MEGHALAYA

Carbon Footprint Study

MEGHALAYA STATE

Submitted to

THE FOREST & ENVIRONMENT DEPARTMENT
GOVERNMENT OF MEGHALAYA

Submitted by

CONFEDERATION OF INDIAN INDUSTRY
CII – SOHRABJI GODREJ GREEN BUSINESS CENTRE
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Disclaimer

This report is a part of the Confederation of Indian Industry, CII – Sohrabji Godrej Green Business Centre's efforts to assist the State Government of Meghalaya to attain Low Carbon Growth for the future.

The recommendations provided in the report are from CII Godrej GBC. The State of Meghalaya does not have any obligation to accept any/all recommendations in the report.

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The study is open for stakeholder consultation and you may write your views and comments to: encon@cii.in

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1. Executive Summary

The Government of India released the National Action Plan on Climate Change for India in June 2008 (NAPCC, 2008) addressing India's climate change concerns, areas of priority and a well-defined action plan.

In addition to the roadmap provided by NAPCC that guides states on prioritizing strategies, the Ministry of Environment and Forests (MoEF) has also developed a common framework that facilitates states in preparing its State Action Plan in line with the objectives of the NAPCC.

Meghalaya emerged as an autonomous state on the 2nd of April, 1970 and as a full-fledged State on the 21st of January 1972 marking the beginning of a new era of the geo-political history of North Eastern India. Meghalaya is located in the biological hotspot region of eastern Himalayas and is one of the seven sister states situated in North-East India. The State of Meghalaya is mostly mountainous with stretches of valley and highland plateaus. It has about 76% of its area under forest and is rich in biodiversity. The state also has a large amount of mineral deposits in the form of limestone, coal and others..

A state carbon footprint or the greenhouse gas inventory of a state, is an accounting procedure for the greenhouse gases (GHGs) emitted to (or removed from) the atmosphere as a result of the state's resources and operations (in the selected baseline year). State government policy makers can make use of the GHG inventories to establish a baseline for tracking the emission trend, to develop enabling policies & strategies for GHG emission mitigation and to assess the progress on a regular basis.

The GHG Emission Inventorisation for the state of Meghalaya was carried out based on the IPCC Guidelines for National Greenhouse Gas Inventory. This includes various sources and removal sinks which fall under the geographical boundaries. The "India Greenhouse Gas Emissions Report 2007" was taken as a reference to define the GHG inventorisation methodology for the state. The approach was adopted to avoid uncertainties and to ensure that the report is aligned with the "India Greenhouse Gas Emissions Report 2007". The emission factors used in this study are a mix of country specific emission factors and default factors from IPCC. Default factors were used only if country specific factors were not available.

The Carbon Footprint study for the Meghalaya state indicates that the total GHG emissions in the baseline year 2012-13 was 2.96 million Tons of CO2 Eq. The contribution from energy, agriculture, waste, industry and land use to the total emissions are described in Table 1. The table also indicates the significant contribution from each of the sub-categories of the major sectors.

Table 1 - Sector-wise contribution to total emmissions

Sr. No	Emission Source	T CO_2 (eq)	% of Source	% of overall
A	**Energy**	**1594871**	**100**	
A-1	Power	56238	3.53	**23.59**
A-2	Transport	1004106	62.96	
A-3	Residential	119278	7.48	
A-4	Other	311115	19.51	
A-5	Fugitive	104133	6.53	
B	**Agriculture**	**1233194**	**100**	**18.25**
B-1	Enteric fermentation	538913	43.70	
B-2	Manure Management	46937	3.81	
B-3	Field burning of agriculture residues	7157	0.58	
B-4	Direct N_2O emissions from agriculture soils	329994	26.76	
B-5	Indirect N_2O emissions from agriculture soils	116250	9.43	
B-6	Rice Cultivation	193942	15.73	
C	**Industry**	**3800543**	**100**	**56.23**
C-1	Cement Industry	3450461	90.79	
C-2	Ferro Alloys Industry	293202	7.71	
C-3	Other Industry	56879	1.50	
E	**Waste**	**129766**		1.92
E-1	Municipal Solid Waste (MSW)	23975	18.48	
E-2	Domestic Water	19103	14.72	
E-3	Industrial Water	86688	66.80	
	Gross Emissions	**6758374**		100.00
D	**LULUCF**	**-3798040**	-	
D-1	Forest land & Fuel Wood	-3389993	-	
D-2	Crop Land	-565335	-	
D-3	Grass Land	157289	-	
	Net Emissions	**2960334**		

