in 2016, more than ten folds' increase in 15 years (Ministry of Road, Transport and Highways). The current projections suggest it will continue to grow at a significant rate in the coming years.

Total Energy Consumption by the transport sector

Nearly 98 percent of the energy needs in transportation are met through petroleum products (Committee, 2014). The transport sector majorly uses two types of fuel, i.e., gasoline and diesel. In 2016-17, the transport sector consumed 70 percent of the total diesel consumption (All India Study on Sectoral Demand of Diesel & Petrol, 2013) and almost 100 percent of the total gasoline consumption of India. For this study, the state-wise breakup of diesel and gasoline consumptions are given in Figure 17,18,19,20 for the year 2017-18, which are again divided into major Indian states and Himalayan/ North eastern states.

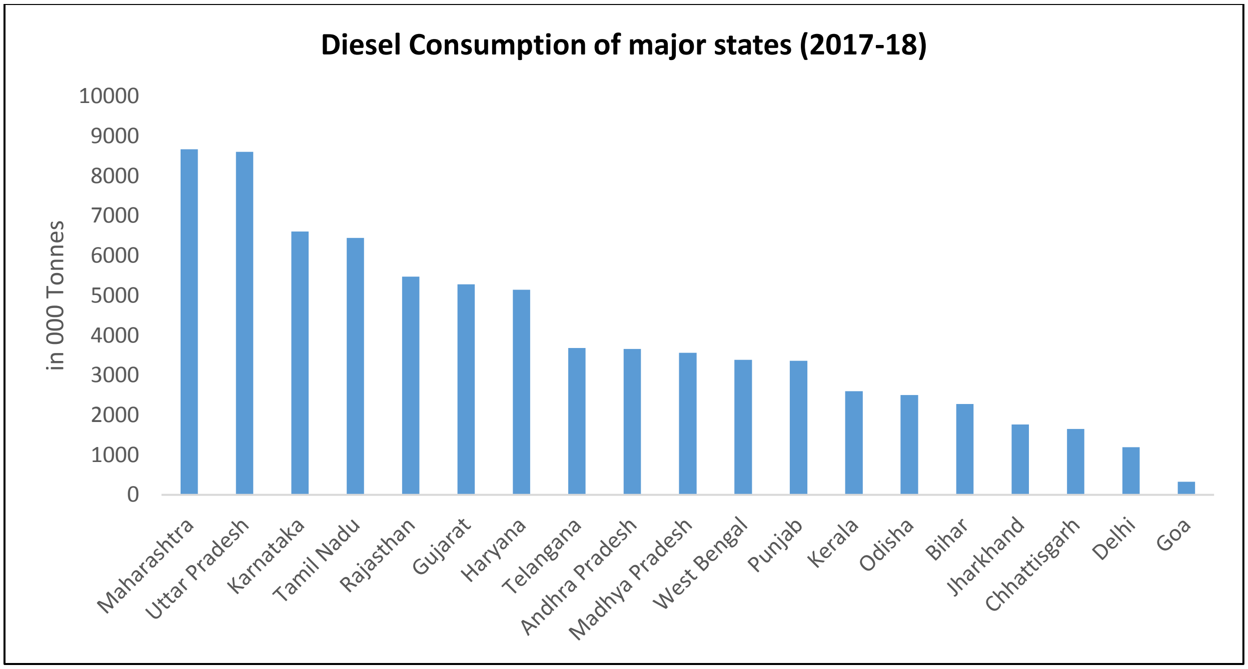

Figure 17: Diesel consumption in major states

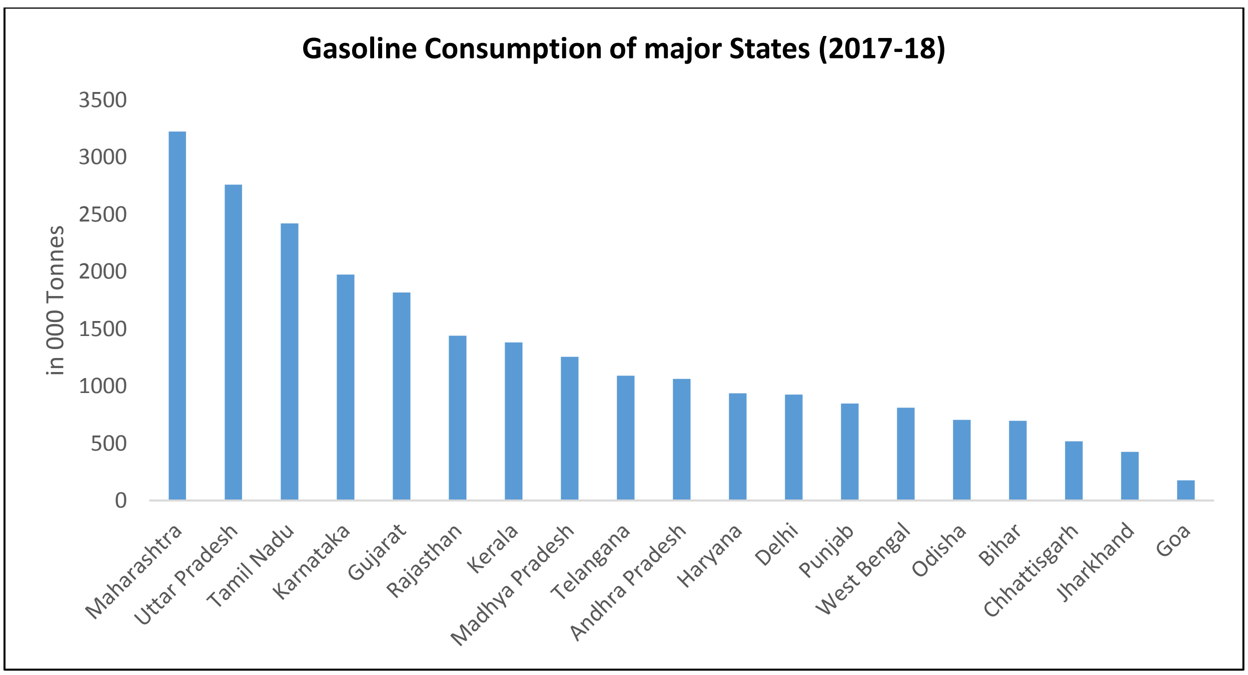

Figure 18: Gasoline consumption in major states

In the group of major states, Maharashtra and Uttar Pradesh have the highest consumption of gasoline and diesel for the year 2017-18. Both these states along with Gujrat and Tamil Nadu are the highest petrol consuming states in the recent past. Whereas Goa, Chhattisgarh, Jharkhand, and Delhi are the least consuming states because of their small population.

