ISSN – 2277-7911
Impact Factor – 5.077
YOUNG RESEARCHER
A Multidisciplinary Peer-Reviewed Refereed Research Journal
Oct-Nov -Dec 2023
Vol. 12 No. 4

A STUDY ON CARBON EMISSION AND CARBON TAX STRUCTURE IN INDIA

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DOI - 10.5281/zenodo.10512230

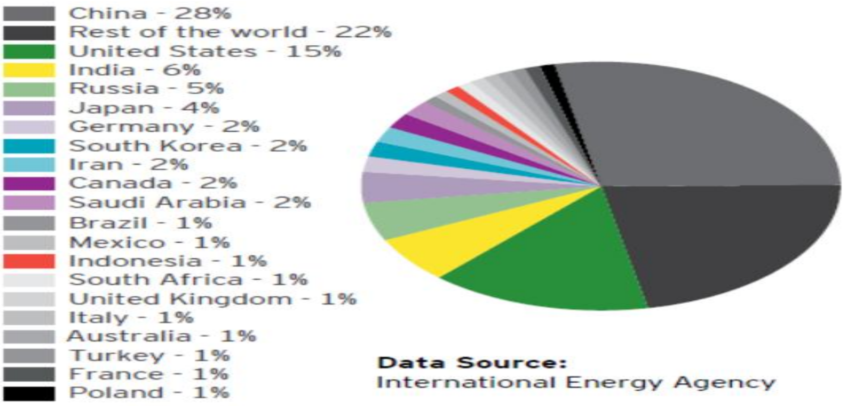
Abstract:

India is one of the fastest growing economies in the world, with a projected growth of 7.5% in 2018 as per World Bank's recent World Economic Outlook. India also supports about 17.5% of the world population and is the third largest emitter of carbon dioxide (CO2) from fuel combustion after China and the United States. India has taken a number of policies that contribute to climate mitigation by reducing or avoiding CO2 emissions. Broadly, two methods or approaches are used for quantification of emissions, i.e., direct measurement approach and indirect measurement approach. Indirect measurement approach is also called as calculation based approach. In the direct measurement approach, emissions are recorded real time on the premises of the emitter using a measuring device that records emissions for auditing purposes. SCC, important not only for evaluating the net impact of GHGs on environment, both positive and negative, but also considering the level of emissions related taxation that can be considered. Using the SCC approach, the carbon tax rate is equated to the social cost of carbon.

Introduction:

Climate Change has emerged as a global challenge, calling for an integrated global response to drive measures towards sustainability, in keeping with the national circumstances and priorities. India is a party to the United Nations Framework Convention on Climate Change (UNFCCC). It is also among the 175 nations who have ratified the Paris Agreement. India, while signing the pledge declared that it will keep in view its national laws and its development agenda, particularly the eradication of poverty and provision of basic needs for all its citizens. It committed to following the low carbon path to progress, on the assumption of unencumbered availability of cleaner sources of energy, technologies and financial resources from around the world. The long-term goals of the Paris agreement include restricting the temperature rise to well below 2°C above preindustrial levels and to 1.5°C above pre-industrial levels. The agreement also calls for reaching a peak in greenhouse gas (GHG) emissions at the earliest and achieving carbon neutrality from 2050 onwards. India is one of the fastest growing economies in the world, with a projected growth of 7.5% in 2018 as per World Bank's recent World Economic Outlook. India also supports about 17.5% of the world population and is the third largest emitter of carbon dioxide (CO2) from fuel combustion after China and the United States. Therefore, it recognizes that its growth needs to be guided by environmental sensibilities so as to achieve a balance between holistic development and sustainability. In fact India is one of the leading economies that the world looks up to, for driving the affirmative action on this front.

Share of Global Carbon Dioxide Emissions from Fuel Combustion



Risks to India:

Climate change is impacted by the actions of countries across the globe; the impact can be different across countries. It is believed that tropical countries like India are more vulnerable to the threat posed by climate change. A study undertaken on behalf of the World Bank has identified the following possible risks to the Indian economy:

- A 2°C rise in the world's average temperatures can make India's summer monsoon highly unpredictable. An abrupt change in the monsoon could precipitate a major crisis, triggering more frequent droughts as well as greater flooding in large parts of India.
- A 2.5°C rise in warming, melting glaciers and the loss of snow cover over the Himalayas are expected to threaten the stability and reliability of northern India s primarily glacier-fed rivers, particularly the Indus and the Brahmaputra. The Ganges could be less dependent on melt water due to high annual rainfall downstream during the monsoon season.