The first step in the overall approach of the emission reduction strategy of Meghalaya should be to frame an aggressive emission reduction target. In line with the national commitment of reducing emission intensity by 33-35% of 2005 levels by 2030[1], this study explored all possible options to facilitate the state of Meghalaya achieve a similar emission intensity reduction. Based on the mitigation options identified, an emission intensity reduction of 30-33% by 2030 for the state of Meghalaya appears to be feasible and promising. Based on its current emission profile, various mitigation options are recommended for the State of Meghalaya.

Some of the key recommendations are:

1. Prepare a State-specific Low Carbon Technology Roadmap for the Cement Sector in Meghalaya that will target a 48% reduction in GHG emission intensity (Tons of CO_2/Tons of Cement) by 2050. The target is aligned with the Low Carbon Technology Roadmap for India. The roadmap should highlight key interventions for reduction in emissions by the cement sector.

2. Co-processing of industrial, municipal and other combustible wastes in cement kilns is another alternate for meeting the dual needs of meeting the cement industry's energy requirements partially, and also addressing the waste management issues of the state. The State should also explore the option of using alternate material for Cement production such as fly ash and slag. This will result in significant reduction of GHG emissions by the cement sector

3. Implement Demand Side Management program in the Domestic Sector :

   a) Domestic : In 2012, the sale of incandescent lamps (ICL) accounted to 1.2 million units[2]. Replacement of ICL with LEDs (consumes 85% lesser energy when compared to ICL) will result in a savings of 79 million units of electricity, which is equivalent to 64,780 tons of CO_2

   b) Domestic: In the State of Meghalaya more than 80% of the population is dependent on fire wood to meet the energy requirement for cooking and heating. This method of cooking is coupled with inefficient stoves which results in more consumption of fire wood and a high amount of pollutants that affect the health of people. In many countries, activities under UNFCCC, focused on promoting Energy Efficient Stoves (Ex. Kenya, Rwanda, Bangladesh). The State of Meghalaya should also explore the option of introducing such programs to improve the household conditions and also to minimize the pollutants..

1- Intended Nationally Determined Contribution – India's Submission to UNFCC
2- Energy Efficiency Services Limited (DELP Scheme)

4. It is suggested that the State should explore the option of utilizing renewable energy through charting out a state-specific renewable energy roadmap to increase the capacity to 1000 MW by 2022. Investments in renewable energy should be aggressively promoted that will enable the state in achieving a significant reduction in carbon emission intensity.

5. Adopt voluntary Renewable Power Obligation (RPO) targets surpassing the mandatory values that government may impose. RPO should be gradually increased from the current levels of 1.5%[3] to 25% by 2025.

6. Create 'Green Fund' that will support the state's climate mitigation efforts through funds raised from larger emission sources. This could serve as an option to resolve environmental concerns to a certain extent without compromising on the citizens' fundamental requirements.

7. Land Use, Land Use Change and Forestry (LULUCF) are excellent carbon sinks. The State should leverage schemes such as REDD+ and other forestry schemes for promotion of Forestry in the State

8. Cleaner production and industry symbiosis can improve the productive use of energy, materials and water, reduce the generation of waste and emissions (including GHGs) and strengthen the sound management of chemicals for Small and Medium Enterprises (SMEs). The new industrial parks that are planned to be set up by the State Government should be built on various principles of Eco-Industrial Parks

9. The funds generated by imposing a fuel cess of Rs 0.50/Litre on diesel and petrol can be utilized to fund bio fuel research and to support technology absorption. Based on the baseline year data, the proposed fuel cess (at the rate of Rs 0.50/Litre) will result in substantial funding towards research and implementation on development of Low Carbon Transport.

10. Consider imposing 'Green Tax' on new vehicles at 1% of the vehicle cost. This green tax can be channeled to develop public transportation system and inter-city transportation across the state.

