Carbon Intensity-Himachal

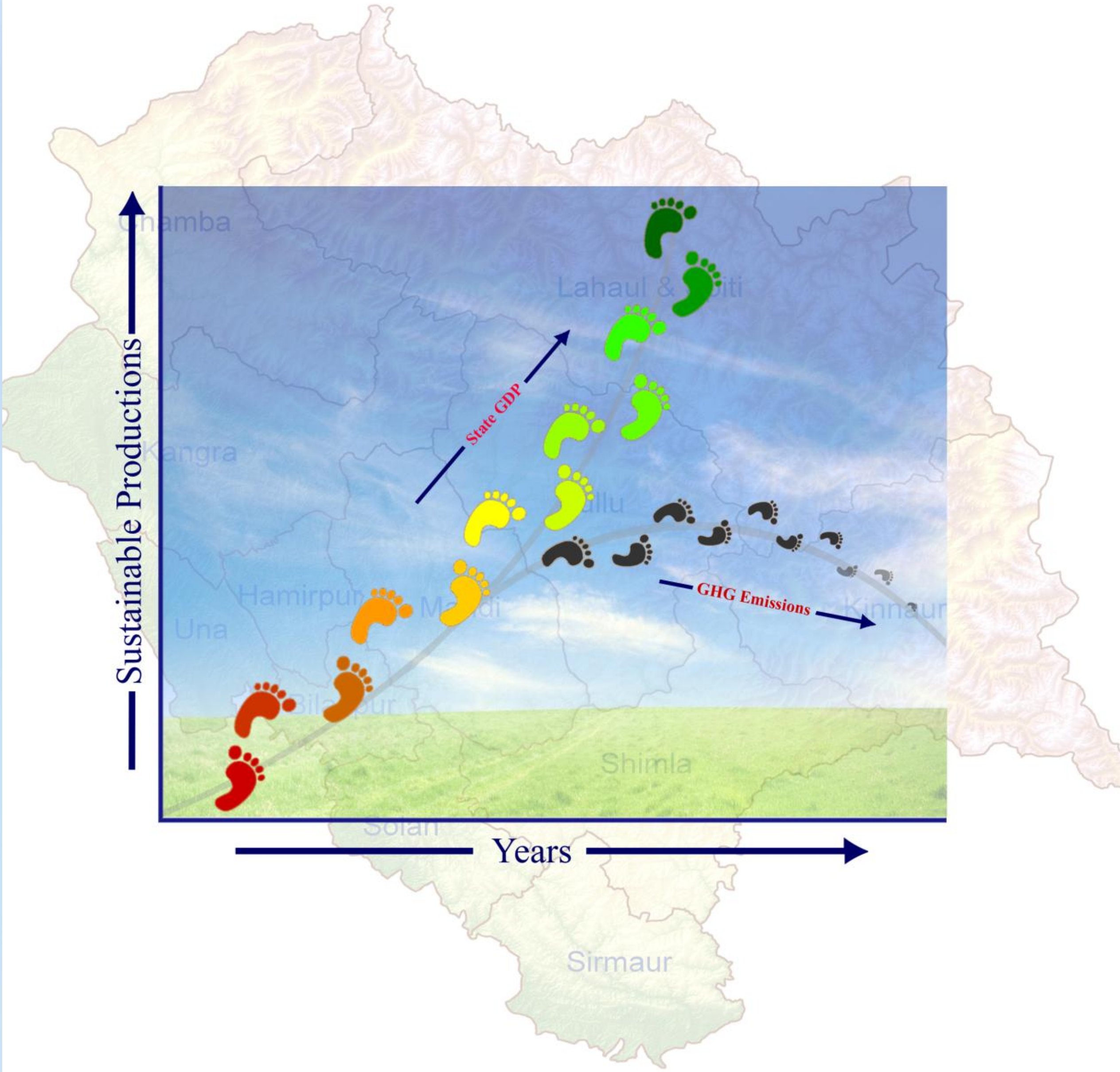
Green House Gas Emissions Inventory

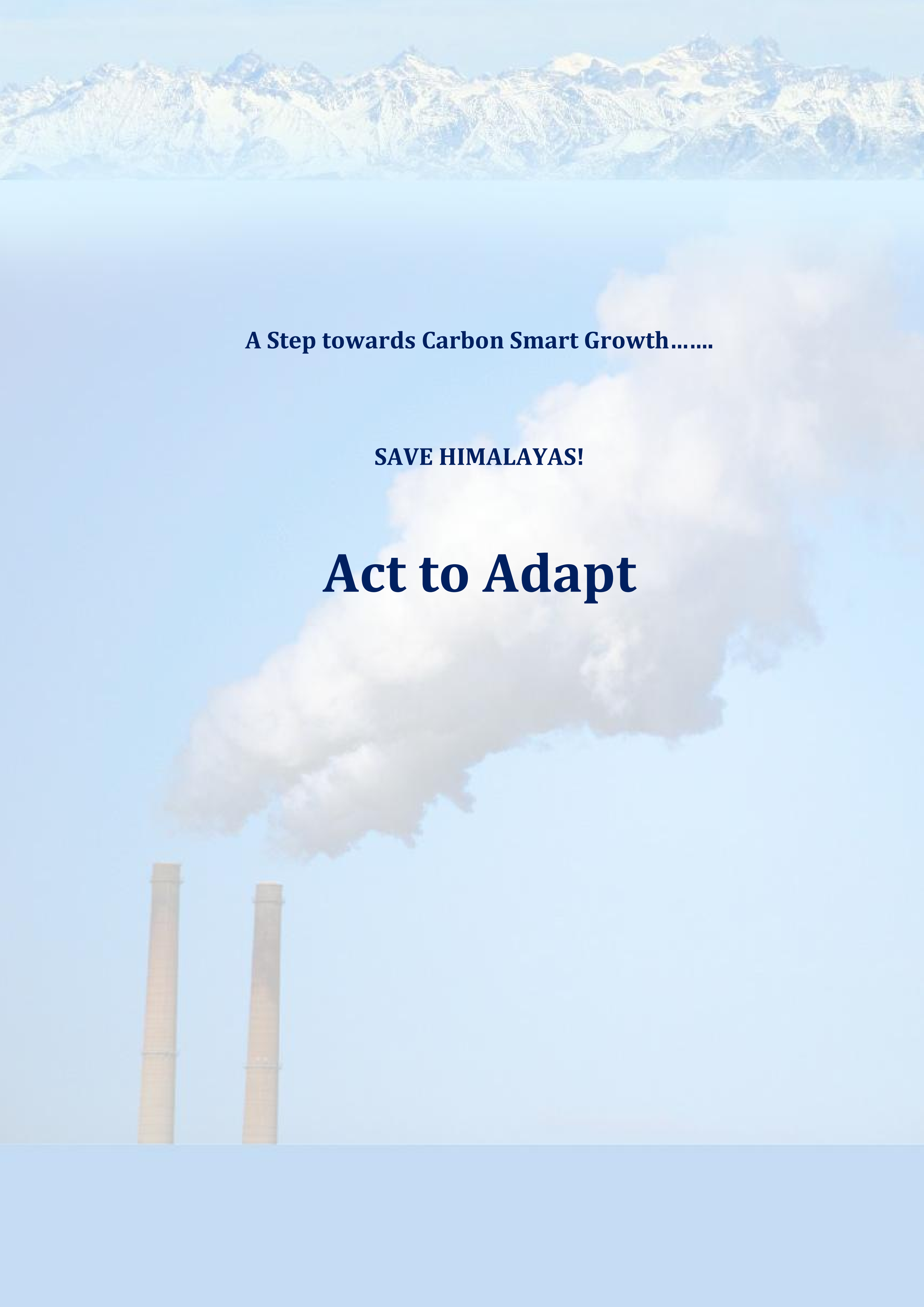
Himachal Pradesh

(Second Report based on 2012-2013 Activity Data)

Department of Environment, Science & Technology
Government of Himachal Pradesh

Carbon Intensity Himachal Pradesh



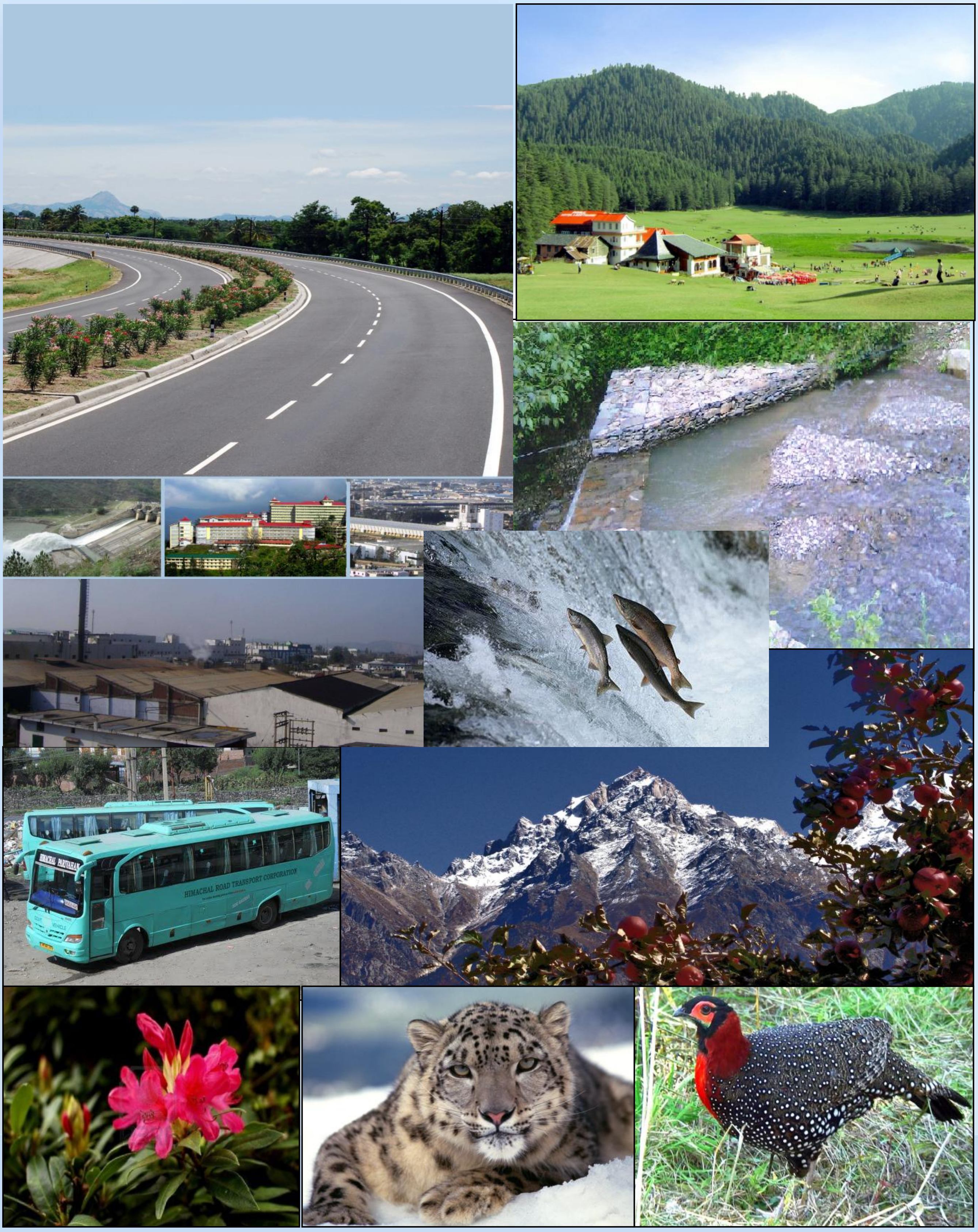


A Step towards Carbon Smart Growth…….

SAVE HIMALAYAS!

Act to Adapt

Committed for Inclusive Green Growth ....



GHGs- Global warming & climate change

Greenhouse gases have always been a natural part of the atmosphere of the earth, absorbing and re-radiating the sun's warmth and maintaining the Earth's temperature at a level necessary to support life. However, human activities are increasing the amount of the gases that trap heat. This is an enhanced greenhouse effect, which is contributing to the warming of Earth's atmosphere and surface.

The phenomenon of climate change phenomenon is very complex and is a result of activities that alter the composition of gases in the atmosphere. Undesirable and unwanted over exploitation of our natural resources has made this more complex. The terms 'global warming' and 'climate change' are often used interchangeably, but there is a difference. Global warming is the gradual increase of the Earth's average surface temperature, due to greenhouse gases in the atmosphere, whereas Climate Change is a broader term. The latter refers to long-term changes in climatic conditions, including changes in average temperature and rainfall due to global warming.

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, which is attributed directly or indirectly to anthropogenic activities that alter the composition of the global atmosphere and which are in addition to natural climatic variability observed over comparable time periods. It is the result of changes in our weather patterns because of an increase in the Earth's average temperature. This is caused by increases in greenhouse gases in the Earth's atmosphere. These gases soak up the heat from the sun but instead of the heat leaving the Earth's atmosphere, some of it is trapped, thus making the Earth warmer.

Climate change emerged on the political agenda in the mid-1980s with the increasing scientific evidence of human interference in the global climate system and with growing public concern about the environment. The United Nations Environment Programme (UNEP) and the World Meteorological Organizations (WMO) established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to provide policy makers with authoritative scientific information. In its first report in 1990, IPCC concluded that the growing accumulation of human made green house gases in the atmosphere would "enhance the green-house effect, resulting in an additional warming of the Earth's surface" by the next century, unless measures were adopted to limit emissions.

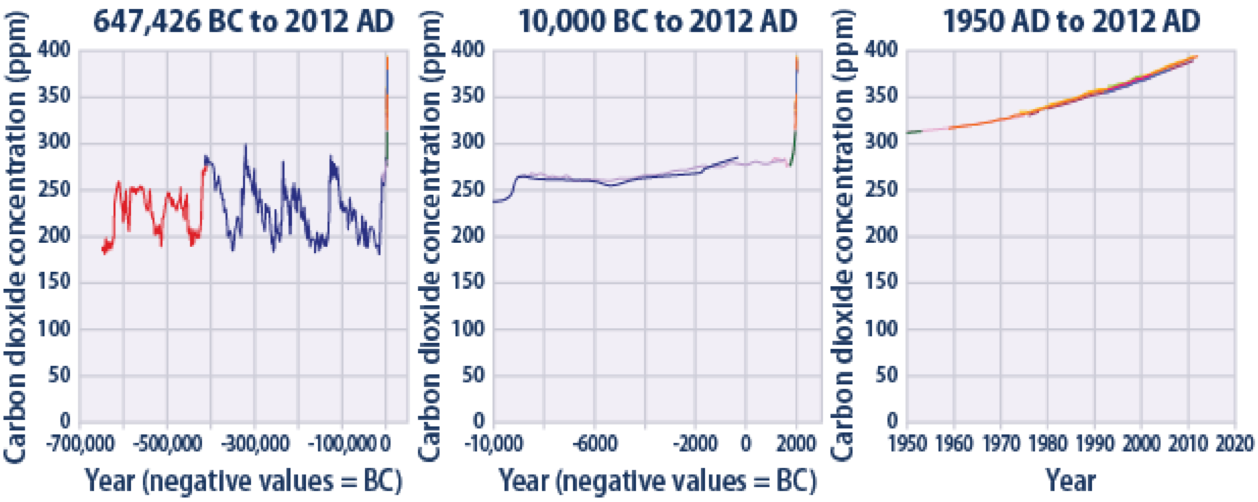
Climate change is a global problem that requires an internationally co-ordinated solution. 189 countries are Party to the United Nations Framework Convention on Climate Change (UNFCCC). Although the Kyoto Protocol (1997) to the UNFCCC was signed by over 170 countries requiring developed countries to reduce their emissions by 5.2% below 1990 levels in the period 2008-2012 as an essential first step towards stabilizing atmospheric concentrations of greenhouse gases, but consensus is still eluding the international fraternity.