Alterations in the flows of the Indus, Ganges, and Brahmaputra rivers could significantly impact irrigation, affecting the amount of food that can be produced in their basins as well as the livelihoods of millions of people (209 million in the Indus basin, 478 million in the Ganges basin, and 62 million in the Brahmaputra basin in the year 2005).

- A 4°C rise in warming would cause: An extremely wet monsoon that currently has a chance of occurring only once in 100 years is projected to occur every 10 years by the end of the century.
- The west coast and southern India are projected to shift to new, high-temperature climatic regimes with significant impacts on agriculture.
- Droughts are expected to be more frequent in some areas, especially in north-western India; Jharkhand, Orissa and Chhattisgarh.
- Crop yields could fall significantly because of extreme heat by the 2040s.

Literature Review:

Prasad, M. (2022), has done a study on "Hidden benefits and dangers of carbon tax" this paper Focuses on carbon tax that could produce a double dividend, reducing emissions at the same time increasing GDP by allowing other taxes to be lowered. Carbon tax, unlike other taxes, will produce less revenue as technologies improve and cleaner-burning fuels develop. If carbon taxes replace other taxes, over time the tax base of the state will wither, and the programs those taxes pay for will be threatened.

Larsen and Nesbakken (1997), comparing actual reported CO2 emissions against a hypothetical counterfactual. Show a decrease of household sector emissions in Norway by 3%-4% between 1991 and 1993, while (because of numerous exemptions) the tax was much less effective in the industrial sector, where emissions were reduced by 0.5% only.

Research Methodology:

This research is based on Secondary sources such as Published Research Papers, Articles, and Report published by various agencies. Theoretical analysis has been done in this paper. Database of several Govt. Departments, Progress report on various projects published on govt. portals have been used for this work.

Objective of the Study:

1. To analyse India's carbon emissions through the DICE Model.
2. To examine the carbon tax from an Indian perspective.

Analysis and Interpretation:

Carbon Tax:

A carbon tax is a tax that is explicitly / directly applied to the GHG emissions, including carbon emissions. Under this tax system, the taxpayer entities report their emissions on an annual basis and pay a tax for each ton of GHG emission. First introduced by Finland in 1990, the carbon tax has seen a growing interest in the recent years. Carbon tax is considered by some countries to be an effective, transparent and low cost means of inducing carbon abatement. It can lead to economy-wide reductions in the CO2 emissions. It is believed that putting a price on CO2 or taxing carbon can produce important co-benefits, for example reductions in air pollution or other negative side-effects of energy use or raising valuable public revenue. Across countries, carbon taxes may take different forms. They may be general taxes applicable to all goods or activities (e.g higher value-added taxes on polluting goods), or those that apply specifically to carbon-intensive goods, such as excise taxes/ duties on fossil fuels. As against these levies, carbon taxes directly put a price on GHG emissions, thus incentivising the taxpayers to reduce emissions, whether by opting for more efficient or cleaner fuels or changing their lifestyle.

India has taken a number of policies that contribute to climate mitigation by reducing or avoiding CO2 emissions. However, those responsible for carbon emissions do not actively monitor and limit their CO2 output. It would be important to identify the key sources of carbon emissions as, to the extent possible, carbon tax should directly be levied on the pollutant or action causing the environmental damage. Another important aspect would be how the carbon tax would interact vis-à-vis other current taxes on the sources of carbon emissions (primarily fossil fuels) such that the 'effective carbon tax burden' on the energy sector does not become excessive. The interaction of carbon tax with the non-fiscal measures such as subsidies for cleaner energy sources, prescribing efficiency standards, earmarking funds for research and development of cleaner technologies and so on, becomes important so as to ensure there are no counteracting measures. Besides providing economic incentives for making changes in usage of fuels, revenues collected from carbon tax can also be used by the society through the government to fund extensive research and development on novel green technologies that cannot be undertaken by individual businesses. India has a history of imposing specific cesses to fund different programmes, e.g., cess to fund highway development, cess for funding education etc. The outcome has been mixed. Therefore, utilisation of revenues from carbon taxes is an important aspect to be considered.