11. Consider clean energy cess on non-fossil fuel based energy such as energy plantations, bio mass, waste to energy, etc.

3- Meghalaya State Electricity Regulatory Commission

12. Promoting Green Village concept by adopting IGBC's Green Village Rating System for Villages in Meghalaya. The green concepts and techniques in the villages will help address concerns such as water availability, energy availability, increased fossil fuel use, waste management and natural resource conservation. Most importantly, these concepts can enhance health and well-being in villages, which are of greater importance.

13. Promote adoption of green buildings in residential & commercial spaces. For example, the government can provide around 8-10% extra FAR for green buildings

14. Demand side management in agricultural pumpsets, water & crop management and Systemic Rice Intensification (SRI) technique to be explored as potential emission reduction opportunities in the agricultural sector.

Disclaimer:

The above mentioned points are recommendations to the State Government of Meghalaya.

This carbon footprint study would assist the Meghalaya State Government in carrying out resilient action for the future and also in developing the state as a strong investment destination in the country. This report has estimated the baseline emissions for Meghalaya for the year of 2012-13 and has highlighted broad opportunities for emission reduction and for achieving low carbon growth for the state.

2. NAPCC AND INDIA GHG EMISSION

The objective of the National Action Plan on Climate Change (NAPCC, 2008) is to reduce GHG intensity by 5% by 2020 (base year 2005). The Action Plan outlined eight missions that will help in mitigating climate change and undertake adaptation measures without compromising on the Nations's economic growth. The Action Plan suggests that the long term convergence of per capita GHG emissions is the only equitable basis for a global agreement to tackle climate change.

The National Missions formulated within the NAPCC include:

1. National Solar Mission – Aims to increase the share of solar energy in the total energy mix and undertake R & D in the lookout for better and affordable technologies.

2. National Mission for Enhanced Energy Efficiency – Aims to enhance energy efficiency in industries, commercial and residential applications. The mission aims at achieving energy savings in excess of 23 Million Tons of Oil Equivalent (MTOE) and cumulative avoided power generation capacity addition of 19,000 MW. The mission will help in reducing 98 million Tons of CO2 per annum.

3. National Mission on Sustainable Habitat – Aims to make habitats sustainable through improvements in energy efficiency in building, management of solid waste and model shift to public transport.

4. National Water Mission – Aims to improve water use efficiency by 20% with respect to the current scenario and ensure integrated water resource management helping conserve water, minimize wastage and ensure more equitable distribution both across and within states.

5. National Mission for Sustaining the Himalayan Ecosystem – Aims to evolve management measures for sustaining and safeguarding the Himalayan glacier and mountain eco-system.

6. National Mission for a "Green India" – Aims to increase the forest cover from the present 23% to 33% in order to preserve ecological balance and biodiversity.

7. National Mission for Sustainable Agriculture – Aims to devise strategies to make Indian agriculture more resilient to climate change.

8. National Mission on Strategic Knowledge for Climate Change – Aims to develop a better understanding of climate science impacts and challenges.

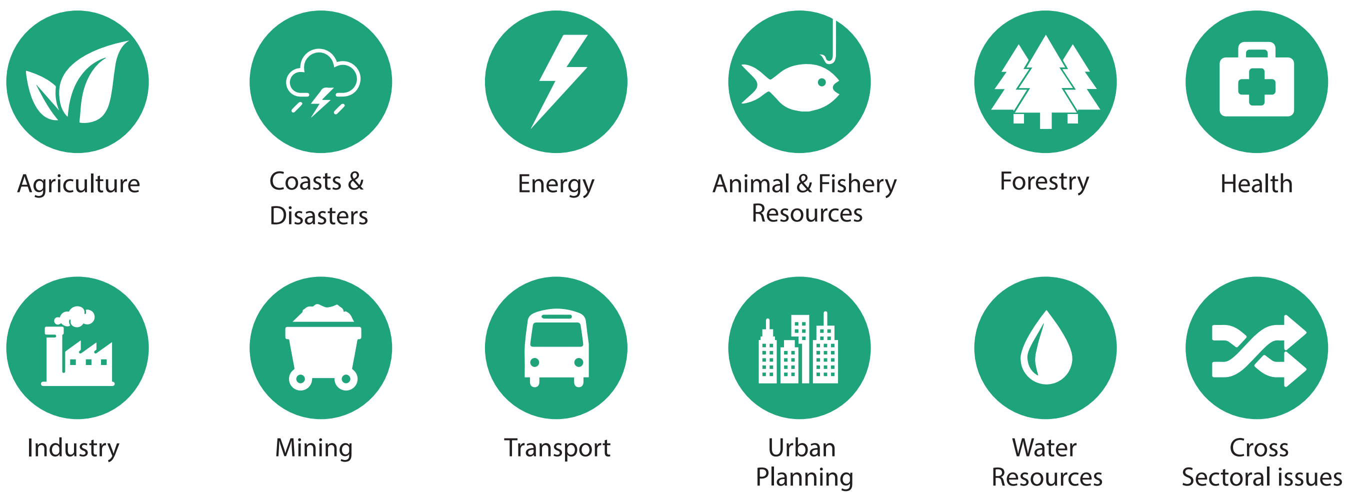
In addition to the roadmap provided by NAPCC, the Ministry of Environment and Forests (MoEF) has also developed a common framework that facilitate states to prepare their state action plans in line with the broad objectives of the NAPCC.