The work of the Intergovernmental Panel on Climate Change (IPCC) represents the consensus of the international scientific community on climate change science. The IPCC is the world's most reliable source of information on climate change and its causes. Despite increasing consensus on the science underpinning predictions of global climate change, doubts have been expressed from time to time about the need to mitigate the risks posed by global climate change.

There will always be some uncertainty surrounding the prediction of changes in such a complex system as the world's climate. Nevertheless, the IPCC's conclusion that it is at least 90% certain that temperatures will continue to rise, with average global surface temperature projected to increase by between 1.4 and 5.8^{0}C above 1990 levels by 2100 is a matter of concern. This increase will be accompanied by rising sea levels, more intense precipitation events in some countries, increased risk of drought in others, and adverse effects on agriculture, health and water resources.

Concentrations of greenhouse gases are measured in parts per million (ppm), parts per billion (ppb), or parts per trillion (ppt) by volume. In other words, a concentration of 1 ppb for a given gas means there is one part of that gas in 1 billion parts of a given amount of air. For some greenhouse gases, even changes as small as a few parts per trillion can make a difference in global climate.

Global Atmospheric Concentrations of Carbon Dioxide Over Time



Data source: Compilation of 12 underlying datasets. See www.epa.gov/climatechange/science/indicators/ghg/ghg-concentrations.html for specific information.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.

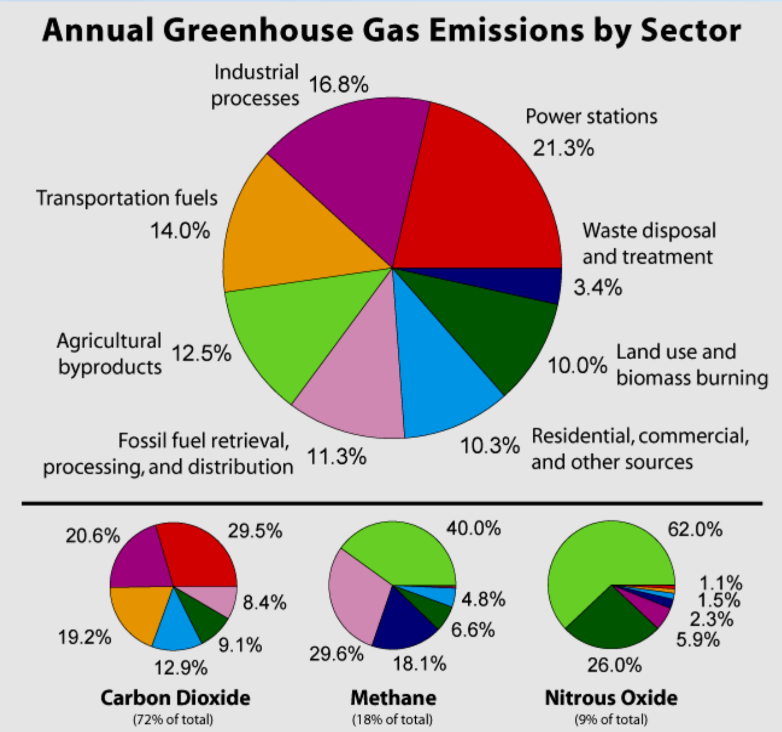
(This figure shows concentrations of carbon dioxide in the atmosphere for hundreds of thousands of years ago to 2012. The data come from a variety of historical ice core studies and recent air monitoring sites around the world. Each line represents a different data source, August 2013.)

Since the Industrial Revolution began in the late 1700s, the human race has added a significant amount of greenhouse gases into the atmosphere by burning fossil fuels, cutting down forests, and other activities (see the U.S. and Global Greenhouse Gas Emissions indicators). When greenhouse gases are emitted into the atmosphere, many remain there for long time periods ranging from a decade to many millennia. Over time, these gases are removed from the atmosphere by emissions sinks, such as oceans, vegetation, or chemical reactions. Emissions sinks are the opposite of emissions sources, and they absorb and store emissions or cause the gases to break down. However, if these gases enter the atmosphere more quickly than they can be removed, their concentrations increase and this leads to the process of climate change.

Sustainable development in an economically, socially and environmentally sound manner is the prime agenda of the State of Himachal Pradesh.

Global– GHG Emissions by Sector

The distribution of anthropogenic greenhouse gas emissions (for the year 2000) into 8 different sectors at Global level is:



This figure shows the relative proportion of man-made greenhouse gases coming from each of eight categories of sources, as estimated by the Emission Database for Global Atmospheric Research version 3.2, fast track 2000 project. These values are intended to provide a snapshot of global annual greenhouse gas emissions in the year 2000.

The top panel shows the sum over all man-made greenhouse gases, weighted by their global warming potential over the next 100 years. This consists of 72% Carbon Dioxide, 18% Methane, 8% Nitrous Oxide and 1% other gases. Lower panel shows the comparable information for each of these three primary greenhouse gases, with the same coloring of sectors as used in the top chart. Segments with less than 1% fraction are not labeled.

The seven sources of CO_2 from fossil fuel combustion are (with percentage contributions for 2000–2004):

Seven main fossil fuel combustion sources	Contribution (%)
Liquid fuels (e.g., gasoline, fuel oil)	36 %
Solid fuels (e.g., coal)	35 %
Gaseous fuels (e.g., natural gas)	20 %
Cement production	3 %
Flaring gas industrially and at wells	< 1 %
Non-fuel hydrocarbons	< 1 %
"International bunker fuels" of transport not included in national inventories	4 %

Climate Change Challenges - India

India is faced with the challenge of sustaining its rapid economic growth while dealing with the global threat of climate change. This threat emanates from accumulated greenhouse gas emissions in the atmosphere, anthropogenically generated through long-term and intensive industrial growth and high consumption lifestyles in developed countries.

National Action Plan on Climate Change released in year 2008 is a consolidated account of the country's position on climate change mitigation and adaptation. In line with the government's adopted policy of shared but differentiated responsibility the plan focuses of efficiency targets through well prioritized and established eight national missions which forms the core of the plan.

- National Solar Mission.
- National Mission for Enhanced Energy Efficiency.
- National Mission on Sustainable Habitat.
- National Water Mission.
- National Mission for Sustaining the Himalayan Ecosystem.
- National Mission for a "Green India".
- National Mission for Sustainable Agriculture.
- National Mission on Strategic Knowledge for Climate Change.

Green House Gas Emissions- India

The Indian Network for Climate Change Assessment (INCCA), a nation-wide network of127 research institutions working on science and impacts of climate change for the Ministry of Environment & Forests, Union of India, filed a report on **India's Greenhouse Gas Emissions 2007** in May, 2010. The report was released by Deputy Chairman, Planning Commission, Mr. Montek Singh Ahluwalia at an INCCA meeting, which made India the first "non-Annex I" (developing) country to publish such national numbers on global warming and climate change.

According to the report, India's ranking in 2007 w.r.t. aggregate GHG emissions in the world is 5th, behind USA, China, European Union and Russia. The report also points out that the 2007 emissions of USA and China are almost 4 times that of India. What is also highlighted in the report is that the emissions intensity of India's GDP declined by more than 30% during the period 1994-2007, which is largely attributed to the proactive efforts and policies being put in place by the Ministry of Environment & Forests, Union of India from time to time. The report mainly focuses on emissions from different sectors such as Energy, Industry, Land-use, Land-use Change and Forestry (LULUF) and Waste.

The net Greenhouse Gas (GHG) emissions from India, that is emissions with LULUCF, are reported to be 1727.71 million tons of CO_2 equivalent (eq) in 2007. Out of this, CO_2 emissions were 1221.76 million tons; CH_4 emissions were 20.56 million tons; and N_2O emissions were 0.24 million tons. The largest percentage of GHG emissions (58%) is from the Energy sector followed by Industry, Agriculture and Waste sectors in that order. Within the Energy sector, 65.4% of total CO_2 eq were emitted from electricity generation while the transport sector contributed to 12.9 % of the total CO_2 eq. The report also points out that for the estimation year 2007, LULUCF sector was a net sink. It sequestered 177.03 million tons of CO_2.

The report calculates India's per capita CO_2eq emissions including LULUCF for the assessment year 2007 at 1.5 tons/ capita. The report is also a step further towards incorporating the 3 M's" – Measurement, Modeling and Monitoring in the essence of formulating policies on climate change.

Existing GHG Emissions by Sector (Transport, Buildings, Industry, Waste, Agriculture & Forests) and Sub-sectors.

	Annual CO_2 emissions (eq) (In thousands of metric tonnes) Giga Gram	**Percentage of Global total**
India	17,27,706.10	<5% of global

Carbon dioxide Emissions (CO_2), metric tons of CO_2 per capita (CDIAC)

Rank	***Country***	***1990***	***1991***	***1992***	***1993***	***1994***	***1995***	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***
145.	*India*	*0.8*	*0.8*	*0.9*	*0.9*	*0.9*	*1*	*1*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*	*1.2*	*1.2*	*1.2*	*1.3*	*1.4*

Rank of India (out of total 215 countries) *the data presented above corresponds to emissions in 2007. The data was collected in 2008 by the CDIAC for the United Nations. It only considers carbon dioxide emissions from the burning of fossil fuels and cement manufacture, but not emissions from land use such as deforestation.*

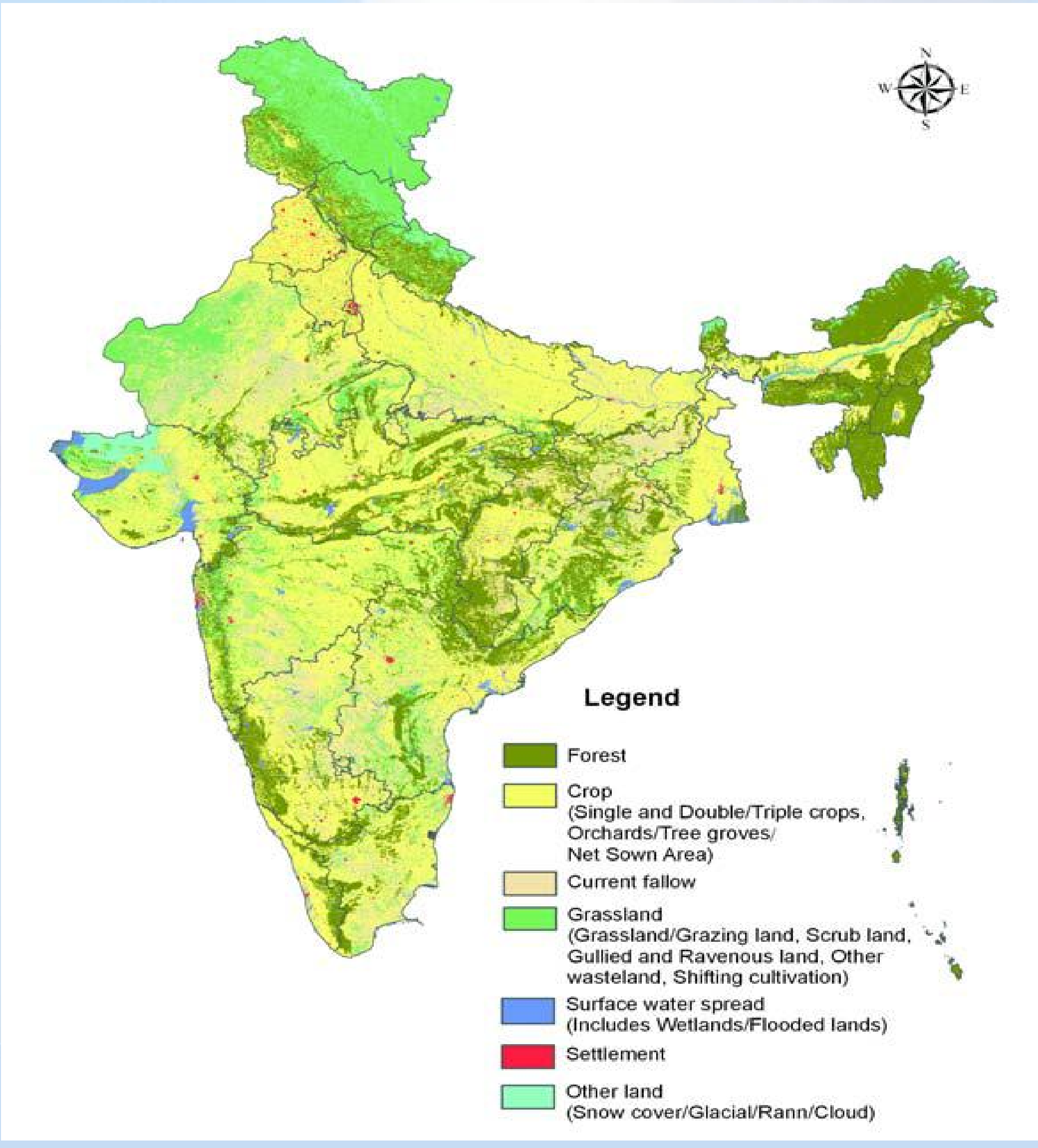
(Emissions by Sources and Removal by Sinks during 2007 (In thousand tons)

	CO_2 emissions	CO_2 removal	CH_4	N_2O	CO_2 equivalent
GRAND TOTAL	**1497029.20**	**275358.00**	**20564.20**	**239.31**	**1727706.10**
ENERGY	**992836.30**		**4266.05**	**56.88**	**1100056.89**
Electricity generation	715829.80		8.14	10.66	719305.34
Other energy industries	33787.50		1.72	0.07	33845.32
Transport	138858.00		23.47	8.67	142038.57
Road transport	*121211.00*		*23.00*	*6.00*	*123554.00*
Railways	*6109.00*		*0.34*	*2.35*	*6844.64*
Aviation	*10122.00*		*0.10*	*0.28*	*10210.90*
Navigation	*1416.00*		*0.13*	*0.04*	*1431.13*
Residential	69427.00		2721.94	36.29	137838.49
Commercial / Institutional	1657.00		0.18	0.04	1673.18
Agriculture/ Fisheries	33277.00		1.20	1.15	33658.70
Fugitive emissions			1509.40		31697.30
INDUSTRY	**405862.90**		**14.77**	**20.56**	**412546.53**
Minerals	**130783.95**		**0.32**	**0.46**	**130933.27**
Cement production	129920.00				129920.00
Glass & ceramic production	277.82		0.32	0.46	427.14
Other uses of soda ash	586.12				586.12
Chemicals	**27888.86**		**11.14**	**17.33**	**33496.42**
Ammonia production	10056.43				10056.43
Nitric acid production				16.05	4975.50
Carbide production	119.58				119.58
Titanium dioxide production	88.04				88.04
Methanol production	266.18				285.37
Ethylene production	7072.52		0.91		7270.64
EDC & VCM production	198.91		9.43		198.91
Ethylene Oxide production	93.64				97.71
Acrylonitrile production	37.84		0.19		37.98
Carbon Black production	1155.52		0.01		1156.07
Caprolactam			0.03		336.22
Other chemical	8800.21				8873.97
Metals	**122371.43**		0.56	1.08	122736.91
Iron & Steel production	116958.37		**0.95**	0.20	117315.63
Ferroalloys production	2460.70		0.85	**1.11**	2462.29
Aluminum production	2728.87		0.08	1.09	2729.91
Lead production	84.13		0.01		86.38
Zinc production	76.11		0.00	0.00	77.99
Copper	63.25		0.00	0.01	64.70
Other Industries	**123969.17**		0.01	0.01	124530.44
Pulp and paper	5222.50		**2.37**	0.00	5248.35
Food processing	27625.53		0.05	**1.65**	27717.25
Textile and leather	1861.11		1.12	0.08	1867.94
Mining and quarrying	1460.26		0.03	0.22	1464.62
Non-specific industries	87799.77		0.06	**239.31**	88232.28
Non energy product use	**849.49**				849.49
Lubricant					776.75
Paraffin wax					72.75
AGRICULTURE		**275358.00**	**13767.80**	**146.07**	**334405.50**
Enteric fermentation		67800.00	10099.80		212095.80
Livestock Manure management		207520.00	115.00	0.07	2436.70
Rice cultivation			3327.00		69867.00
Burning of crop residue		**275358.00**	226.00	6.00	6606.00