The design of carbon tax will involve interplay of several dimensions:

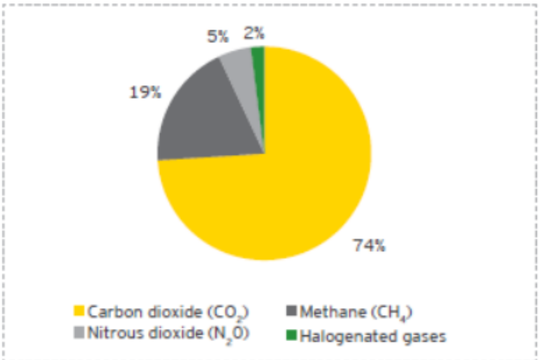
- The fuels or sectors to be taxed (tax base), exemptions if any and the point of incidence
- The level at which the carbon tax can be levied after taking into consideration the social cost of carbon emissions and the existing taxes – explicit or implicit (tax rate)
- The revenues from carbon tax and their application, i.e., whether for lowering other taxes or reducing subsidies or channelizing into clean energy resources
- The cost of administration and compliance and whether the existing administration mechanisms could be utilised for implementing carbon tax
- The possibility of carbon tax leading to any carbon leakage or a negative impact
- The possibility of combining tax with other fiscal and non-fiscal policy instruments to provide for an effective measure to address the problem of rising carbon emissions.

Greenhouse Gas Emissions:

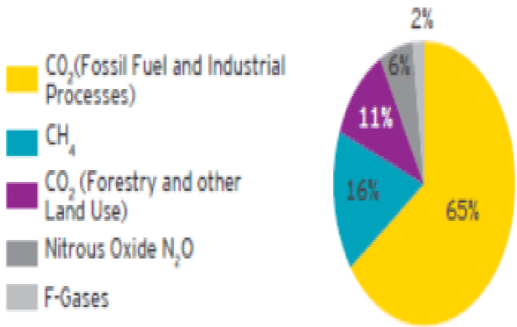
Greenhouse gas (GHG) emissions from anthropogenic factors/ economic activities are attributed to be the most significant factor leading to climate change. GHGs primarily comprise of six gases i.e., water vapour (H2O), carbon dioxide (CO2), nitrous dioxide (N2O), Methane (CH4), Sulphur hexafluoride (SF6) and Halocarbons (PFCs & HCFCs).

- CO2 originates mainly from the combustion of fossil fuels and biomass. Other sources of CO2 emissions are the result of direct human-induced impacts on forestry and other land use, such as deforestation, land clearing for agriculture and degradation of soils. The primary sources of methane are domesticated animals (e.g., dairy cows, pigs), and activities related to rice growing, gas flaring and mining. N2O mainly originates from agricultural land management, animal manure management, combustion of fossil fuels, and the production of fertilizers and nitric acid.
- CO2 emissions constitute more than 70% of global GHG emissions, thus giving rise to the global concerns about reducing carbon emissions and devising ways and means by which carbon emissions can be restricted and cleaner forms of energy can be promoted.

India's GHG Emission by Gas



Global GHG emission by Gas



Approaches for Measurement of Emissions:

Broadly, two methods or approaches are used for quantification of emissions, i.e., direct measurement approach and indirect measurement approach. Indirect measurement approach is also called as calculation based approach. In the direct measurement approach, emissions are recorded real time on the premises of the emitter using a measuring device that records emissions for auditing purposes. The calculation based approach, on the other hand, computes emissions by applying emissions factor to the quantity of the fuel used in an activity.

Emissions factor are important for arriving at reliable emission estimates. Emissions are calculated by multiplying the amount of consumption of the fuels with emissions factor. The product of the two gives the total emissions produced by a specific fuel in an economy for the period of consumption. Emissions factor are expressed in KgCO2/ton of fuel, i.e., kilograms of CO2 equivalent released by burning a unit ton of a specific fuel.

Direct emission computations are very difficult to undertake for an economy as a whole. Data for applying this method for estimating CO2 emissions is not available.