Which includes the following steps:

- Conduct scientific assessment of climate observations and projections, sectoral impacts and vulnerabilities, and prepare an inventory of greenhouse gas emissions in the state in order to identify vulnerable regions, sectors and communities for targeted adaptation and mitigation action.
- Identify adaptation/mitigation options based on the Missions identified under the NAPCC, ongoing programmes and projects in the state, and additional strategies that may not be covered directly under the eight national missions.
- Prioritize adaptation/mitigation options by taking into account the national policies, sectoral strategies under the national missions and state level priorities, through multi-stakeholder consultations and interactions.
- Identify financial needs and sources to implement selected adaptation/mitigation options (MoEF 2010).

Meghalaya State Government in 2010, released its state action plan on climate change "Meghalaya State Climate Change Action Plan". The action plan is comprehensive and addresses the climate change issues with focus on adaptation and mitigation initiatives. The core of the action plan lies in a collective, coordinated approach between the key stakeholders. The government has established a Climate Change Cell to coordinate and implement the different components of this action plan. The plan focuses on addressing the issues of 11 critical sectors that have significant contributions to climate change.

These sectors, listed below, have important bearing on the overall development and livelihood of the people of the state and are most vulnerable to the impacts of climate change.



3. MEGHALAYA AT A GLANCE

Meghalaya – "The Adobe of Clouds" is located in the North Eastern part of India. As a state of the Indian Union, Meghalaya came into being on 21 January 1972. It was created by carving out two districts of the former composite state of Assam, namely, the United Khasi and Jaintia Hills, and the Garo Hills. At present, Meghalaya comprises seven districts: East Garo Hills, East Khasi Hills, Jaintia Hills, Ri-Bhoi, South Garo Hills, West Garo Hills, and the West Khasi Hills. Its capital, Shillong, was also the capital of undivided Assam from 1874 until the creation of the new state of Meghalaya.

The state's area largely comprises of tablelands and hill regions that is heavily forested and with several rivers that pass through the state. It is an abode of tremendous biodiversity, and the soil and climate are conducive to the cultivation of a large variety of agricultural crops, horticultural produce, and flowers.

Meghalaya is blessed with abundant natural resources such as forest, mineral resource, agriculture land, flora and fauna and has forest are of more than 17,000 km2, which constitutes around 76% of overall geographic area of the state. Because of the favorable geographic location, mineral resources and availability of agriculture lands, the state economy has been mainly dependent on agriculture and forestry. Over the past few years, the state has also attracted investment in industrial sectors – cement and Ferro alloys.