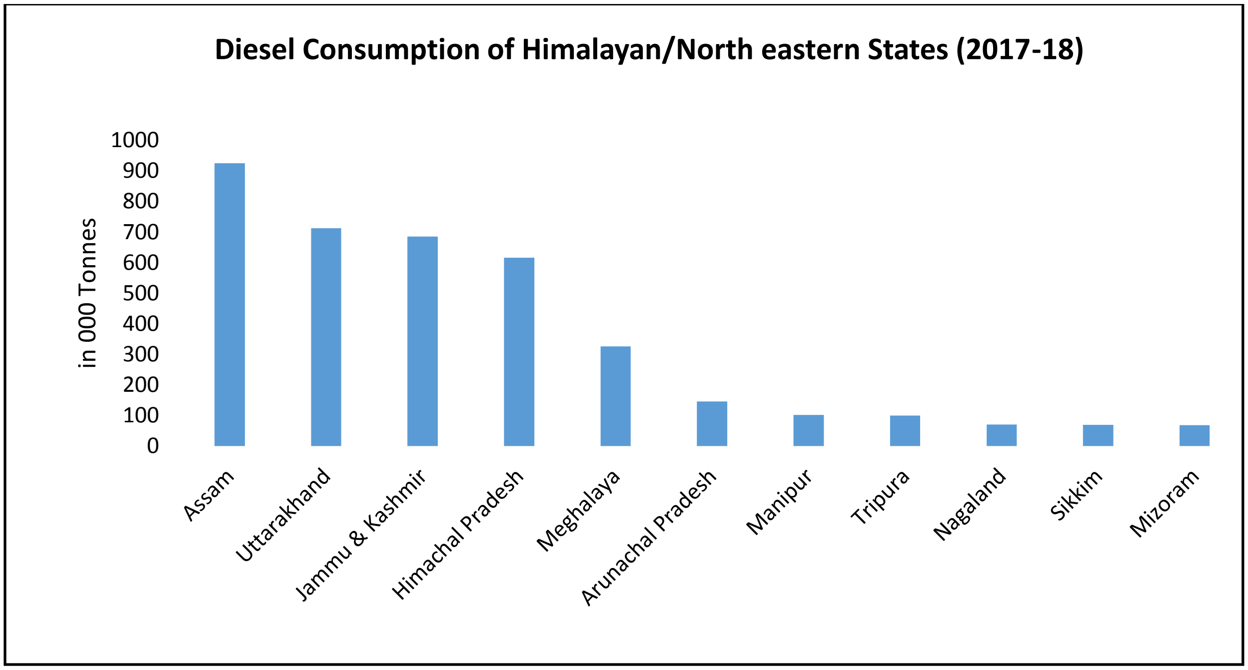

Figure 19: Diesel Consumption of Himalayan/North eastern States

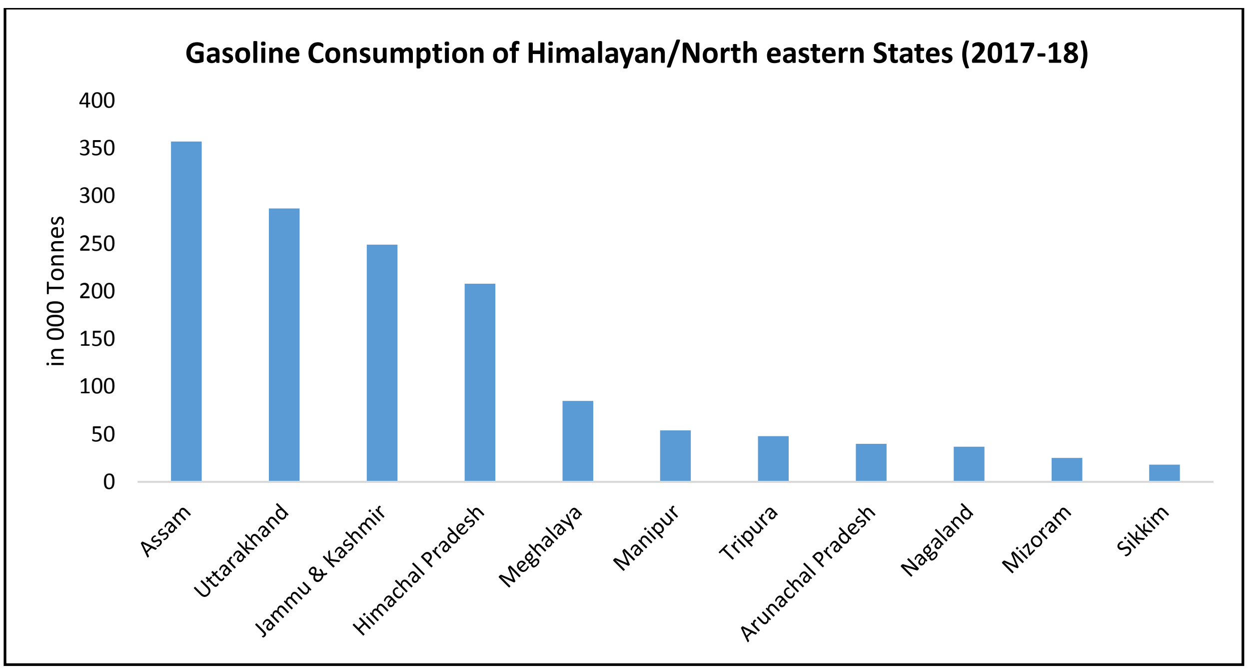

Figure 20: Gasoline Consumption of Himalayan/North eastern States

Considering the Himalayan states Assam, Uttarakhand, Jammu and Kashmir, Himachal Pradesh and Meghalaya are the top consuming states of petroleum products. Whereas Mizoram and Sikkim are the least consuming states. The above analysis shows that the states having a higher population (Uttar Pradesh: 199.81 Million and Maharashtra: 112.372 Million) consume more petroleum products. Similarly, Sikkim and Mizoram are the least populated states, so their consumption of petroleum products is less.