	CO_2 emissions	CO_2 removal	CH_4	N_2O	CO_2 equivalent
LULUCF		67800.00			**-177028.00**
Forestland		207520.00			-67800.00
Cropland	**98330.00**				-207520.00
Grassland		38.00			10490.00
Settlement		**275358.00**			-38.00
Wetland					NE
Other land	10490.00				NO
Fuel wood use in forests					87840.00
Waste	NE				**57725.18**
Municipal Solid waste	NO				12694.71
Domestic waste water	87840.00		**2515.58**	**15.80**	22980.47
Industrial waste water			604.51		22050.00
Bunkers*			861.07	15.80	**3484.45**
Aviation Bunkers			1050.00		3355.31
Marine bunkers			**0.03**	**0.10**	129.14

Source: INCCA Report-2007

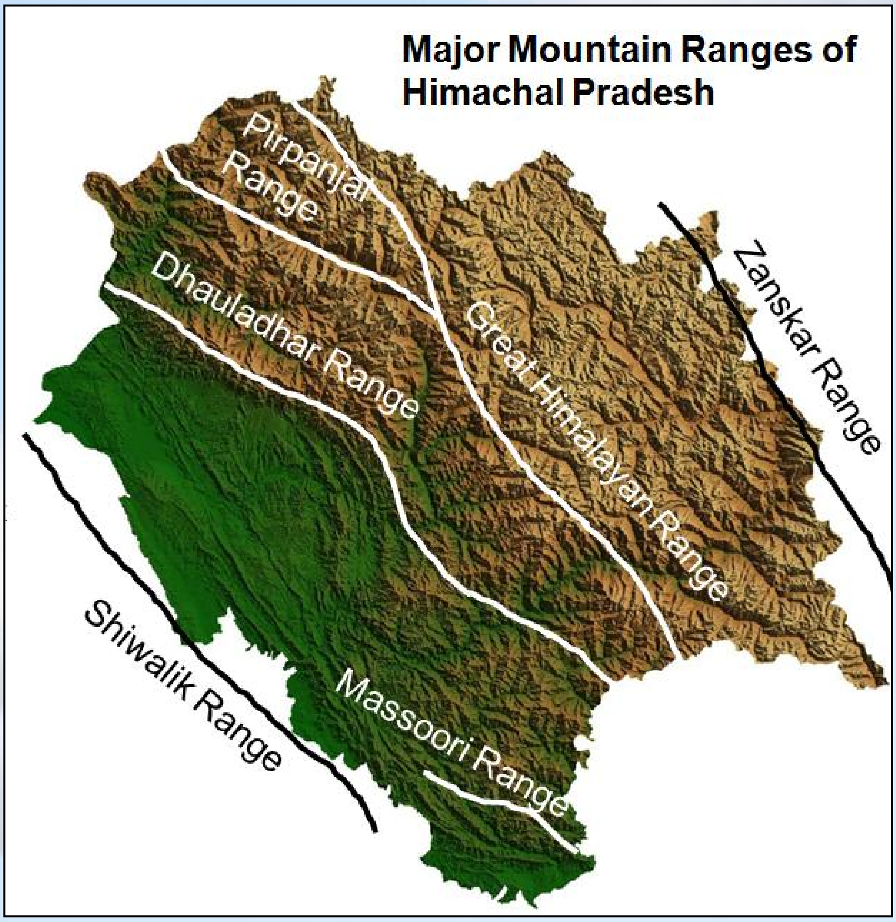
Note: LULUCF: Land Use Land Use Change & Forestry.
* Not included in the National totals.
NE: Not estimated; NO: Not Occurring.



Himachal Pradesh- **an introduction**

Located in the western Himalayas, Himachal Pradesh is in an ecologically sensitive zone. It is the home to thousands of species of plants and animals many of them endemic to the State. Covering an area of 55,673 kilometers (34,594 mi), Himachal Pradesh is a mountainous state with elevation ranging from about 350 meters (1,148 ft) to 6,000 meters (19,685 ft) above the sea level.

It comprises of different eco-physio graphic zones:



1. ***SHIWALIK HILL ZONE** : Climate Sub Tropical, consists of foothills and valley area adjoining to the plains. It occupies about 35% of the geographical area and about 40% of the cultivated area of the State. The major crops grown in this Zone are Wheat, Maize, Paddy, Gram, Sugarcane, Mustard, Potato, Vegetables etc.*

2. ***MID HILL ZONE**: This zone made up of the middle Himalayas region having mild temperate climate. It occupies about 32% of the total geographical area and about 37% of the cultivated area of the State, The major crops are Wheat, Maize, Barley, Black Gram, Beans, Paddy etc. This zone has very good potential for the cultivation of cash crops like Off-Season Vegetables, Ginger and production of quality seeds of temperate vegetables like cauliflower and root crops.*

3. ***HIGH HILL ZONE** : This zone consists of the higher Himalayas regions with humid temperate climate and alpine pastures. It covers about 35% of the geographical areas and about 21% of the cultivated area of the State. The commonly grown crops are Wheat, Barley, Lesser Millets, Pseudo-cereals (Buckwheat and Amaranthus), Maize and Potato etc. The area is ideally suited for the production of quality seed Potato and Temperate Vegetables. This zone possesses good pastures and meadows.*

4. ***COLD DRY ZONE** : It comprises of Lahaul-Spiti and Kinnaur Districts and Pangi Tehsil of Chamba District forming part of the cold desert. It occupies about 8% of the geographical and 2% of the total cultivated area of the State. The major crops grown are Wheat, Barley, Pseudo-cereals like Buck wheat and Amaranthus. It is ideally suited for the production of quality Seed Potato, Temperate and European type of Vegetables and their Seeds, Seed Potato, Peas as green and seed purposes.*

Himachal Pradesh plays a vital role in sustaining life in northern India as it provides ecological security including critical watershed services, biodiversity conservation, carbon sequestration and maintaining the landscape.

Initiatives of Himachal Pradesh –
Tackling threat of Climate Change

Government of Himachal Pradesh with long-term commitment towards environmental sustainability is following the path of green growth and sustainable development. Himachal Pradesh is richly endowed with natural resources and this program is designed to unleash the state's comparative advantage of generating growth through improved stewardship of its natural assets. The economy of HP, like that of other "hill states" in India, is highly dependent on the sound management of its natural resources – in particular its abundant water supplies, fertile soils, forests and biodiversity.

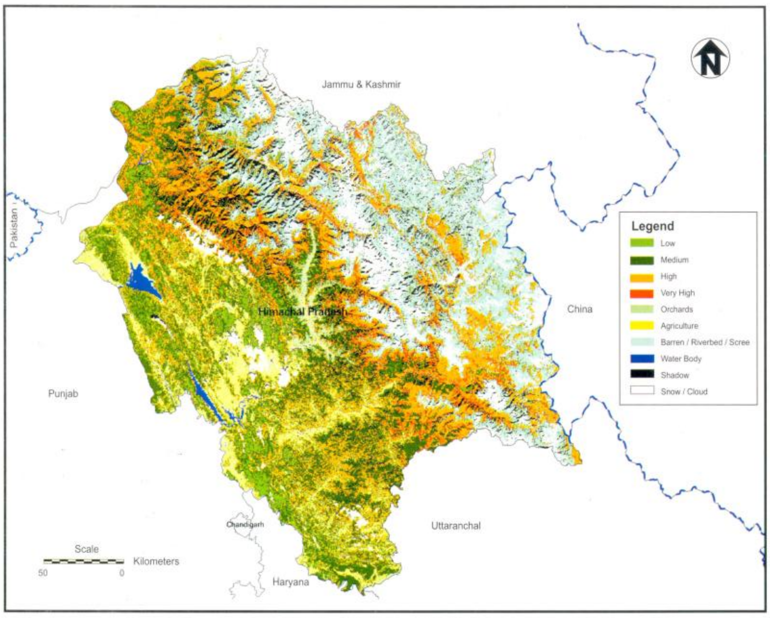


Fig. 55. Biological Richness map of Himachal Pradesh

To address these issues, the Government of Himachal Pradesh (GoHP) is working with various national and international agencies to develop economic engines – energy, industry and tourism – in a socially and environmentally sustainable manner.

Formulation and Implementation of State Strategy and Action Plan on Climate Change: To deal with impacts of climate change a comprehensive action plan has been prepared in the State.

Setting up of State Centre on Climate Change: The H.P. State Centre on Climate Change has been set up within the Department of Environment, Science & Technology to steer the state's efforts to tackle the threat of climate change.

Green roads to eliminate the excess of plastic waste in a sustainable and cost-efficient manner. All the plastic waste was collected, treated, and utilized as construction material for building roads across the state. With this project the GoHP not only efficiently recycled plastic waste but also identified an effective way to significantly reduce the costs of road construction.

Green Buildings: The Government has initiated process for bringing energy efficiency, carry out waste audit and water audit etc. Use of energy efficient devices and making efforts to reduce the consumption of energy and promoting use of solar passive technologies. The solar passive designs have been made mandatory in the State.

Water Harvesting: The provision for Rain water harvesting has been made compulsory. Various programmes support the construction of water harvesting structures in the State.

Promoting environmental sustainability: Natural Capital Accounting: HP's natural capital is among the highest in India. A system of natural capital accounting is being developed.

Biodegradable packaging and bags: In order to protect its rich ecosystem from plastic waste, the GoHP has designed and implemented ambitious environmental regulations. Since 1995, with the Non-Biodegradable Garbage Control Act the government has banned the use of plastic bags in the State.

Environment Master Plan: The Government has prepared comprehensive EMP for the State, wherein spatial vulnerability assessment has been undertaken. Sectoral vulnerability has been assessed at tehsil level with respect to water, air, land, natural critical habitats, climate change, hazard susceptibility, spatial areas of conflict, quality of life (health) and quality of life (education). Sectoral guidelines for all key stakeholder departments have been developed for integrating environmental protection agenda in their policy, programme and plan.

Promoting Social Sustainability: Benefit Sharing Mechanism: Communities living near hydropower projects often have to bear some of the project's negative environmental impacts. Local Area Development Committees (LADC) that include representatives from the district administrative bodies, local governments, and project developers are set up and innovative benefit-sharing mechanism have been developed and are being implemented.

Organic agriculture: Over the past decade the agricultural sector in HP has grown at an average annual rate of 5.7%. In order to ensure that this growth remains sustainable and does not impact the rich natural resources of the state, the GoHP has successfully designed and implemented a comprehensive policy that promotes organic agriculture.

Green tourism: Economic development in hill states is affected by poor market access, rugged topography and higher transport costs. To preserve the environment and unleash the state's economic potential, the GoHP is implementing policies that attract investments in green tourism and environmentally friendly businesses.

Cumulative Environment Impact Assessment: The State Government is preparing the Cumulative Environment Impact Assessment reports of the five key river basins in Himachal Pradesh in view of hydropower development pressure and accordingly to take required measures for sustainable development in these basins.

Through State Climate Change Centre various activities are being under taken such as;

- Launch of Geo-Portal of Himachal Pradesh covering Lithology, Landuse/ Land cover, Geomorphology, Drainage, Soil, Watershed, Seismic Zones etc.
- Multi hazard and flood Hazard Mapping of Soan River catchment in Una district, for the management of floods in the Soan catchment.
- Preparation of a draft document on most vulnerable plant, animal diseases induced by climatic variations.
- Earthquake precursor studies in the Punjab Re-entrant part based on Radon in soil and water using RAD 7 and BAROSOL which is a R&D work.
- Molecular characterization, Distribution Pattern and Food plant Resources of Butterflies(Lepidoptera) of Chirpine forests of Himachal Pradesh
- Estimation of Carbon Stock under different land use classes of district Mandi.
- Climate Change Impact on the Wetlands of Himachal Pradesh.
- R&D work on the health hazard based on Radon sampling in SCSTE premises
- Monitoring of glacial lakes of Satluj Catchment as part of disaster preparedness.
- Monitoring of Parechhu Lake as part of the DM activities
- Snout monitoring and mapping of Nardu Glacier, Baspa basin, District Kinnaur
- Seasonal snow cover mapping for

Green House Gases Inventory
Himachal Pradesh

Himachal Pradesh is one of the few States in the country to have conducted State level inventory of Green House Gases. The first report was released in 2012 using 2008-09 activity data. The salient features of the second report prepared using year 2012-13 activity data is presented below:

	Annual CO_2 emissions (eq) (in thousands of metric tonnes) Giga Gram	**Percentage of Global total**
India	17,27,706.10 (2007 levels)	<5% of global
Himachal Pradesh*	**9196.4748*** ~0.00134 per capita 000'tones* (2012 levels)	~0.53% of India*

** without taking into consideration emission/ removals due to hydro power generation 7957.29 MW contributed to grid as clean energy. ~ (-)* 17094.74000'tons CO_2 eq @ ~45% operational capacity.

This assessment provides information on Himachal Pradesh's emissions of Green House Gases (Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O) emitted from anthropogenic activities at state level from: Energy; Industry; Agriculture; Waste; and Land Use Land Use Change & Forestry (LULUCF).

Existing GHG emissions have been analyzed by sector and sub-sectors (viz; Transport, Buildings, Industry, Waste, Agriculture and Forest).

Green House Gas Emissions by Sources and Removal by Sink (with LULUCF) from Himachal Pradesh in 2012-13 (000'tons) Giga Grams.