Indirect measurement approach to estimate emissions there are three broad ways to compute emissions under the indirect measurement method:

Scope/ Tier I formula is employed when detailed information on the break-up of fuel's heat or carbon content by volume is not available. This is the most basic calculation and due to the data used in calculation of scope I emissions; it is technology independent and represents averaged values of emissions.

Tier I

Emissions = Fuel (tonnes) * EF (tonnes CO_2/tonne of fuel)

Where, Emissions = Mass of CO_2, CH_4, or N_2O emitted

Fuel = Mass or volume of fuel combusted

EF = CO_2, CH_4, or N_2O emissions factor per unit mass or volume

Emissions = Activity Data * Emissions factor

(Fuel) (Volume of fuel) (Carbon Emitted per unit of fuel by Combustion)

Tier I formula has been considered for estimating carbon emissions. The choice has been driven by the following factors:

- Availability of reliable data and ease of computations.
- This formula is used for national carbon accounting by USA, UK, Australia and India as recommended by UNFCCC for calculation of national inventories of CO2.

Sources of Carbon Dioxide Emissions:

For the purpose of analysing the level of CO2 emissions in India, all the key fuels have been taken into consideration. In all, fifteen fossil fuels, biofuel and biomass were considered. Table 1 provides the list of the fuels and their consumption by different sectors; domestic sector, transport, energy, industry and agriculture.

We have not considered the emissions from Land Use, Land Use Change and Forestry (LULUCF) and emissions from domesticated animals like cows, buffalos, camels etc. Despite significant contribution to India's national emissions LULUCF and domestic animals are not accounted for, in national inventories, due to lack of reliable data.

Given below is the break-up and description of the sector that have been considered for estimating emissions in India, based on consumption.

Table 1: Sector-Wise consumption of Fuel

Fuels (In '000 Tonnes)	Domestic Distriution	Transport	Energy	Industrial	Agriculture	Misc.	Total Fuel	Emissions factors
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LPG	17,182	172.0	2.70	1,666	7.0	594	19,623	2,940
Naphtha	0	0.0	50.0	13,221	0.0	0.0	13,271	3,143
SKO (Kerosene)	6,649	0.0	0.0	64.00	0.0	113	6,826	3,165
High Speed Diesel Oil	0.0	71,514	224.0	2,279	630	0.0	74,647	3,210
Light Diesel Oil	0.0	3.70	154.0	63.00	1.30	185	407	3,210
Furnace Oil	0.0	380.00	430.0	5,616.00	57.00	0.0	6,482	3,227
Low Sulphur Heavy Stock/ Hot Heavy Stock	0.0	0.0	51.0	71.0	0.0	29	150	3,470
Motor Spirit (Petrol)	0.0	21,847	0.0	0.0	0.0	0.0	21,847	3,105
Aviation Turbine Fuel	0.0	6,262	0.0	0.0	0.0	0.0	6,262	3,181
Bitumen	0.0	0.0	0.0	5,938.00	0.0	0.0	5,938	3,16,541
Lubes and Grease	0.0	0.0	0.0	3,571.00	0.0	0.0	3,571	3,165.41
Natural gas	0.0	0.0	27,340	18,200.00	0.0	0.0	45,540	2,808.57
Coking Coal	0.0	0.0	0.0	2,03,949	0.0	0.0	20,39,49,000	1,782
Thermal Coal	0.0	0.0	5,55,324	37,902	0.0	81,763	67,49,89,000	1,782
Biofuels	0.0	0.0	505	0.0	0.0	0.0	505	0.0
Biomass	0.0	0.0	0.0	0.0	0.0	0.0	3,600	0.0

Emissions Factor:

The emissions factor considered are based on the following assumptions:

1. In the case of coal, diesel and motor spirit (petrol), emissions factor as provided in India's Economic survey have been considered.
2. For other fuels, UK emissions factor calculation has been employed due to the availability and reliability of standard international values for different fuels. We have considered average values for emission factors.