Total Transport related to GHG Emissions

The fuel we use for a vehicle is generally fossil fuel which releases greenhouse gases on combustion along with other pollutants thus contributing to the GHG effect. In terms of fuel quality and emission standards, India lags behind international best practices. The sulphur content in fuel is still very high (more than 10 ppm) as a result of which the vehicular emission standards are not what they can be. The whole country is still running with BS-III standards which were discarded in many developed and developing nations. All developed countries have already adopted Euro Standard VI (equivalent to BS VI) and many developing nations like Mexico, China, and Turkey, etc. have adopted EURO V. That means India is 10 years behind all those nations. Only a few metropolitan cities in India are running with BS-IV. This has to change soon, if not the transport sector is likely to increase its share in total fuel consumption and total GHG emissions in the near future. The transportation sector is the 4th largest emitter of GHG emissions in India in 2007 (Electricity > Industry >Agriculture > Transport) of about 142 MT CO2eq and it constitutes around 7.5 percent of the total national GHG emissions India Transport Sector: Moving towards 2032). Road transport is the dominant mode emits 87 percent of the total transport sector emissions. Figure 21 and 22 show recent, i.e. (2017-18) state-wise emissions of GHG gases.

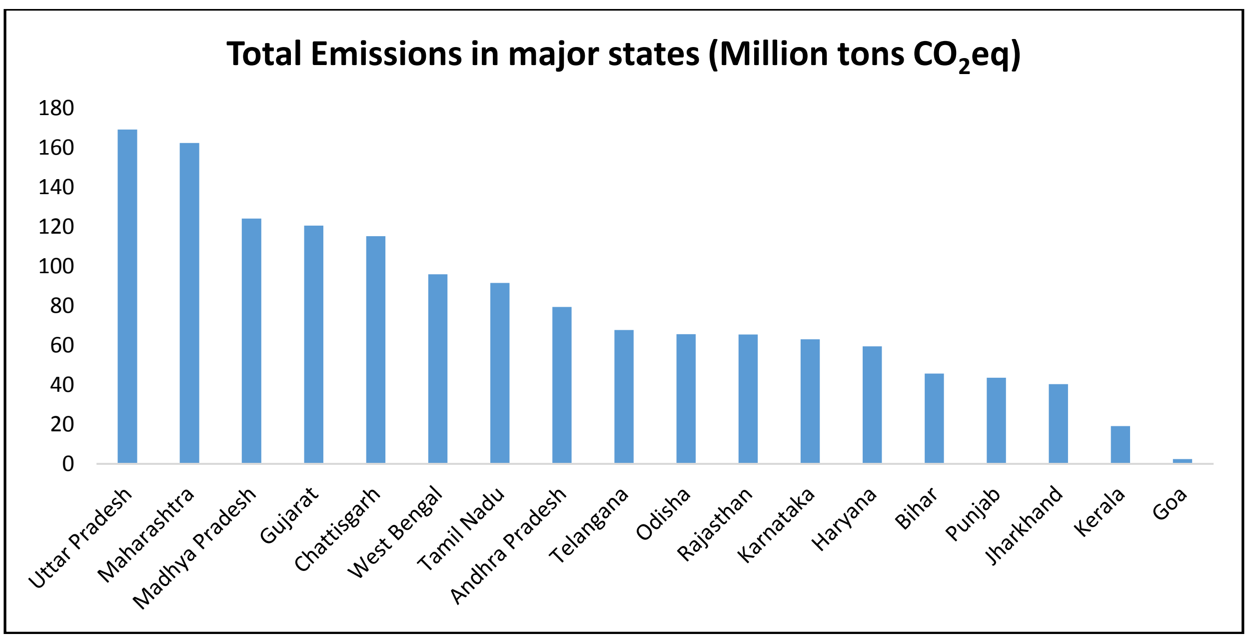

Figure 21: Total Transport Emissions in major states

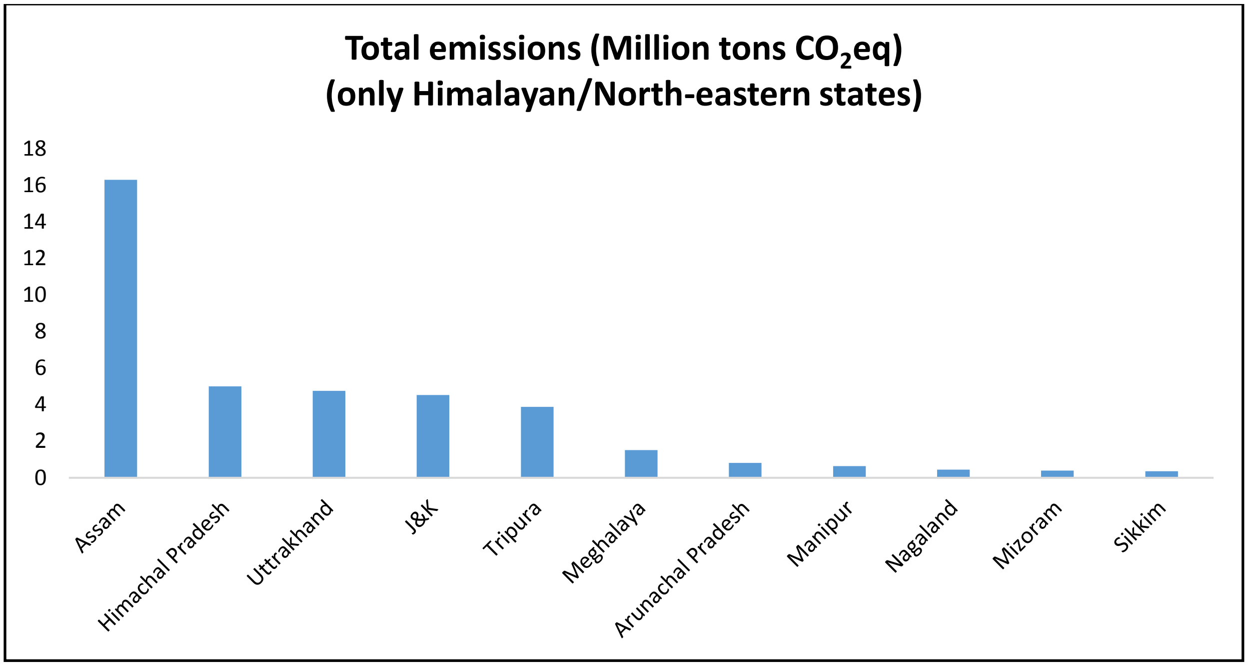

Figure 22: Total emissions Himalayan/North-eastern states

Vehicle Statistics

Energy use in the transportation sector is primarily led by the use of private vehicles in urban areas and heavy commercial vehicles. The intensity of private vehicle use is directly proportional to the growth of urban development in India as public transport is not well established and inadequate to meet the increased travel demand in most cities. Analysis of registered vehicles shows that the share of buses has declined heavily in the last decade and at the same time there has been a significant increase in several two-wheelers and private cars in metropolitan cities. Table 1 shows the mode wise registered vehicles in India. This indicates that private vehicles (cars and two-wheelers) constitutes more than 80 percent of the share of registered vehicles in 1990 and increases to 90 percent in 2015 implying privatisation of transport.

Table 1. Total Registered Vehicle in India (in Millions)

Years	Two Wheelers	Three Wheelers	Private Cars	Taxis	Buses	Light Commercial Vehicles	Middle Commercial Vehicles	Heavy Commercial Vehicles	Total Registered Vehicles
1990	11.98	0.70	2.43	0.25	0.30	0.37	0.86	0.34	17.25
2000	34.89	1.58	5.85	0.60	0.68	0.82	1.92	0.79	47.14
2010	91.60	3.62	15.51	1.59	1.54	2.93	3.50	1.62	121.90
2015	154.30	5.03	26.35	2.26	1.97	4.88	4.46	2.04	201.29