(Following IPCC convention of calculating GHGs footprint at source of production and not consumption)

Sr. No.	Type	GHG (000'tones) G grams			
		CO_2	CH_4	N_2O	CO_2 eq
A.	**Electricity/ Energy**				
1.	Captive Generation and Consumption	243.484	0.01246	0.000505	244.024
2.	**Transport**				
a.	Road	714.505	0.0131	0.003488	716.002
b.	Railways	0.0012	-	-	0.0014
c.	Aviation	0.0011	-	-	0.0012
3.	**Others**				
a.	Residential	1129.554	4.4053	0.5908	1405.213
b.	Industrial/ Commercial/ Institutional/ Bulk mics.	2730.185	0.2968	0.06587	2756.838
c.	Agriculture	24.552	0.00088	0.00087	24.840
Total	**A**	**4842.2823**	**4.72854**	**0.661533**	**5146.9196**
					B. Industry
1	**Mineral**				
a.	Cement Production	5310.93	-	-	5310.93
b.	Glass Production	0.89226	-	-	0.89226
2	**Chemical**				
a.	Carbide Production	19.884	-	-	19.884
b.	Methanol	3.979	0.001366	0.00659	6.0510
3	**Metal**				
a.	Ferroalloys	61.950	0.002985	-	62.0130
b.	Aluminum	148.880	0.000545	-	148.891
C.	Lead (Secondary Production)	22.142	-	-	22.142
d.	Zinc production	0.0025	-	-	0.0025
4	**Other Industries**				
a.	Pulp & Paper	0.02173	0.00000021	0.000000314	0.02180
b.	Textile & Leather	0.01336	0.00000072	0.0000053	0.01350
c.	Food Processing	0.04097	0.00000036	0.000000084	0.04102
d.	Mining and Quarrying	0.0023	-	-	0.0023
Total	**B**	**5568.73812**	**0.004897**	**0.0065957**	**5570.88438**

Sr. No.	Type	GHG (000'tones) G grams			
		CO_2	CH_4	N_2O	CO_2 eq
A.	**Agriculture**				
1.	Enteric fermentation	-	0.12104	-	2.542
2.	Manure management	-	0.00138	0.00000076	0.0292
3.	Rice cultivation	-	7.0445	-	147.9936
4.	Crop residue	-	0.4650	0.03886	21.812
5.	Soils	-	-	0.00183	0.5670
Total	**C**	**-**	**7.6319**	**0.040691**	**163.9438**
D	**Land Use, Land Use Change & Forestry**				
1.	Forestland	(-)3040.40	**-**	**-**	(-)3040.40
2.	Cropland	(+)76.060	**-**	**-**	(+)76.060
3.	Grassland	(-)40.336	**-**	**-**	(-)40.336
4.	CO_2 loss due to fuel wood use	(+)1319.40	**-**	**-**	(+)1319.40
Total	**D**	**(-)1685.276**	**-**	**-**	**(-)1685.276**
E	**Waste**				
1.	MSW	**-**	1.0489	-	**-**
2.	Industrial Waste Water	**-**	0.001441	-	0.0030
Total	**E**				
Grand Total A+B+C+D+E	**2012-13 (2nd report)**	**8725.744**	**13.41568**	**0.70882**	**9196.4748**
	2008-09 (1st report)	**8974.437**	**11.60369**	**0.608734**	**10082.87**

Methodology Adopted for Estimation of GHGs Emissions

The estimated volume of the Greenhouse Gas emissions in Himachal Pradesh have been calculated out as per the standard methodologies contained in IPCC Guidelines (IPCC 1997, 2000 and 2003):

$$Emissions_{gas} = \Sigma_{category} A \times \text{Emission Factor (EF)}$$

Where; $Emission_{gas}$ is the emissions of a given gas from all source categories.
A is amount of individual source category utilized that generate emissions.
EF is the emission factor of a given gas as per type of source category.

The source of the activity data taken for deriving calculations is primarily taken from the published documents of different organizations in the State and studies carried out in the State by different organizations such as HP State Council for Science, Technology & Environment, HP State Pollution Control Board, Transport Department, Department of Economic and Statistics, HP State Electricity Board, Department of Forests and Department of Agriculture etc. The emission factors used in calculations have also been drawn from the INCCA country specific references available in IPCC publications. The methodology tier level is also a mix type.

Following sectors have been considered in the State contributing for GHGs emissions:

Energy, Industry, Agriculture, Land Use, Land Use Change * Forest (LULUCF) and Waste.

The emission reductions by the project activity (ER_y) during a given period of year y are the product of the baseline emissions factor (EF_y, in tCO_2e/MW) times the electricity supplied by the project to the grid at the same period of year y (EG_y, in MW), as follows: *(*ref. Cachoeira Encoberta*).

$$ER_y = EF_y \cdot EG_y$$

As in all scientific endeavors; any estimate provided is necessarily contingent upon the availability of data and information. Over time the coefficients will be refined, methodologies and data sources improved therefore, it is anticipated that there will be adjustments in future iteration, to keep pace with scientific convention and good practice.

Methodology Tiers:

Tier 1 approach employs activity data that are relatively coarse, such as nationally or globally available estimates of deforestation rates, agricultural production statistics, and global land cover maps.

Tier 2 use the same methodological approach as Tier 1 but applies emission factors and activity data which are defined by the country.

Tier 3 approach uses higher order methods are used including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by disaggregated levels.

Key Findings

- The net Green House Gas (GHG) emissions from Himachal Pradesh that is emissions with LULUCF, for activity data base for year 2012-13 were 9.197 million tons of CO_2 equivalent (eq) in comparision of 10.083 million tons in 2008-09. During the year 2012;
    - CO_2 emissions were 8.73 million tons;
    - CH_4 emissions were 0.134 million tons; and
    - N_2O emissions were 0.0070 million tons.
- GHG emissions from Energy, Industry, and Agriculture sectors constituted 47.299% (5146.9196 Gg), 51.195% (5570.8844 Gg), 1.506% (163.9438 Gg)) of the net CO_2 eq emissions respectively. The contribution of Waste sector is marginal.
- Energy sector emitted 5.15 million tons of CO_2 eq, of which 2.756 million tons of CO_2 eq were emitted from electrcity consumption in Industrial, Commercial and Institutional sectors and 1.405 million tons of CO_2 eq were emitted from energy consumption in Residential sector.
- Industry sector emitted 5.57 million tons of CO_2 eq.
- LULUCF sector was a net sink. It seqestrated 1.68 million tons of CO_2 eq.
- Himachal Pradesh per capita CO_2eq emissions including LULUCF showed a decreasing trend and were 1.341 tons/ capita in 2012 that of 1.47 tons/ capita levels in 2008-09.

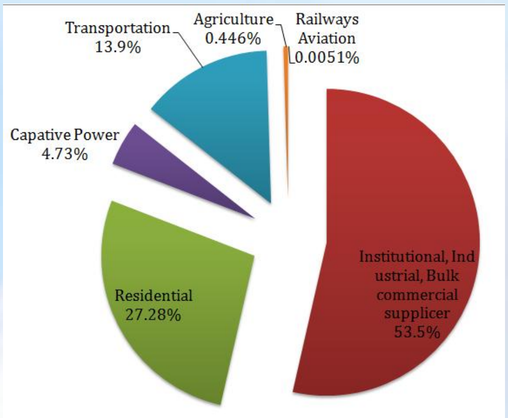
Comparison of CO_2eq emissions by sector from Himachal Pradesh with National estimates for 2007 (INCCA Report) in million tons:

Analysed Source of Emission	GHGs at National (2007, INCCA Report)	2009		2012	
		GHGs Himachal Pradesh estimates	Percentage of Nation (%)	GHGs Himachal Pradesh estimates	Percentage of Nation (%)
Electricity Generation (Other than Hydro)	719.30	0.359	0.1	0.244	**0.034**
Transportation	142.04	0.667	0.47	0.716	**0.50**
Residential	137.84	1.81	1.31	1.405	**1.02**
(Industrial, Commercial, mics.) Other Energy	100.87	3.23	3.20	2.757	**2.73**
Cement	129.92	5.17	3.98	5.311	**4.09**
Iron & Steel	117.32	0.281	0.24	0.167	**0.14**
Other Industries	165.31	0.034	0.021	0.034	**0.021**
Agriculture	334.41	0.165	0.049	0.248	**0.074**
Waste	57.73	0.00001	0.00002	0.000003	**0.0000052**
Total without LULUCF	**1904.73**	**11.716**	**0.615**	**10.882**	**0.57**
LULUCF	(-)177.03	(-) 1.633	-	(-)1.685	**-**
Total with LULUCF	**1727.71**	**10.083**	**0.584***	**9.197**	**0.53**

** Estimates are without the Emissions/ Removals from Hydro Power generation.*

Energy

In Himachal Pradesh during the year 2012-13, the Energy sector emitted 5.147 million tons of CO_2 equivalent as compared to 6.0655 million tons in 2008-09. During this period, 4.842 million tons were emitted as CO_2, 0.00.00473 million tons as CH_4 and 0.0007 million tons as N_2O. These figures do not include emission/ removals from electricity generation from hydro projects for distribution through grids. Of above, about 53.56% (2756.84 Gg) of the total CO_2 equivalent emissions from the Energy sector were due to electricity consumption by Industry, Commercial, Institutions and Tourism. The Residential sector has a rural and urban spread, and therefore it combusts both fossil fuel as well as biomass which together emitted 27.30% (1405.213 Gg) of the total GHG emitted from the Energy sector. The Transport sector emitted 13.91% (716.002 Gg) of the total CO_2 equivalent emissions. Emissions due to captive power generation by various industries contributed about 4.74% (244.024 Gg). Rest of the 0.483% (24.84 Gg) GHG emissions were from energy consumption for agriculture. Based on activity data the GHGs emission 000' tones (or Giga Gram) from Energy sector in Himachal Pradesh is as under



CO_2 Emissions for
Energy Consumption in HP

Following the procedures laid in estimation of emissions by IPCC, in Himachal Pradesh the key constituent of GHGs emissions from energy sector are the electricity generation, combustion of fossil fuels, transportation, energy consumption by commercial, tourism, institutional, residential and agriculture sectors. The emission factor of the fossil fuels such as coal, oil and natural gas are the most important considerations in the country but in case of Himachal Pradesh it is very minute contributor.

Sr. No.	Type	GHG emission 000' tones (or Giga Gram)			
		CO_2	CH_4	N_2O	CO_2 eq
Electricity					
1.	Captive Generation and Consumption	243.484	0.01246	0.000505	244.024
2. Transport					
	Road	714.505	0.0131	0.003488	716.002
	Railways	0.0012	-	-	0.0014
	Aviation	0.0011	-	-	0.0012
3. Others					
	Residential	1129.554	4.4053	0.5908	1405.213
	Industrial/ Commercial/ Institutional/ Bulk mics./Tourism	2730.185	0.2968	0.06587	2756.838
	Agriculture	24.552	0.00088	0.00087	24.840
	Total:	**4842.2823**	**4.72854**	**0.661533**	**5146.9196**

Residential and commercial activities contribute to emissions in a variety of ways:

Combustion of natural gas and petroleum products for heating and cooking requirements emits carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Emissions from natural gas consumption represent about 77% of the direct fossil fuel CO_2 emissions from the residential and commercial sectors. Coal consumption is a minor component of energy use in both of these sectors. Fluorinated gases (mainly hydro fluoro carbons, or HFCs) used in air conditioning and refrigeration systems can be released during servicing or from leaking equipment.

Removals - Hydro Power Generation

The equivalent GHGs emission from hydro power generation to the State assuming that the operational capacity is only @45% of total capacity annually are:

Sr. No.	Type	GHG emission 000' tones (or Giga Gram)			
		CO_2	CH_4	N_2O	CO_2 eq
Hydro Power Generation					
1.	Power Generation (Hydro Power only) Estimated CO_2 removals are equivalent to kwh power to be replaced by hydro power contributed to the grid.	(-) 17094.74	-	-	(-)17094.74

Through preliminary hydrological, topographical and geological investigations, it has been estimated that about 27436 MW of hydel potential can be exploited in the state by constructing various major, medium, small and mini/micro hydel projects on different river basins. Himachal Pradesh has vast hydroelectric potential in these five river basins, namely Yamuna, Satluj, Beas, Ravi and Chenab. Out of this hydel potential so far till year 2012, only 7957.290 MW has been harnessed by various agencies. Although the requirement of energy in the State is not so huge but in the national interest the State is committed to contribute the clean energy to the national grid. The Government of Himachal Pradesh is promoting run-of-river projects which are environmentally benign.

A paper reports on the findings of a recent IAEA (International Atomic Energy Agency) expert meeting on the assessment of greenhouse gas (GHG) emissions from the full 'lifecycle' of hydropower. It discusses the different categories of hydropower plants in view of the two main sources of GHG emissions: first, direct and indirect emissions associated with the construction of the plants; second, emissions from decaying biomass from land flooded by hydro reservoirs. In terms of GHG emissions, this report shows that, in most cases, hydropower is a good alternative to fossil fuelled power generation. For hydropower plants in cold climate, a typical GHG emission factor is 15 g CO_2 equivalent/kWh, which is 30-60 times less than the factors of usual fossil fuel generation. For some hydropower plants in tropical climates, theoretical calculations have shown that reservoir emissions could be very high. However, no measurements of emissions were taken from tropical reservoirs and the current level of research does not allow for a reliable evaluation. Research is urgently needed on this aspect in humid tropical climates.

Emissions/ Removals from Hydro Power Generation

Hydropower's contribution to GHG emission control is related to avoided emissions (i.e., emissions that would occur if hydroelectricity had to be replaced by another fossil-fuelled energy source). The estimation of an appropriate value for avoided emissions is complicated, because there is not a single equation to calculate the emissions that are *not* produced at hydropower projects. The characteristics of avoided emissions depend on the type of power that is displaced by hydropower generation. If a kilowatt-hour (kwh) were not generated at the hydro plant, what plant would have generated it? The answer depends on a range of factors: the time of day, the plants already on the system, the plants available, their variable costs, the type of fuel they use, their efficiencies, even the transmission losses and constraints. The production of hydroelectricity is associated with significant reductions in the nation's GHG emissions, although the specific amount of this benefit is difficult to measure directly.

Experts of the view that impoundment of hydroelectric reservoirs induces decomposition of a small fraction of the flooded biomass (forests, peat lands and other soil types) and an increase in the aquatic wildlife and vegetation in the reservoir. The result is higher greenhouse gas (GHG) emissions after impoundment, mainly CO_2 (carbon dioxide) and a small amount of CH_4 (methane). However, these emissions are temporary and peak two to four years after the reservoir is filled. During the ensuing decade, CO_2 emissions gradually diminish and return to the levels given off by neighboring lakes and rivers. Hydropower generation, on average, emits one-thirty-fifth of the GHGs that a natural gas generating station does and about one-seventieth the GHGs that a coal-fired generating station does. (Ref. Hydro- Quebec's- Sustainable Development a specialized documentation).

The details of generation, consumption of energy in the State of Himachal Pradesh:

Sr. No.	Type	Quantity	
		2008-09	**2011-2012**
1.	Total Generation (Hydro Power only)	6419 MW	7957.29MW
2.	Captive Generation and Consumption	~ 100 MW	~68MW
3.	Electricity purchased from BBMB & other States	6047.497MU	7957.290 MU
4.	Energy Consumed by the State:	**6958.716MU**	**6633.045MU**
	(a) Domestic	1089.118	1578.482
	(b) Non Domestic &Non-Commercial	80.585	103.924
	(c) Commercial	274.663	398.971
	(d) Public lighting	13.013	13.602
	(e) Agriculture	28.738	45.050
	(f) Industries	3385.303	3852.340
	(g) Govt. Irrigation & Water Supply Scheme	389.331	447.328
	(h) Temporary Supply	22.705	23.918
	(i) Bulk & Misc.-Tourism	1675.26	167.591
5.	**Fuel Consumption**		
	(a) Diesel *	**~530400 KL**	**~5,41,112 KL**
	(b) Petrol*	**~244800 KL**	**~272073 KL**
	(c) Kerosene*	**~86000KL**	**~65324KL**
	**As per total sale/ consumption in Himachal Pradesh*		
6.	Transport (Vehicles registered) ± Tourist Taxis.	~5,38,341Nos.	~5,87,122 Nos
7.	LPG (including DBG) Approx.		
	Indian Oil Corpn.	**~76800MT/annum**	**~782123 MT**
	Hindustan Petroleum	**~56100MT/annum**	**~572013 MT**

Source: HP Statistics Department, Indian Oil Corpn, HP Oil Corpn, and Transport. Department.