Table 2: Emissions produced by different sectors/ fuel wise; contribution to total national emissions:

Fuels (In '000 Tonnes)	Domestic Distriution	Transport	Energy	Industrial	Agriculture	Misc.	Total emissions (fuel wise) Million tonnes CO2 equivalent	Total CO_2 emissions (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LPG	50.51	0.51	2.7	1,666	7	594	19,623	2,940
Naphtha	0.0	0.0	50	13,221	0.0	0.0	13,271	3,143
SKO (Kerosene)	21.05	0.0	0.0	64	0.0	113	6,826	3,165
HSD(Diesel)	0.0	229.56	224	2,279	630	0.0	74,647	3,210
LDO	0.0	0.01	154	63	1.3	185	407	3,210
Furnace Oil	0.0	1.22	430	5,616	57	0.0	6,482	3,227
LSHS	0.0	0.0	51	71	0.0	29	150	3,470
Motor Spirit	0.0	67.83	0.0	0.0	0.0	0.0	21,847	3,105
ATF	0.0	19.92	0.0	0.0	0.0	0.0	6,262	3,181
Bitumen	0.0	0.0	0.0	5,938	0.0	0.0	5,938	3,16,541
Lubes	0.0	0.0	0.0	3,571	0.0	0.0	3,571	3,165.41
Natural gas	0.0	0.0	27,340	18,200	0.0	0.0	45,540	2,808.57
Coking Coal	0.0	0.0	0.0	2,03,949	0.0	0.0	20,39,49,000	1,782
Thermal Coal	0.0	0.0	5,55,324	37,902	0.0	81763	67,49,89,000	1,782
Biomass	0.0	0.0	505	0.0	0.0	0.0	505	0.0
Biofuels	0.0	0.0	0.0	0.0	0.0	0.0	3,600	0.0
Total Emissions (sector wise) million tonnes CO_2	71.56	319.06	1,069.32	584.73	2.23	148.50	2,195.40	100%
	3.26%	14.53%	48.71%	26.63%	0.10%	6.76%	100%	

Analysis of Table 2:

Coal contributes more than 70% of the CO2 emissions in India. It also makes up for 77% of the total power generation capacity in India. Coal is also extensively used in manufacturing industries in India. Diesel (including both high speed diesel and low density oil) is the second highest carbon emitter with 10.9% of the total emissions. Natural gas and motor spirit/petrol contribute 5.83% and 3% respectively to the total emissions in India. Other notable sources of emissions are LPG (2.63%), naphtha (1.90%), kerosene (0.98%), ATF (0.91%), bitumen (0.86%) and lubes (0.51%).

At an overall sectorial level, the energy sector is the highest contributor with 48.71% of CO2 emissions, followed by the industrial sector with 26.63% and transport with 14.53% contribution to the total emissions.

According to the global and Indian estimates, agriculture plays a larger part in contribution to total GHG emissions. However, the emission estimates given in Table 2 for agriculture are much lower than the international and national estimates. This discrepancy is because some elements such as land use changes, forestry and other land use under the category of agriculture have not been included in the overall estimates for calculation in table 2. Estimates of emissions are solely based on the consumption of selected fuels in the sector. Agriculture uses naphtha and furnace oil for production of fertilizer and diesel as transport fuel which have been accounted here. For instance, the diesel used in agriculture is considered under transportation rather than agricultural consumption due to lack of a reliable break-up of diesel consumption.

Determining the Carbon Tax Rate:

There could be different approaches to determine the carbon tax rate. The tax rate could be based on the amount of revenues the government may want to generate through carbon tax (revenue approach), or on the level of reduction in the quantum of emissions that the country wants to achieve (abatement approach), or the rate could be linked to the social costs of the emissions (social cost of carbon approach). Some jurisdictions also use the benchmarking approach for determining the rate of carbon tax wherein they link the rate to that being charged in other jurisdictions who may be neighbouring countries or trading partners or competitors.

Social cost of carbon (SCC) approach:

SCC is an estimate of the cost that the society bears from the emission of one tonne of CO2 or carbon equivalent emissions at a given point of time. Some of the costs associated with high levels of carbon emissions are costs to human health, damages to property from natural disasters such as more frequent floods and droughts, impact of changed pattern of climate on agricultural productivity, loss of ecosystem by extinction of species, shifting of tropical heat belts resulting in increased cost for air conditioning as against lower cost of heating, etc Social Cost of Carbon (SCC) estimates the monetary value of the above mentioned costs.