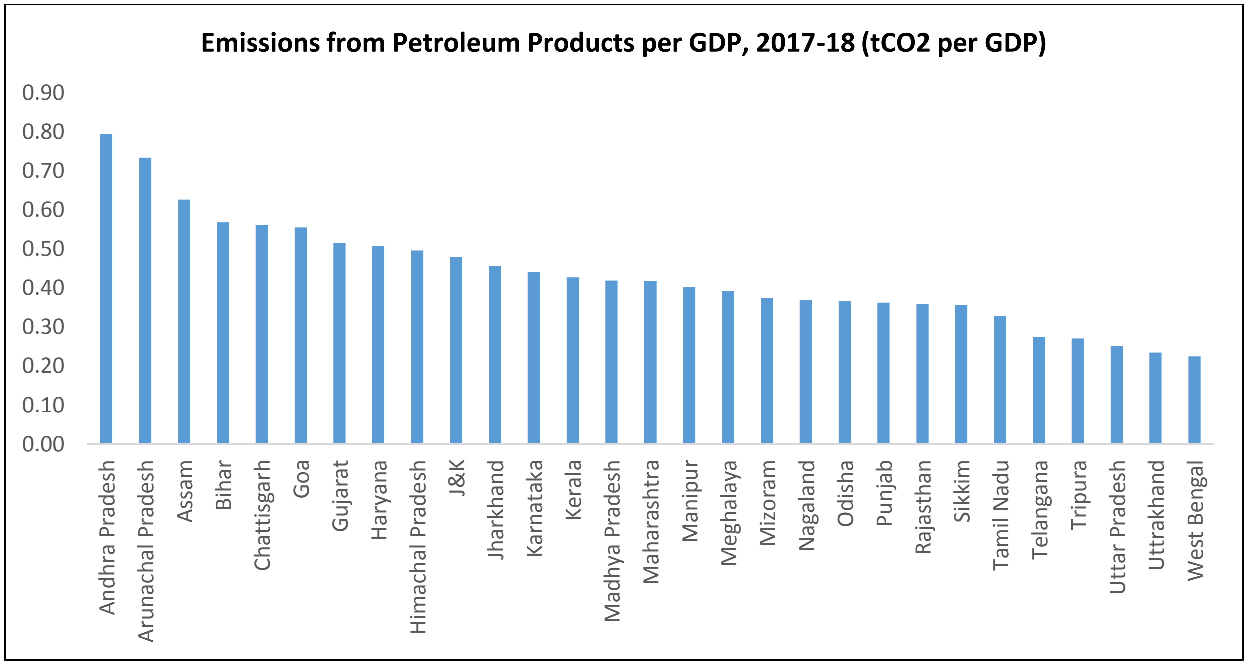

Figure 23: Emissions from Petroleum Products per GDP

The above figure 23 shows that the emission intensity from petroleum products consumption is high in developed states like Andhra Pradesh (0.79), Gujarat (0.52) and Karnataka (0.44). Among developing states, Bihar, Chhattisgarh, Haryana, Jharkhand, Madhya Pradesh, Odisha also have high emission intensities. Among the Himalayan states, Arunachal Pradesh, Assam, Himachal Pradesh, and Jammu and Kashmir have the highest emissions intensities from petroleum products consumption.

4. Selected States

As pointed out at the beginning, the broad goal of the proposed study is: 1) to identify state-level low carbon growth strategic policy options for selected states to achieve India's NDC targets, 2) to suggest market-based solutions and business models that facilitate implementation, and 3) to promote shared learning dialogues through state-level stakeholder consultations/meetings and expert workshops at state and national levels. To achieve this objective, the study has selected three states for the intensive case study and to come up with the state level strategy and solutions which could be implemented by various other states. The states do not act solely as mere implementers of central government's top-down policy but instead, have own initiatives for climate action in line with central government commitment.

India has 29 states and 7 union territories; union territories are not considered for grouping as they are under the direct administrative control of the central government. First, these states are divided into three groups based on the geography and the per capita income (states in different groups are given in table 2. These states are analysed on three broad cardinals (1- Economic indicators, 2- GHG emission and 3- Sectoral emissions (selected sectors only)) and 1 ordinal parameter (state willingness).