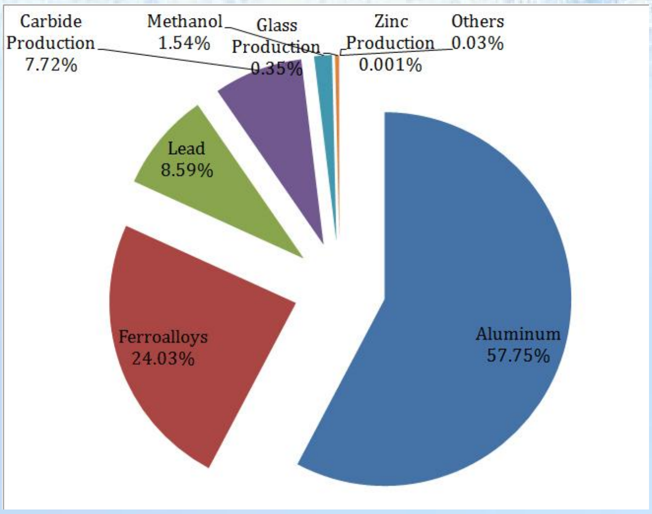
Industry

The GHG emissions from the Industry sector in 2012-13 were5.571 million tons of total CO_2 equivalent emissions in comparison of year 2008-09 which were 5.484 million tons. Of this 5.569 million tons were of CO_2, 0.004897 000'tons of CH_4 and 0.0066 000'tons of N_2O. 95.33% of the total CO_2 equivalent emissions from Industry sector were from Cement production showing about 1.04% growth against that of 2008-09 levels in this sector. However under other types the emissions have shown downward trend such as Mineral based industries and Glass production industries which presently emitted only 0.016%. 4.19% of the total GHG emissions were from Metal industries and about 0.466% of the total GHG emissions were from chemical industries. The other industries consisting of pulp and paper, food & beverage, non-specific industries, textile & leather, and mining/ quarrying together emitted 0.0014% of the total GHG emission from the energy sector. The Industry sector includes emissions due to various processes involved and burning of fossil fuels. Broad categories which have been covered are Mineral, Chemical, Metal, Other including viz. Textile, Pulp and Paper, Food processing units.

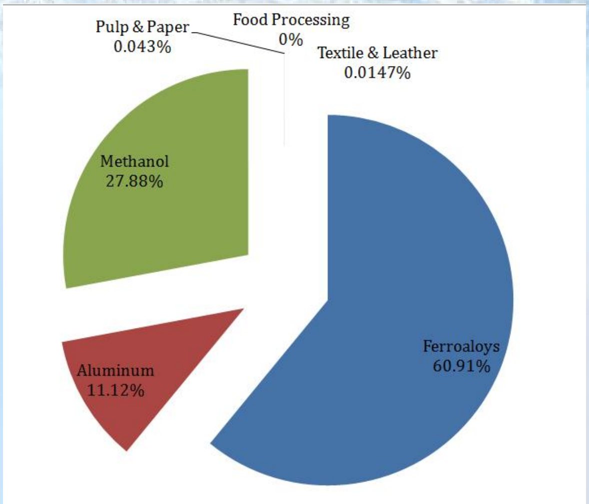
Category	Emission Factor	Gas	Source
Cement	0.537 tCO_2/ t Clinker produced	CO_2	CMA 2010
Glass Production	0.21 tCO_2/ t glass (Container Glass); 0.22tCO_2/t glass (Fiber Glass); 0.03tCO_2/t glass (Specialty Glass)	CO_2	IPCC, 2006
Carbide Production	1.1tCO_2/$tCaC_2$ produced	CO_2	IPCC 2006
Methanol	0.67 tonsCO_2/tons TiO_2 produced 2.3 kg CH_4/tons Methanol produced	CO_2 CH_4	IPCC 2006
Ferroalloys	4.8 tonsCO_2/ton Ferrosilicon produced; 1.5 ton CO_2/ton Ferromanganese produced; 1.1 kg CH_4/Ferrosilicon produced	CO_2 CH_4	IPCC 2006
Aluminum	1.65 ton CO_2/ton Aluminum produced	CO_2	IPCC
Lead (Secondary Production)	0.58 ton CO_2/ton Lead produced (Imperial Smelting Furnace); 0.25 ton CO_2/ton Lead produced (Direct Smelting); 0.2 ton CO_2/ton Lead produced (Secondary Production);	CO_2	IPCC 2006 (Avg. EF)
Zinc production	0.53 ton CO_2/ton Zinc produced (Pyro-metallurgical Mrocess)	CO_2	IPCC 2006

Source: IPCC & NICCA Report 2007.

Type	GHG emission 000' tones (or Giga Gram)			
	CO_2	CH_4	N_2O	CO_2 eq
Mineral				
Cement Production	5310.93	-	-	5310.93
Glass Production	0.89226	-	-	0.89226
Chemical				
Carbide Production	19.884	-	-	19.884
Methanol	3.979	0.001366	0.00659	6.0510
Metal				
Ferroalloys	61.950	0.002985	-	62.0130
Aluminum	148.880	0.000545	-	148.891
Lead (secondary production)	22.142	-	-	22.142
Zinc production	0.0025	-	-	0.0025
Other Industries				
Pulp & Paper	0.02173	0.00000021	0.000000314	0.02180
Textile & Leather	0.01336	0.00000072	0.0000053	0.01350
Food Processing	0.04097	0.00000036	0.000000084	0.04102
Mining and Quarrying	0.0023	-	-	0.0023
Total	**5568.73812**	**0.004897**	**0.0065957**	**5570.88438**



CO_2 Emission from Industrial activities other than cement in Himachal Pradesh

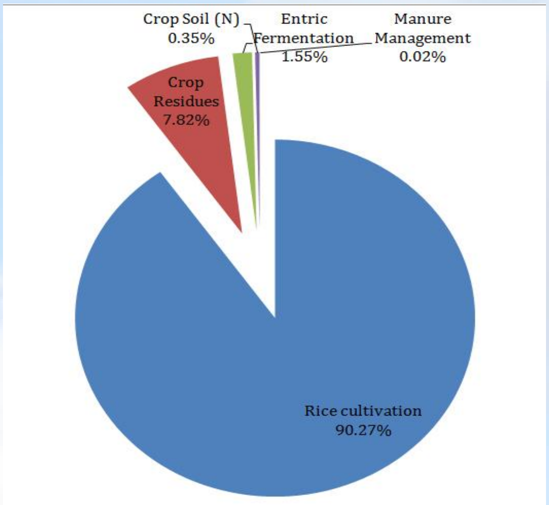


CH_4 Emissions from Industrial Production in Himachal Pradesh

Agriculture

Agricultural activities - the cultivation of crops and livestock for food - contribute to emissions in a variety of ways:

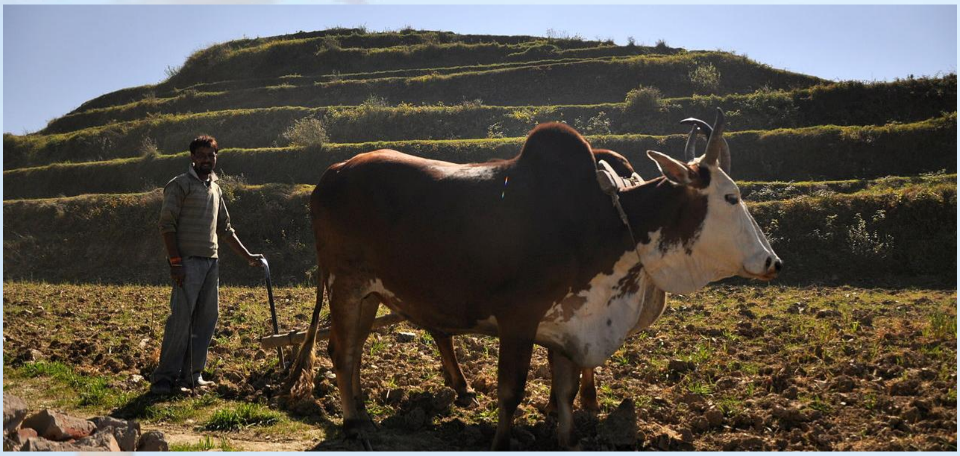
- Livestock, especially cattle, produce methane (CH_4) as part of the digestion process. This is called enteric fermentation, and it accounts for almost one third of the emissions from the Agriculture sector.
- The way in which manure from livestock is managed also contributes to CH_4 and N_2O emissions. Manure storage methods and the amount of exposure to oxygen and moisture can affect how these greenhouse gases are produced. Manure management accounts for about 15% of the total greenhouse gas emissions from the Agriculture sector in the United States.
- Smaller sources of emissions include rice cultivation, which produces CH_4, and burning crop residues, which produce CH_4 and N_2O.
- Various management practices for agricultural soils can lead to production and emission of nitrous oxide (N_2O). Different activities that can contribute to N_2O emissions from agricultural lands range from fertilizer application to methods of irrigation and tillage. Management of agricultural soils accounts for about half of the emissions from the Agriculture sector.*



CH_4 Emissions from Agriculture Sector in Himachal Pradesh

During year 2012-13, Agriculture sector emitted 0.164 million tons of CO_2 equivalent, of which 0.00762 million tons were CH_4 and 0.407 thousand tons were N_2O. The majority of emissions i.e. about 90.27% were from rice cultivation. It showed about 2% decrease in 2012-13 against of levels of 2008-09. Burning of crop residue emitted 7.82% of the total CO_2 equivalent emissions from this sector showing a 1.8% hike which may be due to the enhanced crop area, where as 1.55% of the emissions were due to enteric fermentation. However, Crop soils emitted 0.35% of the total CO_2 equivalent emission from Agriculture and 0.018% of the emissions were from Livestock manure management.

The emissions from Agriculture sector are mainly in the form of CH_4 from rice paddy cultivation and enteric fermentation. However, the N_2O emissions are due to use of fertilizers in the agricultural fields. The sources included for calculations in Himachal Pradesh are livestock; enteric fermentation, animal manure, rice cultivation; irrigated & rain fed, agriculture soils; direct emissions & indirect emissions, and field burning of agriculture crop residue etc.

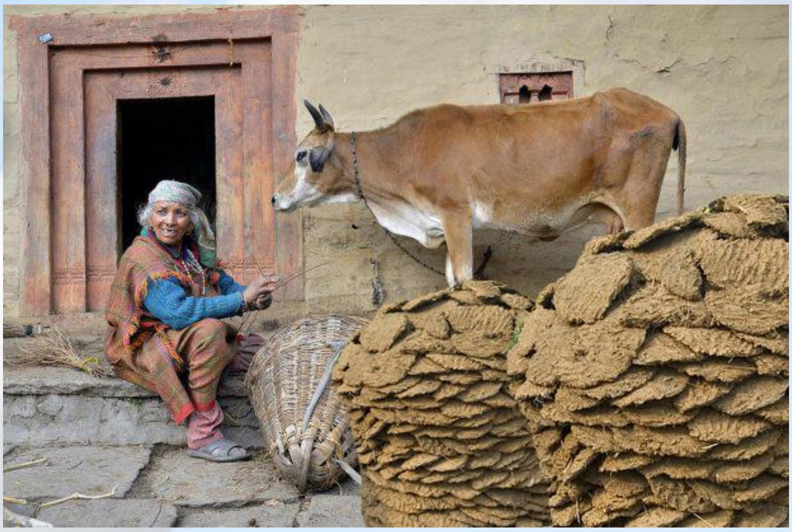


Enteric Fermentation

In Himachal Pradesh livestock rearing is an important activity and forms part of the agricultural system. Live stock which includes cattle, buffaloes, sheep, goat, horses, ponies, mules, donkeys, pigs, dogs, yaks, and other live stock are the major source of methane emissions (CH_4). Cattle and buffalo are the main milk producing animals in the State and constitute about 56 % of the total live stock population with almost no change in their population. In order to estimate the CH_4 emission from livestock, the cattle population has been divided into dairy and nondairy categories. The emission factors provided in the report (NATCOM, 2004) have been used to calculate the emissions.

Animal Waste/Dung:

In Himachal Pradesh the waste –dung is mainly converted into manure. A small proportion is used as dung cake for energy purposes in the rural areas. The dung management practices vary in different districts depending upon the need of the fuel and manure. The dung is collected on a heap near the animal shed for converting cattle and buffalo dung in to manure. The residual feed and ash (available from kitchen etc.) are also put on the heap.



The dung, thus collected is exposed to the weather conditions and methane emission is expected from the inner core of the heap due to the anaerobic fermentation of organic matter. The manure thus prepared is generally taken to the fields and orchards at the time of soil preparations after the monsoon season or at the time of need.

Part of the dung of cattle and buffaloes goes directly to the soil is deposited on the soil during the course of grazing. In Himachal Pradesh, large forest areas and natural pastures are available for grazing and animals not only survive on grazing in such areas but also are allowed to graze on road side, canal bunds, fallow lands and harvested fields. The excreta of grazing animals dry up quickly due to the mixing with soil during the trampling by the animals and does not produce methane as suggested by IPCC (1997).

Type	GHG emission 000' tones (or Giga Gram)	
	Methane (CH_4)	N_2O
Enteric fermentation	0.12104	-
Manure: Animal Waste/ dung	0.00138	0.00000076

The dung of goat and sheep goes directly to the soil and farmer's value this source of Nitrogen (N), Phosphorous (P), and Potassium (K) for their soil. Normally in winters (from November to February), farmers in many parts of the state invite the nomadic shepherds along with their flock after the harvesting is over so that the flock can remain on the harvested field and consume the stubble and provide the nutrients from their dung and urine to the field. Traditionally shepherds are obliged with food and shelter till their flock sits on the field. The dung of other species such as donkey, horses directly goes to the soil due to their daily mobility.

Rice Cultivation

Rice cultivation in the State is done in about 79,000 hectare area. The rain fed area is around 45% and irrigated area is 55% of the total cropped area. The emissions from the sector are:

Eco system	Rice cultivation area ha	Methane (CH_4) (000'tons)
Rain fed (upland only)	35,550	-
Irrigated	43,450	7.0445

Source: HP Agriculture Department

In India, rice is cultivated under various water management systems, depending on the availability of water across the country. In the mountainous regions, rice is grown in terraces created along the side of the mountains. In most of the northern plains and some parts of the eastern region, rice is cultivated by irrigating the fields intermittently or continuously, for a considerable period of time. In other parts of the country, however, rain-fed rice cultivation is predominant where water is only available in the fields during rains. Deep-water rice cultivation, with a water depth ranging from 50-100 cm. is also practiced in the coastal regions of West Bengal and Orissa. In coastal areas two or three crops are taken annually.

The CH_4 emissions from rice cultivation have been estimated by multiplying the seasonal emission factors by the annual harvested areas. The annual amount of CH_4 emitted from a given area of rice is a function of the crop duration, water regimes and organic soil amendments. The total annual emissions are equal to the sum of emissions from each sub-unit of harvested area using the following equation.

$$CH_4 \text{ Rice} = \sum_{i,j,k} (EFi, j, k \times Ai, j, k \times 10^{-6})$$

Where;

CH_4 Rice = Annual methane emissions from rice cultivation, Gg CH_4 /yr;

EFijk = A seasonal integrated emission factor for i, j, and k conditions, kg CH_4 /ha;

Aijk = Annual harvested area of rice for i, j, and k conditions, ha /yr;

i, j, and k = Represent different ecosystems, water regimes, type and amount of organic amendments, under which CH_4 emissions from rice may vary.