SCC also represents the value of damages that can be avoided through a reduction in emissions. Its estimation is therefore important not only for evaluating the net impact of GHGs on environment, both positive and negative, but also considering the level of emissions related taxation that can be considered. Using the SCC approach, the carbon tax rate is equated to the social cost of carbon. The SCC approach is useful as it helps balancing the costs and benefits of the measures for reducing CO2 emissions. The carbon tax is determined at the level where the costs of reducing the CO2 emissions equal the benefits from the reduction in the emissions.

It is dependent on a number of factors and assumptions such as level of emissions, the GHG concentration in the atmosphere, the valuation of the social damages, the discount rate and so on.

Models for estimating SCC:

The most accepted model globally for estimating the social cost of carbon is the Integrated Assessment Model (IAM). These estimates are widely used by global agencies like UNFCCC, and countries such as the United States. Interagency Working Group (IAWG) on Social Cost of Carbon (SC-CO2) in United States has been publishing SCC estimates under federal executive order 12866, since 2010.

While these models do not include all the damages caused by higher level of GHGs, they represent an accepted standard for approximation. It is important to point out that these models make a number of assumptions which make up for their inherent subjective nature with regard to parameters such as future levels of emissions of greenhouse gases, i.e.,

- The effects of past and future emissions on the climate system
- The impact of changes in climate on the physical and biological environment
- The translation of these environmental impacts into economic damages

Three models used in (Integrated Assessment Model) IAM's are Dynamic Integrated model for Climate and Economy (DICE), Policy Analysis of Greenhouse Effect (PAGE) and Climate Framework for Uncertainty, Negotiation and Distribution (FUND).

Methodology of calculating Social Cost of Carbon by Interagency Working Group

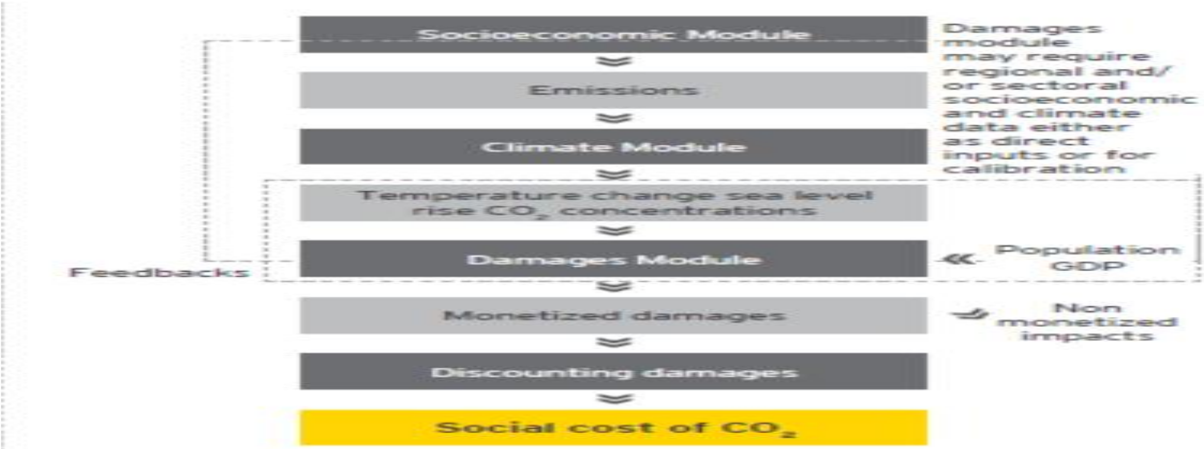
Integrated Assessment Models (IAM): IAWG employs three IAMs to arrive at an average value of SCC. Three models are:

- DICE (Dynamic Integrated Climate and Economy Model)
- PAGE (Policy and Analysis of Greenhouse Effect)
- FUND (Climate Framework for Uncertainty, Negotiation and Development)

The models differ in their initial assumptions, data used, mathematical models and approaches applied to translate temperature changes into economic damages. The key similarity of the three models is that they are relatively simpler compared to the myriad other climate damage models available and are relatively easier to comprehend. These models, translate changes in atmospheric greenhouse gas concentrations into temperature changes. Thereafter, the models estimate the impact of temperature changes on economic damages in terms of global and regional GDPs. IAMs75 use four modules or steps for estimation