Table 2: Top 5 states for each Indicator

	States having per capita income above INR 1 lakh (Group 1)	Sates having per capita income below INR 1 lakh (Group 2)	Himalayan/North eastern states (Group 3)	Comments
Indicators/States	Maharashtra, Goa, Tamil Nadu, Gujarat, Karnataka, Telangana, Kerala, Punjab, Andhra Pradesh, Haryana	Chhattisgarh, Odisha, Bihar, West Bengal, Uttar Pradesh, Madhya Pradesh, Jharkhand, Rajasthan,	Sikkim, Uttrakhand, Himachal Pradesh, Mizoram, Assam, Jammu and Kashmir Tripura Arunachal Pradesh, Meghalaya, Nagaland, Manipur	
Total Absolute Emissions 2017-18	Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh, Telangana	Uttar Pradesh, Madhya Pradesh, Chhattisgarh, West Bengal, Odisha	Assam, Himachal Pradesh, Uttrakhand, J&K, Tripura	
Per capita Emissions 2017-18	Haryana, Gujarat, Telangana, Andhra Pradesh, Punjab	Chhattisgarh, Madhya Pradesh, Odisha, Jharkhand, West Bengal	Tripura, Himachal Pradesh, Arunachal Pradesh, Sikkim, Meghalaya	Assam is sixth
Emissions Intensity of GDP for 2017-18	Andhra Pradesh, Haryana, Telangana, Gujarat, Tamil Nadu	Chhattisgarh, Madhya Pradesh, Jharkhand, Odisha, Uttar Pradesh	Tripura, Assam, Meghalaya, Arunachal Pradesh, Himachal Pradesh	
Power Generation for 2017-18	Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh, Telangana	Uttar Pradesh, Chhattisgarh, Madhya Pradesh, West Bengal, Odisha	Himachal Pradesh, J&K, Uttrakhand, Sikkim, Tripura	Assam is sixth
State wise renewable power production capacity target to be achieved by 2022	Maharashtra, Tamil Nadu, Andhra Pradesh, Gujarat, Karnataka	Rajasthan, Uttar Pradesh, Madhya Pradesh, West Bengal, Bihar	Himachal Pradesh, Uttrakhand, J&K, Assam, Arunachal Pradesh	Odisha is sixth closely tied with Bihar
Total number of energized irrigation pumps	Maharashtra, Karnataka, Tamil Nadu, Gujarat, Telangana	Madhya Pradesh, Rajasthan, Uttar Pradesh, Kerala, Chhattisgarh	Himachal Pradesh, Uttrakhand, J&K, Tripura, Assam	Odisha is eighth
Total number of solar irrigation pumps	Gujarat, Tamil Nadu, Karnataka, Maharashtra, Andhra Pradesh	Rajasthan, Chhattisgarh, Uttar Pradesh, Odisha, Madhya Pradesh	Tripura, Assam, Manipur, J&K, Mizoram	

Diesel consumption	Maharashtra, Karnataka, Tamil Nadu, Gujarat, Haryana	Uttar Pradesh, Rajasthan, Madhya Pradesh, West Bengal, Kerala	Assam, Uttarakhand, J&K, Himachal, Meghalaya	Odisha is sixth
Petrol consumption	Maharashtra, Tamil Nadu, Karnataka, Gujarat, Telangana	Uttar Pradesh, Rajasthan, Kerala, Madhya Pradesh, West Bengal	Assam, Uttarakhand, J&K, Himachal, Meghalaya	Odisha is sixth
Total Transport Emissions	Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh, Telangana	Uttar Pradesh, Madhya Pradesh, Chhattisgarh, West Bengal, Odisha	Assam, Himachal Pradesh, Uttrakhand, J&K, Tripura	
Emissions from Petroleum Products per GDP	Andhra Pradesh, Goa, Gujarat, Haryana, Karnataka	Bihar, Chhattisgarh, Jharkhand, Kerala, Madhya Pradesh	Arunachal Pradesh, Assam, Himachal Pradesh, J&K, Manipur	Odisha is sixth

As shown in the table above, among the high income or developed states which is group 1, Gujarat appears in the top 5 for all the indicators considered. In the category of developing states or group 2 Odisha and Chhattisgarh appear in top 5 in most. In the case of some parameters, Odisha is ranked close sixth. Only in the case of total energised irrigation pumps, Odisha ranks eight. This, however, may indicate untapped potential. Between Chhattisgarh and Odisha, we have chosen to go with Odisha because of stronger political will and willingness of the state government. In the case of Himalayan states, Assam seems to be in the top 5 states for most parameters. In fact, it is the top state among Himalayan states in many categories.