Separate calculations were undertaken for each rice ecosystems (i.e., irrigated, rainfed upland rice production).

The upland rice area is 35550 ha and is a net sink of CH_4, as no anaerobic conditions are generated at these heights.

Agricultural Soils

Using the methodology given below, during the year 2012-13 the total N_2O emissions from agriculture soils of Himachal Pradesh are estimated to be 0.00183 (000' tons) in comparison of 0.00152 (000' tons) during 2008-09. The emission factors used for rice–wheat systems are 0.76 for rice and 0.66 kg ha^{-1} N_2O –N for wheat for urea application.

N_2O emissions are estimated using details of human-induced net N additions to soils (e.g., synthetic or organic fertilizers, deposited manure, crop residues, sewage sludge), or of mineralization of N in soil organic matter following drainage/ management of organic soils, or cultivation/land-use change on mineral soils (e.g., Forest Land/Grassland/Settlements converted to Cropland). Nitrous oxide is produced naturally in soils through the processes of nitrification and denitrification. Nitrification is the aerobic microbial oxidation of ammonium to nitrate, and denitrification is the anaerobic microbial reduction of nitrate to nitrogen gas (N_2). Nitrous oxide is a gaseous intermediate in the reaction sequence of denitrification and a by-product of nitrification that leaks from microbial cells into the soil and ultimately into the atmosphere. One of the main controlling factors in this reaction is the availability of inorganic Nitrogen (N) in the soil.

In Himachal Pradesh, the distribution of fertilizers (in nutrients) N, P & K in year 2012:

Nitrogen (N) = 37420 MT

Source: HP Economics & Statistics Department

The use of nitrogen (N) fertilizers has shown increase to 31042 MT levels in year2008-09. The emissions of N_2O that result from anthropogenic N inputs or N mineralization occur through both a direct pathway and through two indirect pathways: (i) following volatilization of NH_3 and NO_x from managed soils and from fossil fuel combustion and biomass burning, and the subsequent re-deposition of these gases and their products NH_4^+ and NO_3^- to soils and waters; and (ii) after leaching and runoff of N, mainly as NO_3^- from managed soils. Therefore, total N_2O emitted from soils can be represented as:

$N_2O\text{-}N_{TOTAL} = N_2O\text{-}N_{DIRECT} + N_2O\text{-}N_{INDIRECT}$

Burning of Crop Residues

Crop residues are burnt in the fields as per prevailing practices in many districts of the State such as Kangra, Mandi, Una, Kullu, Shimla, Hamirpur, Bilaspur, Solan producing CO, CH_4, N_2O, NO_x, SO_2 and many other gases. We have calculated only the CH_4 and N_2O emissions by using the equation given below.

EBCR = Σ crops (A x B x C x D x E x F)

Where, EBCR= Emissions from Residue burning

A = Crop production
B = Residue to crop ratio
C = Dry matter fraction
D = Fraction burnt
E = Fraction actually oxidized
F = Emission factor

The estimation of emission of targeted species was arrived at by first estimating the amount of biomass actually burnt in the field using the IPCC Revised Inventory Preparation Guidelines (IPCC, 1996). Currently, wastes from three crops viz., rice, wheat, maize are subjected to burning. The state's crop production figures for 2012 have been used as the basic activity data.

The dry matter fraction of crop residue is taken as 0.8 (Bhattacharya and Mitra, 1998), 0.25 as fraction burned (IPCC, 1997) in field and 0.9 as the fraction actually oxidized (IPCC, 1997). Crop specific values of carbon fraction were as per IPCC default values. The default N/C ratios were taken from IPCC (2006). Further, the emission ratio was calculated using emission factors given by Andreae and Merlet (2001) which are the default factors mentioned in IPCC (2006) National Inventory Preparation Guidelines.

Using this methodology, it is assumed that in Himachal Pradesh 0.478 (000' tons) of CH_4 and 0.0399 (000' tons) of N_2O was emitted from burning of crop residue in the fields and no change has been observed between years 2012 and 2008-09.

Over all the GHG emissions (000'tons) from the agriculture sector are as under:

Sr. No.	Type	CO_2	CH_4	N_2O	CO_2 eq
1	Enteric fermentation	-	0.12104	-	**2.542**
2	Manure management	-	0.00138	0.00000076	**0.0292**
3	Rice cultivation	-	7.0445	-	**147.9936**
4	Crop residue	-	0.4650	0.03886	**21.812**
5	Soils	-	-	0.00183	**0.5670**
	Total	**-**	**7.6319**	**0.040691**	**163.9438**

Land Use, Land Use Change & Forest (LULUCF)

Land Use, Land Use Change and Forest (LULUCF) are one of the key components of the Greenhouse Gas Emissions. It involves estimation of carbon stock changes, CO_2 emissions and removals and non-CO_2 GHG emissions. For estimating GHG emissions from this sector, the GHG inventory guidelines followed at National level i.e. *IPCC – 2003 GPG* approach were adopted.

Methodology*: IPCC GPG 2003* adopted six land categories to ensure consistent and complete representation of all land categories, covering the total geographic area of a country or a State.

The GPG 2003 adopted three major advances over IPCC 1996 guidelines, such as:

- Introduction of three hierarchical tiers of method that range from default data and simple equations to use country specific data.
- Land use category based approach for organising the methodologies.
- Provides guidelines for all the 5 carbon pools.

Methods adopted in Good Practice Guidelines (GPG 2003) are as under:

1. Land category based approach covering forest land, cropland, grassland, wetland, settlement and others.
2. These land categories are further sub divided into; - land remaining in the same use category differently - other land converted to this land category.
3. Methods given for all carbon pools; AGB, BGB, dead organic matter and soil carbon and all non-CO_2 gases.
4. Key source/sink category analysis provided for selecting significant land categories; - sub-land categories- C-pools - CO_2 and non-CO_2 gases.
5. Three tier structures presented for choice of methods, Activity Data and Emission Factors.
6. Biomass and soil carbon pools linked particularly in Tier 2 and Tier 3.

Carbon Stock Changes

Carbon stock change is the sum of changes in stocks of all the carbon pools in a given area over a period of time, which could be averaged to annual stock changes. A generic equation for estimating the changes in carbon stock for a given land use category is as follows:

$$\Delta C_{LUi} = \Delta C_{AB}+\Delta C_{BB}+\Delta C_{DW}+\Delta C_{Li}+\Delta C_{SC}$$

ΔC_{LUi} is the carbon stock change for a land use category,
AB is above ground bio mass, BB is below ground bio mass, DW is dead wood, Li is litter and SC is the soil carbon.

For the purpose of this equation the stock change has been estimated for each pool by using following method- Carbon 'stock-change' or stock difference'

$$\Delta C = (C_{t2}-C_{t1})/\ (t_2-t_1)$$

Where: ΔC is the annual carbon stock change in the pool, C_{t1} is at time t_1 and C_{t2} is at time t_2 in the same pool.

In Himachal Pradesh GHG inventory has been prepared by taking the activity data available at National and State levels. Land use change matrix has been prepared using land use data for 2007 and 2011. The area under forest has been obtained from Forest Survey of India Report, 2011 and area under other land categories has been sourced from Directorate of Land Record reports for the years 2007 and 2011.

Land Use pattern of Himachal Pradesh (*Source FSI*)

Land Use	**Sub Category**	**Area ha**	
		2007	**2011**
Forest	Very dense	3,22,400	3,22,400
	Moderately dense	6,38,300	6,38,100
	Open	5,06,100	5,07,400
	Total	**14,66,800**	**14,67,900**
Crop Land	Net sown area	54,300	53,950
	Fallow	7,400	7,920
	Total	**61,700**	**61,970**
Grass land	Grazing land and pastures	1,50,100	1,70,620
	Scrubs	32,700	33,100
	Total	**1,82,800**	**2,03,720**
Other land	Other land	**38,56,000**	**38,33,710**

Land Use Change Matrix

The recorded forest area of the State is 37,033 km^2. Reserved Forests constitute 5.13%, Protected Forests 89.27% and Un classed Forests 5.60% of the total forest area. About two third of the State's geographical area is under recorded forests. However a substantial part of this is not conducive for tree growth, being under permanent snow, glaciers and cold deserts. The forest cover in the State, based on interpretation of satellite data, is 14,679 km^2, which is 26.35% of the State's geographical area. In terms of forest canopy density classes, the State has 3,224 km^2 very dense forest, 6,381 km^2 moderately dense forest, and 5,074 km^2 open forest. As per data there has been a decrease of 2 km^2 in the moderately dense forest and an increase of 13 km^2 in open forest.

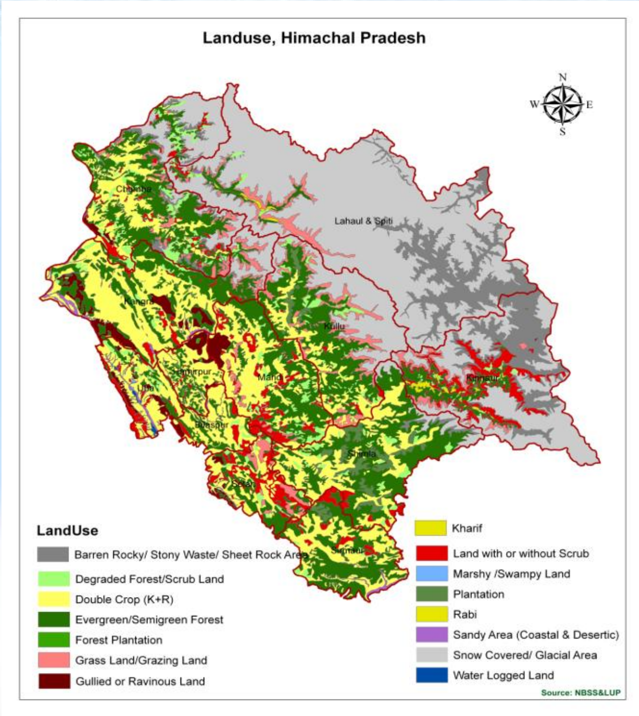


Table: Land Use Change Matrix of Himachal Pradesh

Land Use	Sub Category	Area ha 2007	Area ha 2011	Change in area ha
Forest	Very dense	3,22,400	3,22,400	-
	Moderately dense	6,38,300	6,38,100	(-)200
	Open	5,06,100	5,07,400	(+)1300
Crop Land	Net sown area	54,300	53,950	(-)350
	Fallow	7,360	7,920	(+)520
Grass land	Grazing land and pastures	1,50,100	1,70,620	(+)20,520
	Scrubs	32,700	33,100	(-)400
Other land	Other land	38,56,000	38,33,710	(-)22,290

(*Source FSI and Agriculture, Land Records Reports*)

Assessment of Carbon Stock from Forests:

An assessment of Growing stock, Biomass and Carbon stock of Indian forests strata wise have been made by FSI based on SFR, 1997 data base, as per the 2002 report the Forests carbon stocks are as under:

	India (1997)	HP (1997)
Forest Cover (KM²)	6,33,357	12,521
Growing Stock (000, m³)	43,40,027.96	2,47,483.99
Bio Mass (000, tons)	23,95,373.45	1,06,442.18
Carbon (000 tons)	10,83,809.74	48,909.11

Similarly, the estimates for year 2007 and 2011 for Carbon stock under Forest sector are as under:

	India		HP	
	2005	2007	2007	2011
Forest Cover (KM²)	6,90,200	6,91,600	14,668	14,67,900
Growing Stock (000, m³)	47,29,540.05	47,39,133.67	2,89,920.50	3,21,314
Bio Mass (000, tons)	26,10,357.11	26,15,651.95	1,24,694.03	1,38,196.50
Carbon (000 tons)	11,81,080.31	11,83,479.75	57,295.65	57,710.2

Source: FSI Report

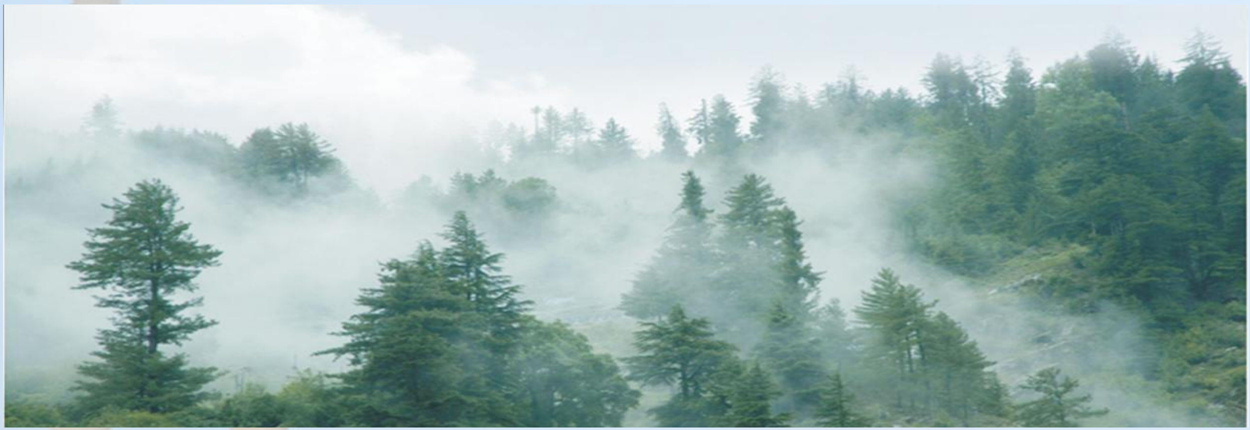
Soil Carbon Stock

As per Forest Survey of India report, 2009 the forest cover in the State was spread over 14,66,800 ha which was 14,67,900 ha in 2011 and the agriculture-crop area was 61,700 ha in 2009 and 67,350 ha in 2012. Based on an assessment of carbon store in Giri catchment of the State conducted by Forest Research Institute, Dehradun, it has been inferred that on an average HP Forests have 61.68 t/ha soil carbon store and 53.74 t/ha average soil carbon store in agriculture sector. Therefore, applying these averages the following soil carbon stock has been estimated for H.P.:

	HP in hectare		C stock in million tons/ ha	
	2007	2012	2007	2012
Forest Cover (ha)	14,66,800	14,67,900	90.47	90.58
Crop Land (ha)	61,700	67,350	3.316	3.620
Total estimated area	**15,28,500**	**15,35,250**	**93.786**	**94.20**

The carbon stock estimates combined in terms of;

- Above ground biomass
- Below ground bio mass and
- Soil Carbon.