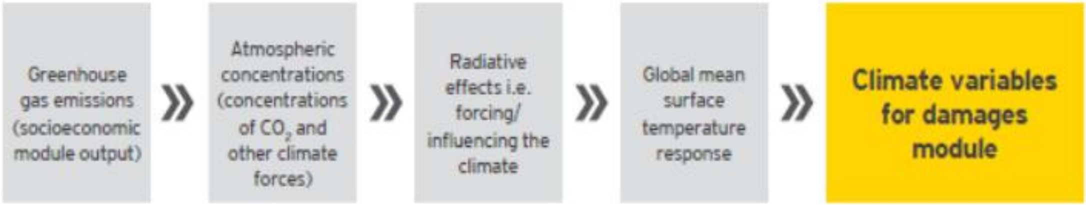
- Socio economic module
- Climate module
- Damages module
- Discounting

Socio Economic Module: This module estimates the population growth and economic parameters such as the GDP growth. Based on these estimates, future emissions are calculated. The estimates for emissions are used to compute the baseline climate trajectory. The baseline trajectory of emissions influences the response of the climate to a pulse of CO2 emissions. Population and GDP estimates are also used as direct inputs for the subsequent modules.



Climate Module: The climate module uses the outputs of the socioeconomic module such as the CO2 emissions and other climate influencing/forcing agents and estimates their effect on physical climate variables such as temperature, Precipitation, humidity, etc, over a period of time.

It is therefore important that the climate module accurately represents within a probabilistic context the current understanding of the climate and carbon cycle systems and the associated uncertainties. As mentioned earlier there is subjectivity involved in translating the impacts of climate change. Simple earth system models are used to translate the emissions and other variables into physical responses. Some of the key metrics used in the process are ECS (Equilibrium climate sensitivity), TCR (Transient climate response), TCRE (Transient climate response to emissions) and IPT (Initial pulse timescale)



Damages Module: The damages module estimates the physical impacts and, if possible, monetized damages based on the socio-economic variables (e.g., income and population) and physical climatic variables (e.g., changes in temperature and sea level) as estimated in previous modules. The Integrated assessment models for calculating social cost of carbon (SCIAMs) include damage representations that are either simple and global (e.g., global damages as a function of global mean temperature and gross world product), or are regionally disaggregated for a particular sector (e.g., agricultural damages as a function of regional temperature, precipitation change, CO2 concentrations and the economic value added or GDP of relevant sectors or regions).

Discounting Module: The discounting module estimates the present value of the future stream of monetized damage estimates through the use of a suitable discount rate. Since the impact of CO2 emissions in any particular year would persists for years to come, the value of avoiding those impacts depends on how much society discounts those future impacts. Due to the power of compounding, small differences in the discount rate can have large impacts on the estimated value of SC-CO2.

Abatement Approach:

The abatement approach is useful in the cases where the carbon tax aims to meet a specific emissions reduction target, for example, the targets promised in the NDCs under the UNFCCC. As opposed to balancing the cost and benefit of the carbon abatement measures, this approach determines the carbon tax for achieving a given level of reduction in the emissions.

India's NDC targets for 2030 include, among others, lowering of the emissions intensity of GDP by about 33–35% below 2005 levels.

No emission estimates have been made for biomass and biofuels owing to two factors:

- Non availability of reliable data for biomass since no breakup is available for the usage of fuels like cow dung, wood, crop residues, and other farm residues which are burnt as biomass, calculating emissions based on such vague information is difficult. Though the data for biofuels is available, but accounting only for biofuels and not for biomass would lead to double counting of emissions.

- Double counting: CO_2 is emitted and absorbed at various stages in a single process.

Formula of CO2 Emission

Tier I CO_2 Emissions= Fuel Consumption* Emission Factor

Total Emissions = 2195.40 million tones CO2

Carbon Pricing Estimates by Corporations Carbon Disclosure Project (CDP):

CDP 2016, is an annual disclosure of corporates approaching climate change and managing their carbon risk by pricing carbon internally. CDP is a non-profit organization running disclosure system for corporates and sub-national governments. Corporates across the globe anticipate that policies in the future can place a price on carbon. Companies are using an internal price of carbon to act as an incentive for allocating capital and resources towards low carbon activities. A number of companies have disclosed that through the usage of a carbon price, investments have shifted towards energy efficiency measures, low-carbon initiatives and development of low carbon product offerings.