Based on the analysis of states in different groups on cardinal and ordinal parameters (as discussed in section 3 of this report) **Gujarat** is selected from group 1, **Odisha** from group 2 and **Assam** from group 3 for extensive analysis (table 2).

5. Way forward

India is working to combat climate change while sustaining rapid development. In the recent past, the central government of India has developed a range of policies, plans, and targets to address climate change while supporting the country's long-term development agenda. However, how to convert and adapt the national level policy imperatives to state-level actions is a challenge. Moreover, the impacts of climate change are likely to be very different from state to state. For example, increased rainfall intensity will cause more flooding in some states, while increasingly severe droughts may threaten water supplies in other states.

To achieve the national goal states may take their lead from the national policies or programs while formulating their state-specific strategies to address climate change issues. State-specific strategies will address state priorities in a better way while creating enabling an environment for the implementation of national strategies. There is a wide array of heterogeneity among the states as far as the climate issues, the endowment of resources, administrative machinery, etc. are at the disposal of state governments.

There is a need for comprehensive state-specific policies, strategies and action plans which will be more aligned with the states resource and development priorities at the same time also addresses the national climate commitment. The proposed research will try to address this gap by doing state and sector-specific strategies to meet national climate commitment. There selected sectors are the major emitters majorly contributing to the total state emissions. The selected states are representatives of a group of states. Therefore, the strategies or action plan for these selected states may be replicated to other states of India.

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7. Annexures

Annexures A: Data Sets and its sources

Sectors	Particular	Data Source	Year of consideration
General	SGDP[2]	Ministry of Statistics and Programme Implementation	2014-15
	Sectoral state GDP	Ministry of Statistics and Programme Implementation	2014-15
	Population	United Nations Population Estimates	2017-18
Emissions	State wise consumption of petroleum products	Ministry of Petroleum and Natural Gas	2017-18
	State wise consumption of natural gas	Ministry of Petroleum and Natural Gas	2017-18
	State wise consumption of Coal	Central Electricity Authority of India	2017-18
Power and Energy	Power Generation	Ministry of Power	2017-18
	Renewable Energy Capacity	Ministry of New and Renewable Energy	Target for 2022
Agriculture	Total Energized Pumps	Ministry of Power	2017
	Installed Solar Pumps	Ministry of Power	2017
	Solar Potential	Ministry of Power	2017
Transport	Registered Vehicles	Ministry of Road Transport and Highways	2015-16
	Fuel Consumption by Transport Sector	Petroleum Planning & Analysis Cell	2017-18

[2] The latest data available with Ministry of Statistics and Programme Implementation is for the 2014-15. Using the CAGR method, the SGDP is projected for the year 2017-18 which is required for the estimation emission intensity of GDP for the latest year.

Annexures B: Emission Factors considered in the study

Fuel Type	Product	Emission Factor (tCO2/TJ)	Source
Petroleum Products	Naphtha	73.3	Ministry of Environment, Forest and Climate Change, India
	Liquefied petroleum gas	63.1	Central Electricity Authority of India
	Motor Spirit	69.3	Intergovernmental Panel on Climate Change
	Superior Kerosene Oil	71.9	Department of Energy and Climate Change, U.K.
	Automatic transmission fluid	71.9	Intergovernmental Panel on Climate Change
	High Speed Diesel	74.1	Intergovernmental Panel on Climate Change
	Light Diesel Oil	74.1	Intergovernmental Panel on Climate Change
	Fuel Oil	77.4	Intergovernmental Panel on Climate Change
	Low Sulphur Heavy Stock	74.7	Intergovernmental Panel on Climate Change
	Lubricants	73.3	Intergovernmental Panel on Climate Change
	Bitumen	80.7	Intergovernmental Panel on Climate Change
	Others	73.3	Intergovernmental Panel on Climate Change
Natural Gas	Natural Gas	56.1	Intergovernmental Panel on Climate Change
Coal	Coking coal	93.6	Ministry of Environment, Forest and Climate Change, India
	Non-coking Coal	95.8	Ministry of Environment, Forest and Climate Change, India
	Lignite	106.2	Ministry of Environment, Forest and Climate Change, India

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