The estimated emissions from Forest sector in Himachal Pradesh during 2009, based on 2007 and 2011 stock changes, is given below:

Carbon Pools	C stock in million tons 2009 (on 2007 assessment basis) A	C stock in million tons 2011-12 B	Change in C stock in million tons (2003-2007) C=A-B	CO_2 removal in million tons during 2007 D= C x 44/ 12
Above ground biomass	57.296	58.056	-0.4152*	-1.5224
Below ground biomass				
Soil Carbon	93.786	94.200	-0..414	-1.5180
Total	**151.082**	**157.699**	**- 6.617**	**-3.0404**

The emissions and removals for biomass and soil carbon for land categories with land remaining in the same categories based on National Mean Annual Increments are:

Land Use categories	MAI in perennial above ground biomass (t/ha/y) A	MAI in perennial below ground biomass (t/ha/y) B	MAI in total perennial biomass (t/ha/y) A+B	MAI in soil carbon (t/ha/y) C	MAI in total Carbon (t/ha/y) D=(A+B)/2 +C	Net DC (Mt C) E= D x Area	Net Change in CO2 (Mt) F= E x 3.6666 (+ is Emission, - is Removal
Crop Land	0.130	0.046	0.176	0.220	0.308	0.020744	0.076060
Grass Land	0.003	0.001	0.004	-0.056	-0.054	(-)0.011001	(-)0.040336

The net CO_2 emission/ removal for LULUCF sector is given below. This includes CO_2 net emissions and removals from land categories. The net CO_2 emissions include gain and loss of CO_2. The loss of CO_2 is largely due to extraction and use of fuel wood from felling of trees which is not very significant. The net CO_2 emissions / removal estimate shows that the sector is a net sink of 1,685.276 (000' tons) CO_2. The sector is a net sink due to uptake of CO_2 by the cropland followed by forest land. **This is a preliminary estimate and may change with improved activity data and emission factor estimates.**

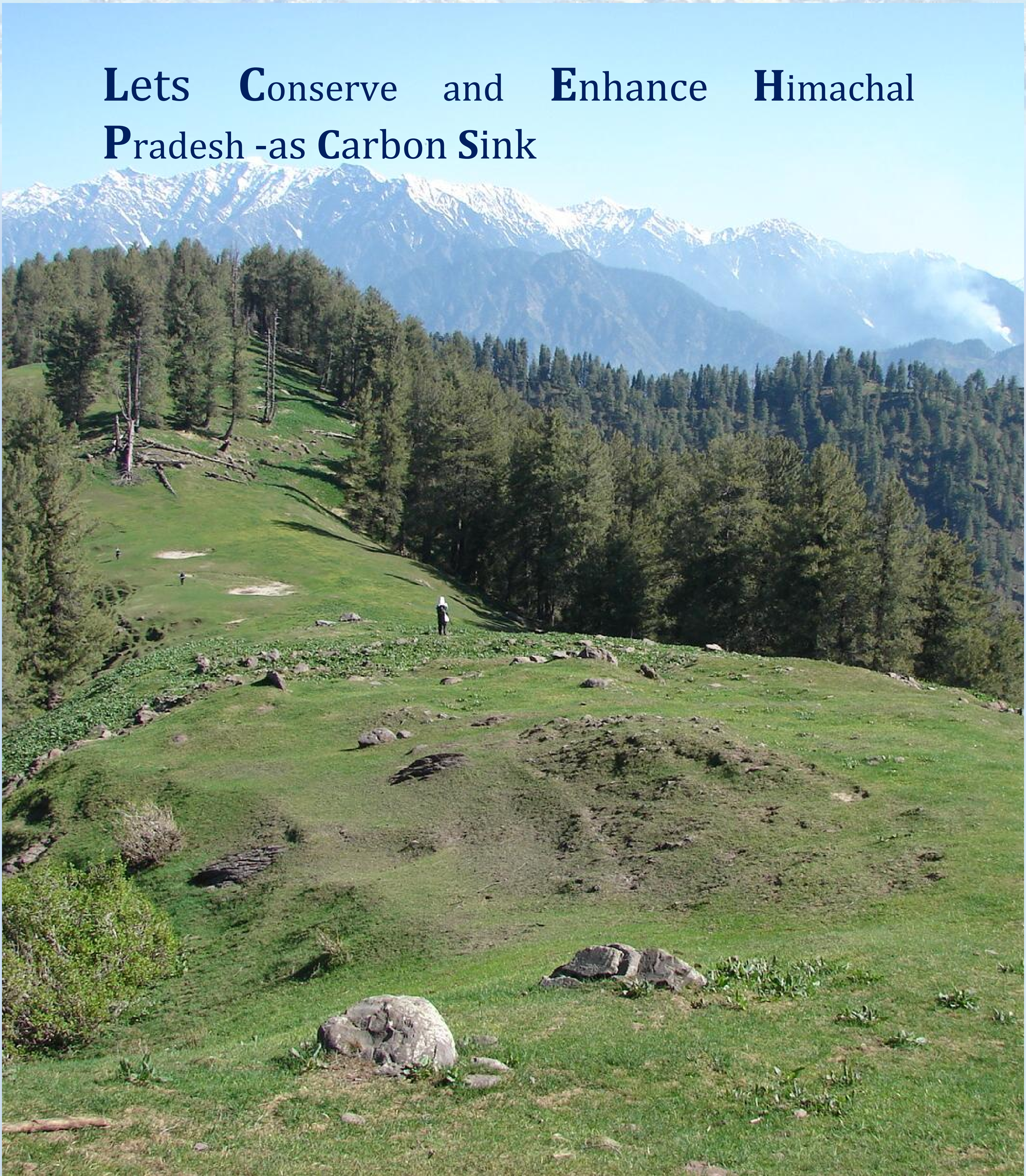
Emissions in 000'tons

Land use categories	CO_2 emissions/ removals	CO_2 loss due to fuel wood use	Net CO_2 emissions/removal
Forestland	(-) 3040.4	(+) 1319.40	(-) 1,685.276
Cropland	(-)76.060		
Grassland	(+)40.336		
Total	**(-) 3004.676**	**(+) 1,319.40**	**(-) 1,685.276**

Removal (-) Emission (+)

Green Felling of trees is completely banned in Himachal Pradesh; therefore the use of fuel wood in the State is much lower than the assumed National level %age. Source of fuel wood is also not known, so assumed to come from all land categories. About 2-3% of the fuel wood consumption is estimated to come from felling of trees leading to net CO_2 emission.

Lets Conserve and Enhance Himachal Pradesh -as Carbon Sink



Solid Waste & Waste Water (Industrial)

The total GHG released from waste sector in Himachal Pradesh 3.12 tons of CO_2 equivalent, of which, 1.44 tons were emitted as Methane (CH_4). Municipal Solid Waste is the dominant source of Methane (CH_4) emission in the state.

The greenhouse gases and their source categories considered in this sector include:

- Municipal solid waste disposal resulting in CH_4 emission.
- Domestic waste water disposal emitting CH_4 and N_2O.
- Industrial waste water disposal leading to CH_4 emissions.

Methane (CH_4) Gas is the main gas which is produced and released into the atmosphere as a by-product of the anaerobic decomposition of solid waste. In fact methanogenic bacteria break down organic matter in the waste. Similarly, wastewater is also a source of Methane (CH_4) when treated or disposed anaerobically. It also releases Nitrous oxide (N_2O) emissions due to protein content in waste water generated from activities at domestic level. The total GHG released from waste sector in Himachal Pradesh is 3.12 tons of CO_2 equivalent, of which, 1.44 tons were emitted as Methane (CH_4). Municipal Solid Waste is the dominant source of Methane (CH_4) emission in Himachal Pradesh it emits almost 99.6% of total emissions from this sector. About 0.45% of the total CO_2 equivalent emissions from the waste sector were from disposal and treatment of industrial waste water.

Effluent Treatment System for treatment of industrial waste water.

Municipal Solid Waste

In Himachal Pradesh, there are 56 urban local bodies viz. 1 – Municipal Committee, 20- Municipal Councils, 28- Nagar Panchyats and 7- Cantonment Boards of which 33 have provided the MSW dumping facility where waste is partially collected and disposed in a systematic way at waste disposal sites under these ULBs in various towns, resulting in CH_4 emission from anaerobic conditions. In rural areas, waste is scattered and as a result the aerobic conditions prevail with no resulting CH_4 emission. In towns, the municipal solid waste is disposed in landfills by means of open dumping. However, a small fraction is used for composting in some of the disposal sites. In the major towns such as Shimla, Kullu, Dharamsala, Solan, Baddi the rate of generation of MSW is high due to tourists and the population growth rate. The rate of disposal of MSW varies from place to place, therefore, the estimation of CH_4 generated from MSW State level also becomes highly uncertain unless year wise data on MSW generation is incorporated in the estimates. In the present calculations IPCC 2000 guidelines have been used. Average CH_4 Emission Factor derived from a study by NEERI in 69 cities (NEERI, 2005) has been applied to calculations.

For calculating the amount of degradable organic matter (DOm) in waste method used is as per following equation:

$DOm = W \times DO \times DO_f \times MCF$

Where;

DOm = mass of decomposable DO deposited m Gg

W = mass of waste deposited, Gg

DO = degradable organic carbon in the year of deposition, fraction, Gg C/Gg waste

DO_f = fraction of DO that can decompose (fraction)

MCF = CH_4 correction factor for aerobic decomposition in the year of deposition (fraction)

The methane generated in a year has been calculated as per following method:

Methane generated in year Y

$CH_4 = DOm\ decopom_Y \times F \times 16/12$

Where;

F = Fraction of CH_4 by volume

16/12 = molecular weight ratio, CH_4/C

$CH_4\ Emitted_Y = (\Sigma\ CH_4\ generated_{X,Y} - R_Y) \times (1 - OX_y)$

Where;

RT = recovered CH_4 in year Y, Gg

OX_Y = Oxidation factor in year Y, (fraction)

On an average for towns waste generation rate is 0.350kg/capita/day and that 60% of the waste is reaching the landfill site.

IPCC default factor (IPCC, 2002) such as the methane correction factor of 0.4, fraction of degradable organic carbon that decomposes (DO_f) as 0.5, fraction of methane in landfill gas as 0.5, rate constant (K) as 0.17 year -1 are used in the estimation. The factor related to degradable organic carbon fraction (DO) in the waste disposed is taken as 0.11 (NEERI, 2005). Considering that the amount of recovered methane is zero and oxidation factor is zero, the total methane CH_4 emitted from solid waste disposal site is estimated to be 17.17 (tons) in the State.

Component	Quantity 2008-09	Quantity 2012
Urban population	6,88,704	7,10,328
Waste generation rate (kg/capita/day)	0.350	0.350
MSW generated (tons)/day/capita	241.05	248.615
Quantity of waste reaching the landfill site(tons)	140.09	149.169
DOm disposed (tons)	4.512	4.778
DOm accumulated (tons)	14.20	15.0368
DOm decomposed (tons)	2.400	2.5414
Estimated Methane (CH_4) emitted (tons)	**2.714**	**2.87393**

Source: HP Economics & Statistics Department, ULBs

Waste Water

In Himachal Pradesh the wastewater originates from a variety of domestic, commercial and industrial sources. In industrial and commercial establishments waste water is treated on site. However, the waste water being generated from domestic sources in towns where the treatment facility is available is collected in centralized treatment plants but the percentage is very low. As per information obtained from HP State Pollution Control Board there are about 30 Sewage Treatment Plants installed in the State by various Urban Local Bodies out of which only 6 have been granted permission by the State Board for operation. About 34 more STPs are being installed in the State which will definitely enhance the capacity of State to treat the waste from domestic sources. Majority of waste water is disposed without any treatment. The methane (CH_4) is emitted from waste water when it is treated or disposed anaerobically. For Himachal Pradesh the calculations have been carried out in following manner:

- CH_4 and N_2O from domestic waste water
- CH_4 from Industrial waste water

In Himachal Pradesh, it is estimated that about 4,813.56 K litres per day (KLD) of domestic wastewater is generated from urban areas against 52034.46 KLD industrial wastewater. The waste water generated from rural areas is not treated in any way, therefore, as it decomposes in an aerobic condition, it is not considered as a source of CH_4. Domestic wastewater have been categorized under urban and rural, since the characteristics of the municipal wastewater vary from place to place and depends on factors, such as economic position, food practice of the area, water supply status and climatic conditions of the area.

Treatment System for treatment of domestic waste water. (Source-IPH)

Waste water treatment and discharge pathways for the wastewater generated in the urban areas is partial and about 70 % of the wastewater generated from the urban centres is not collected. Treatment is provided to only 10% of what is collected is not very significant. The waste water gets disposed of in aerobic conditions. Therefore, no specific calculations have been made.

The CH_4 emission from waste water generated from Industry has been estimated based on data available with ULBs and Industries department. The industries have been included for estimating CH_4 from industrial waste water:

Waste water generated in major industries in Himachal Pradesh

Sector	Waste Water generated	
	2008-09	2011-12
Industrial	49,144.97 KLD	52034.46 KLD
Domestic	4,476.98 KLD	4,813.56 KLD

Source: ULBs and Industry Deptt.

The emissions have been calculated using as per IPCC approach by incorporating country specific emission factors and State specific data. The general equation followed to estimate CH_4 emissions from industrial wastewater is presented in equation below:

Ti = i (TOWi – Si) EFi – Ri

Where;

Ti	CH_4 emission in inventory year, kg CH_4/yr;
i	Industrial sector.
TOWi	Total organically degradable material in waste water for industry i in inventory year, kg COD/year.
Si	Organic component removed as sludge in inventory year, kg COD/year (Default Value 0.35).
EFi	Emission factor for industry i, kg CH_4 kg/CODfor treatment/discharge pathway or system used in inventory year.
Ri	Amount of CH4 recovered in inventory year, kg CH_4/year.

GHG Emitted from Waste Water Sector ('000 tons)

Activity	CH_4	CO_2 equivalent
Industrial	0.0001441	**0.0030**

Root Zone Biotech plant at ACC Gagal for waste water treatment

GHG Intensity of the Economy

GHG intensity of economy (or GHG per GDP) is a measure of greenhouse gas emissions per unit of economic output. GHG emissions, depending on user preference, can include the sum of state emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and F-gases (perfluorocarbons-PFCs, hydrofluorocarbons-HFCs, and sulfur hexafluoride - SF_6).

GHG intensity of the economy is largely a function of two variables:

- Energy intensity, or the amount of energy consumed per unit of GDP. This reflects both a state's level of energy efficiency and its overall economic structure, including the GHG content of goods imported and exported. An economy dominated by heavy industrial production, for instance, is more likely to have higher energy intensity than one where the service sector is dominant, even if the energy efficiencies within the two economies are identical.
- Emissions intensity is fuel mix or, more specifically, the GHG content of the energy consumed in a state. The product of energy intensity (E/GDP) and fuel mix (GHG/E) is equal to GHG intensity (GHG/GDP).

When non-CO_2 gases are included in this indicator, additional factors beyond energy intensity and fuel mix affect intensities and trends. For instance, CH_4 and N_2O emissions from agricultural sources might be influenced significantly by commodity prices and shifts in international livestock and grain markets.

The State of Himachal Pradesh has emergeds a leader in Hill Area Sustainable Development in India. Itis an ideal destination for investment in Power and Tourism sectors. Responsive administration and conducive macro-economic conditions have induced a competitive environment in the economy of Himachal Pradesh. The economy of the state is expected to achieve a growth rate of 6.2 percent in the current financial year which is comparatively better than the national growth of about 5.0 percent.

The State Gross Domestic Product (GSDP) at factor cost at constant (2004-05) prices in 2011-12 is estimated at 41,939 crore as against 39,036 crore in2010-11 registering a growth of 7.4 percent during the year as against the growth rate of 8.7 percent during the previous year. At current prices, the GSDP is estimated at 63,812 crore as against 56,355 crore in 2010-11 showing an increase of 13.2 percent during the year.

The Per Capita Income at current prices witnessed an increase of 10.7 percent as it increased to 74,694 in 2011-12 from 67,475 in 2010-11. The increase in total State Domestic Product is mainly attributed to 20.0 percent increase in Community & Personal services sectors, 8.9 percent in Transport and Trade, 8.1 percent in Finance & Real estate. Whereas the Primary sector decreased by 5.2 percent. Food-grains production, which was 14.94 lakh MT during 2010-11 has increased to 15.54 lakh MT during 2011-12 and is expected to increase to 15.80 lakh MT (anticipated) in 2012-13. The fruit production has decreased by 63.7 percent i.e from 10.27 lakh MT in 2010-11 to 3.73 lakh MT in 2011-12 and during 2012-13 (up to December, 2012) production was 4.67 lakh MT.