Regions	Number of companies reporting	Lowest carbon price reported (US$)	Highest carbon price reported
North America (USA & Canada)	136	1	150
Europe	255	1.19	160.41
China	13	0*	6.17*
Japan	50	8.93*	893.29*
Australia and New Zealand	21	1.30*	36.75*
India	12	2.12*	29.41
Brazil	16	1.13	93
South Africa	22	0.47	9.26

Social Cost of Carbon for India:

India's SCC according to different models for standard:

The Dynamic Integrated model of Climate and the Economy (DICE) model, developed by William Nordhaus, make provisions for the calculation of a social cost of carbon. The DICE model defines the SCC to be "equal to the economic impact of a unit of emissions in terms of t-period consumption as numeracies".

Policy Analysis for Greenhouse Effect Model (PAGE)

Climate Framework for Uncertainty, Negotiation, and Distribution (FUND)

Index	Global SCC (US$)	India's SCC (%)	India's SCC(US$)
DICE 2010	40	12	4.8
PAGE	74	22	16.28
FUND	22	5	1.1
DICE2013R#	50	12[@]	6
DICE2016R#	87	12[@]	10.44

SCC for Various Regions:

The DICE model is a globally aggregated model. The RICE model, however, accounts for geographical variations.

Regions	RICE 2010, % global
United States	10
EU	12
Japan	2
Russia	1
Eurasia	1
China	16
India	12
Middle East	10
Africa	11
Latin America	7
Other High income	4
Other	12
Global (Total)	100

Conclusion:

India's regional SCC is calculated based on the DICE model. We refer DICE because it has been revised an updated in 2013 and again in 2016, which gives us the leverage to use updated data for calculating regional SCC of India. Assuming that India's contribution in global SCC estimates is equal to DICE2010 @ 12%, multiplying this percentage with DICE2016R latest values of global SCC yields (US$ 87), gives the value for India's regional SCC based on latest values of 2016 and updated/revised model of DICE. As per this methodology, India's social cost of carbon is taken at US$ 10.44 or, rounding off, at US$ 10.

Business as usual (BAU) model first used for fuel used and then projecting energy prices and GDP The impacts of policy reforms, including carbon tax, are then assessed by computing induced changes in fuel and electricity prices, the resulting changes in energy efficiency, use of energy products, and hence fuel demand. The resulting change in carbon emissions are calculated from the changes in fuel use.

The study analyses that between the years 2015 to 2030, India's real GDP is expected to expand rapidly (by over

7% a year), implying that it would be about three times as large in 2030 compared with 2015. During the same period, the total energy consumption would also expand, but at a much slower rate. The energy consumption would be about 85% higher in 2030 compared with 2015. As a result, the energy intensity of GDP would fall by 37% from 2005 levels. The decline in energy intensity is due to a combination of improving energy efficiency, rising fuel prices which dampen the growth in energy demand, and an assumption that income elasticity for energy products are slightly below unity.

The study further notes that the share of coal as an energy source is expected to rise between 2015 and 2030, while that of biomass declines, as thermal based electricity reaches more number of low income households that currently rely on biomass. As a result, the CO2 emissions are expected to rise by 112% between 2015 and 2030. Thus, in a BAU scenario, even as the overall energy intensity of GDP falls by 37%, the emissions intensity of India will fall only by 24% by 2030 compared to 2005 levels. The NDC target is to reduce the carbon intensity by 33-35% by 2030 as against the 2005 levels.

The study estimates that a carbon tax of US$ 10 per tonne of CO2 emission could further reduce the carbon intensity by 8% as against BAU levels. A higher carbon tax of US$ 35 per tonne of CO2 emission could reduce the emissions intensity by 22% against BAU levels. To avoid a sudden increase in tax burden and make it more acceptable for the stakeholders, the carbon tax could be increased in phases such that it reaches US$ 35 (INR 2,310) per tonne of CO2 emission by the year 2030.

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