The economic growth in the State is predominantly governed by agriculture and its allied activities which showed minor fluctuations during nineties as the growth rate remained more or less stable. The decade showed an average annual growth rate of 5.7 percent, which is at par with national level. The economy has shown a shift from agriculture sector to industries and services as the percentage contribution of agriculture and allied sectors in total State Domestic Product has declined from 57.9 percent in 1950-51 to 55.5 percent in 1967-68, 26.5 percent in 1990-91 and to almost 20 percent in 2011-12. The share of industries and services sectors respectively has increased from 1.1 & 5.9 percent in 1950-51 to 5.6 and 12.4 percent in 1967-68, 9.4 & 19.8 percent in 1990-91 and to 18.0 and 12.3 percent in 2011-12. However, the contribution of other sectors showed a favorable shift i.e. from 35.1 percent in 1950-51 to 49.7 percent in 2011-12.

The declining share of agriculture sector does not, however, affect the importance of this sector in the State economy as the state economic growth still is being determined by the trend in agriculture and horticulture production. It is the major contributor to the total domestic product and has overall impact on other sectors via input linkages, employment and trade. Due to lack of irrigation facilities our agricultural production to a large extent still depends on timely rainfall and weather conditions. High priority has been accorded to this sector by the Government.

The hydro power is emerging as a powerful mechanism for speedier economic growth and overall development of the State. As a source of energy, hydro power is economically viable, non-polluting and is environmentally sustainable. The power policy of the State attempts to address all aspects like capacity addition energy security, access and availability, affordability, efficiency, environment and assured employment to people of Himachal.

High priority has also been accorded to Tourism sector, which has also emerged as a major sector in the development of economy of the State. The government has also developed appropriate infrastructure for its development which includes provision of public utility services, roads, communication network, airports, transport facilities, water supply and civic amenities etc.

In Himachal Pradesh with 100% electrification achieved, energy conservation programmes are in place for sustainable development, increasing solar energy usage, efficiency in the residential and commercial sectors, energy savings from space heating, air conditioning, refrigeration and lightening, capacity building of stakeholders in infrastructure development on energy saving options and technological innovations have been adopted. These all are evident from the fact that during the year 2011-12 energy consumption was 6633.045 Million units against that of 6958.497 million units in 2009 and the energy intensity has declined by 4.68%. Total CO_2 emissions from energy use were about 2.97% below 2008 levels in year 2012. Over the period 2008-2012, CO_2 emissions from energy use have decreased on an average by 3% although the economic activity (GDP) at constant price based on 2004-05 year has shown an average growth of 7.05% between this period. The GDP have increased steadily by 0.57% per year on an average until 2010-11 and further decreased slowly again during the year 2012 by about 1.02%.

The total CO_2 emissions per capita have decreased from 1.47 tons in year 2008-09 to 1.34 tons in 2012 that is to say a decrease of about 8.84%. Almost 80-85 % of reductions in CO_2 intensity are due to the decrease in energy use or increase in use of low GHG emitting sources of energy per unit of GDP. The CO_2 intensity decreased more rapidly than that of the energy intensity.

SUMMARY OF RESULTS

The sector wise summary of results are presented below:

1. **Energy:** The Energy sector emitted 5.147 million tons of CO_2 eq due to fossil fuel combustion in electricity generation in captive plants, transport, commercial/institutional establishments, agriculture, and energy intensive industries such as cement, steel and secondary metallurgical processing plants, including energy demand from Residential sector. Fugitive emissions from vehicles also accounted for emissions in the Energy sector.

    a. **Energy consumption for Industry, Tourism, Commercial, Institutional etc.:** The energy demand/ consumption in Industry, Tourism, Commercial, Institutional etc. activities emitted 2.757 million tons of CO_2 eq. which is about 53.56 % of the total CO_2 eq. emissions from Energy sector.

    b. **Residential:** The Residential sector in Himachal Pradesh is one of the major consumers of electricity, fuel, LPG etc. outside the energy consumed by industries. Total green house gas emissions from this sector were 1.41 million tons of CO_2 eq. about 27.30 % of of the total CO_2 eq emissions for Energy sector.

    c. **Transport:** The Transport sector emissions are reported from road transport, aviation, railways. In Himachal Pradesh, the Transport sector emitted 0.716 million tons of CO_2 eq. i.e. 13.91% . Road transport, being the dominant mode of transport in the State, emitted 99.95% of the total CO_2 equivalent emissions from the Transport sector. Railway and aviation in comparison only emitted 0.05% of the total CO_2 eq emissions.

    d. **Captive Power Generation and Consumption:** The total greenhouse gas emissions from captive power generation and consumption by industries were 0.244 million tons CO_2 eq. The CO_2 eq emissions from electricity generation were 4.74 % of the total CO_2 eq emitted from the Energy sector. It has been assumed that coal use constituted about 55% of the total fuel mix used.

    e. **Agriculture:** The energy demand/ consumption in agriculture activities emitted 0.0248 million tons of CO_2 eq. which is about 0.48 % of the total CO_2 eq. emissions from Energy sector.

2. **Industry:** In Himachal Pradesh industrial activities together emitted 5.57 million tons of CO_2 eq of GHG against a total of 9.196 million tons of CO_2 eq. Industry sector emissions have been estimated from data base for production process manufacturing of cement, glass, metals, chemicals, other specific industries. The emissions covered in the Industry sector include the process based emissions.

    a. **Cement and Glass Production:** The cement industry emitted 5.31 million tons of CO_2, which is 95.33% of the total CO_2 eq emissions from the Industry sector. The emissions cover all the large, medium and mini cement plants and grinding plants. The others like glass production emitted 892.3 000' tons of CO_2 eq.

    b. **Metals:** The metal industry namely, aluminium, ferroalloys, lead, zinc and copper production lead to an emission of 0.233 million tons of CO_2 eq. about 4.18% of the total of CO_2 eq emissions.

    c. **Chemicals:** The chemical industries together emitted 0.0259 million tons of CO_2 eq. about 0.466% of the total of CO_2 eq emissions.

    d. **Other Industries:** Other industries comprising of pulp/paper, leather, textiles, food processing , mining and quarrying, and non specific industries comprising of rubber, plastic, watches, clocks, transport equipment, furniture etc., together emitted 0.0786 000' tons of CO_2 eq. which constitute only about 0.0014% of total emissions from this sector.

3. **Agriculture:** The Agriculture sector estimated to be emitting 0.164 million tons of CO_2 eq. Estimates of GHG emissions from the Agriculture sector arise from enteric fermentation in livestock, manure management, rice cultivation, on field burning of crop residue and agricultural soils.

    a. **Livestock:** Enteric fermentation in livestock released 2.542 000' tons of CO_2 eq (0.12104 000 tons of CH_4). This constituted 1.55% of the total GHG emissions (CO_2 eq) from Agriculture sector in the State. The estimates cover all livestock, namely, cattle, buffalo, sheep, goats, donkeys, horses and others. Manure management emitted 0.0292 000' tons of CO_2 eq.

    b. **Rice Cultivation:** Rice cultivation emitted 0.148 million tons of CO_2 eq or 7.0445 000' tons of CH_4. The emissions cover both type of rice cultivation, namely, irrigated, rainfed and upland rice cultivation. The upland rice is zero emitter with irrigated fields being the only emitter of methane per unit area.

    c. **Agricultural Soils and Field Burning of Crop Residue:** The total CO_2 eq emitted from these two sources were 13.37 000' tons about 8.15% of total CO_2 eq emissions. Agricultural soils are a source of N_2O, mainly due to application of nitrogenous fertilizers in the soils. Burning of crop residue leads to the emission of a number of gases and pollutants. Amongst them, CO_2 is considered to be C neutral, and therefore not included in the estimations. Only CH_4 and N_2O are considered in this study.

4. **Land Use Land Use Change and Forest:** The LULUCF sector in Himachal Pradesh was a net sink. It sequestered 1685.276 000' tons of CO_2. The estimates from LULUCF sector include emission by sources and or removal by sinks from forest land, crop land, grassland. Wet lands have not been considered due to lack of data.

    a. **Forest Land:** Analysis indicate that forest land sequestered 3040.40 000' tons of CO_2 in Himachal Pradesh. However, deforestation due to developmental activities, fuel wood extraction in non-sustainable manner from forests led to an emission of 1319.40 000' tons of CO_2 in the State. This includes estimates of emissions and removal from biomass in very dense, moderately dense, open forests, and scrub lands.

    b. **Crop Lands:** The crop land emitted 76.060 000' tons of CO_2 in Himachal Pradesh. The emission estimates have been made from net sown area as well as fallow land.

    c. **Grassland:** Pasture, grassland resulted in the sequestration of 40.336 000' tons of CO_2 due to changes in grass land area over a period of time.

5. **Waste:** The Waste sector emissions were 1.0489 000' tons of CH_4 from municipal solid waste management and industrial waste water management.

    a. **Municipal Solid Waste (MSW):** It has been estimated that the MSW generation and disposal resulted in the emissions of 1.0489 000' tons of CH_4 in Himachal Pradesh. Systematic disposal of solid waste is carried out only in the major towns resulting in CH_4 emissions due to aerobic conditions generated by accumulation of waste over long periods. It is observed that municipal solid waste is the major nuisance in emission of GHGs in the State.

    b. **Waste Water:** The waste water generation emissions are estimated only for waste water disposal from industries. Waste water management from industries emitted about 0.0030 000'tons of CO_2 eq.

The Way Forward

- The major source of GHGs emission is bulk demand of energy from industry, commercial, tourism and developmental activities. There is a need for adaptation and mitigation measures including introduction of cleaner production technologies, waste minimization, environmental audits including energy efficiency in these areas.

- The energy demand from residential areas is also showing need for mitigation measures in the State. We need to make people aware about importance of energy conservation.

- The Cement industries in the State are also a major source of GHGs emission. We need to strategise further developments in this sector in light of GHGs emissions so that there are energy savings and use of alternative fuel in the cement kilns.

- GHGs emissions from road transport are also comparatively high. There is a need for promoting mass transportation, alternatives like ropeways etc.

- Need to encourage run-of-river micro hydel projects, solar passive technologies, rain water harvesting, green housing, green transportation, green industry, green jobs etc. in the State.

- Attention is also drawn towards changes in land use, grasslands, pastures leading to GHGs emissions. There is a need to enhance the afforestation activities/ programmes in the State for carbon sequestration.

- Urban local bodies, urban development sector needs to take action for disposal and management of municipal solid wastes in the State. We need to have effective waste management facilities in the State to bring down emission from this sector.

- There is a need for integration of activity based data representing State specific conditions, bridging data gaps and eliminating uncertainties using some hill area specific GHG emission factors.

- Capacity building is critical at institutional and individual levels. Capacity at the institutional level addresses the needs of inventory preparation at State, sectoral and local point source level that requires collection and archiving of data on a continuous basis.

- Establishment of a State GHGs Emissions Inventory Management System is necessary by involving additional institutions with varied research experience, to widen the pool of researchers and enable the integration of latest practices.

- The Green House Gases emissions inventory of the State should be done on a five year cycle.

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Glossary

Agriculture: This includes emissions from enteric fermentation, manure management, rice cultivation, managed soils and burning of crop residue.

Chemicals: In this document chemicals include production of ammonia, nitric acid, carbide, titanium dioxide, black carbon, methanol, ethylene, ethylene oxide, acrylonitrile, ethylene dichloride and vinyl chloride, monomer and other chemicals (dyes and pigments, inorganic acids except nitric acid, acyclic hydrocarbons, inorganic compounds, alkalies etc).

CO_2 Equivalent: It is the sum total of all Greenhouse Gases in terms of their global warming potential. In this document the CO_2 equivalent includes the sum of Carbon dioxide, Methane multiplied by its GWP (21) and Nitrous oxide multiplied by its GWP (310).

Country Specific Data: Data for either activities or emissions that are based on research carried out on-site either in a country or in a representative country.

Emission Factor: A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factor are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.

Emissions: The release of greenhouse gases and/ or their precursors into the atmosphere over a specified area and a period of time.

Energy: This category included all GHG emissions arising from combustion of fossil fuel and fugitive release of GHG's. Emissions from the non-energy use are not included here and are reported under the industry sector. This category includes emissions due to fuel combustion from energy industries (captive electricity generation), transport, commercial / institutional, residential, agriculture / forestry , and other fugitive emissions etc.

Enteric Fermentation: A process of digestion in herbivores (plant – eating animals) which produces methane as a by-product.

Estimation: The process of calculating emissions and / or removal

Fossil Fuel Combustion: Is the intentional oxidation of fossil fuel that provides heat or mechanical work to process.

Global Warming Potential (GWP): GWPs are calculated as a ratio of radiative forcing of 1 kilogram greenhouse gas emitted to the atmosphere to that from 1 kilogram CO_2 over a period of time (e.g. 100 years).

Good Practice: Is a set of procedures intended to ensure that GHG inventories are accurate, that neither over nor underestimated and that uncertainties are reduced as far as possible. It covers choice estimation methods, quality assurance and quality control, quantification of uncertainties and processes for data archiving and reporting.

INCCA: Indian Network for Climate Change Assessment - an initiative being coordinated by the Ministry of Environment and Forests, Government of India.

Industry: This includes emissions from industrial processes and emissions due to fossil fuel combustion in manufacturing industries. The emissions are estimated from mineral industry (cement, lime, glass, ceramics, soda ash use), chemical industries (ammonia, nitric acid, carbide, titanium dioxide and black carbon, methanol, ethylene, etc.), metal industry (iron and steel, ferroalloys, aluminium, magnesium, lead etc.), other industry and non-energy products from fuels and solvent use (paraffin wax and lubricants).

Land Cover: The type of vegetation, rock, water, etc. covering the earth surface.

Land Use: The type of activity being carried out by unit of land.

Land Use Land Use Change and Forestry (LULUCF):
Includes emissions and removal from changes in areas of forest land, crop land, grass land, wet land, settlements and other lands.

Million Tons: equal to 10^6 tons.

Non Energy Products: Primary or secondary fossil fuels which act as diluent. Examples, lubricants, paraffin wax, bitumen, etc.

Non-specific industries: Includes rubber, plastic, medical precetion equipments, watches, clocks, other transport, furniture, re-cycling etc.

Other Industry: Includes GHG emissions from production of food processing, textile, leather, mining and quarrying, non specific industries and use of lubricants and paraffin wax.

Per Capita Emissions: GHG emissions in CO_2 eq per person.

Removals: Removal of greenhouse gases and or their precursors from the atmosphere by a sink

Sequestration: The process of storing carbon in a carbon pool.

Sink: Any process, activity or mechanism which removes greenhouse gases from the atmosphere.

Source: Any process or activity which releases a greenhouse gas.

Tier I: Its approach employs activity data that are relatively coarse, such as nationally or globally available estimates of deforestation rates; agriculture production statistics and global land cover maps.

Tier II: It uses the same methodological approach as Tier 1 but it applies emission factors and activity data which are defined by the country.

Tier III: Applies higher order methods are used including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by disaggregated levels.

Uncertainty: Lack of knowledge of the proper value of a variable.

Waste: Includes methane emissions from anaerobic microbial decomposition of organic matter in solid waste disposal sites and methane produced from anaerobic decomposition of organic matter.

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