Table 1 - Sector-wise contribution to total emmissions

Particulars	Meghalaya
Capital City	Shillong
Administrative Districts	11
Geographical area-Sq. km (9th)	22,429 (0.68%)
Population in millions (23rd)	2.96
Male population	1.49
Female population	1.47
Literacy rate in % (25th)	74.43
Source :http://censusindia.gov.in	

Meghalaya, with abundant deposits of coal, limestone, kaolin feldspar, quartz, granite, industrial clay and uranium and a small deposit base of sillimanite, bauxite, base metals, thereby iterating the fact that there is a huge industrial potential. With the objective of promoting industrial development in the state, the Government of Meghalaya has introduced the Meghalaya Industrial and Investment Promotion Policy (MIIPP) – 2012 and has also restructured Meghalaya Industrial Development Corporation for facilitating effective industrial development in the state. The state attracted good amount of investment in the last few years with many cement plants being commissioned in the state.

From the perspective of power availability, the State of Meghalaya is a power deficit state. The power generation in the state is mainly through Hydro Power. The state has a potential of around 3,000 megawatt (MW), of which only 314.5 MW has been utilised so far[4].
Following is the scenario of power availability:

Table 3 - Power Scenario in the State of Meghalaya (Meghalaya Energy Corporation Limited)

Year	Unrestricted Peak Demand (MW)*	State Generation (MU)	Power Purchase (MU)	Total Availability (MU)
2004-05	220	635.35	757.96	1393.31
2005-06	280	514.44	871.66	1386.10
2006-07	350	389.09	929.30	1318.39
2007-08	385	663.06	924.15	1587.21
2008-09	352	552.84	968.92	1521.76
2009-10	339	534.79	947.29	1482.08
2010-11	289	507.90	1129.15	1637.05
2011-12	373	517.54	1170.54	1688.08
2012-13	381	704.55	1056.78	1761.33
2013-14	396	861.79	1028.76	1890.55

Note: * Unrestricted Peak Demand is based on the (Connected Load *0.85 * 0.6)

The state is witnessing a rapid economic growth. In 2013-14, Meghalaya State was the fastest growing state in India with a Gross State Domestic Product of 9.7%[5]. Meghalaya is among the fastest growing states in the North-Eastern part of India and is emerging as the center for cement businesses in India. It is attracting majority of the investments in Cement, Agriculture and metal sectors. Listed below are a few comparative advantages that Meghalaya state has over other states.

- A storehouse of vast natural resources, namely, minerals, agricultural products, forest products, hydel power, etc.
- Special Central Government and State Government incentives for investment in Meghalaya
- Adequate infrastructure particularly in terms of power, transportation, communication, banking, medical facilities, education etc.
- Investment friendly state in the country

4- http://meecl.nic.in/network.htm
5- India Brand Equity Foundation and Business Standard

Following are some of the initiatives taken by the Meghalaya State Government for promotion of sustainable growth in the country

Sustainable Agriculture Practices

Meghalaya's economy is basically an agrarian economy, with more than 80% of the population dependent on agriculture. In the past, Meghalaya has taken many initiatives for promoting sustainable agriculture. The state Department of Agriculture is creating awareness and providing technical know-how to farmers for practising improved and modern methods of farming, use of chemical fertilizers, plant protection measures and introduction of High Yielding Variety (HYV) seeds of Paddy, Wheat, Maize and many more. These initiatives have contributed to the increase in production of food grains.

In the recently introduced State Action Plan on Climate Change by the Government of Meghalaya, agriculture sector has a special focus and many initiatives are on-going under the plan. The Government of Meghalaya has also taken initiatives to promote Systematic Rice Intensification (SRI) for paddy cultivation which not only helps in improving the yield but also addresses the concerns of climate change. The government has also been addressing the climate change concerns for agriculture by undertaking many climate change adaptation measures for the agriculture sector. The other initiatives by the Government of Meghalaya include – Watershed Management, Water Management, Pest Management, Nutrient Management and many more.

Renewable Energy

Renewable Energy has been promoted by Government of Meghalaya since late 1980s. The Government established Meghalaya Non-Conventional and Rural Energy Development Agency in 1987 as a State Nodal Agency for the Ministry of New and Renewable Energy Sources. The objective of the Agency is to formulate and implement demonstration, experimental, promotional and extension projects and programs related to New and Renewable Energy.

Recent studies indicates that the State of Meghalaya has renewable energy potential of more than 3 GW. To utilize the potential, the Government of Meghalaya has introduced a Policy for promoting generation of Power through Non-conventional Energy sources. The Central Government has announced the target of 175 GW of Renewable Energy by 2022 and has allocated 161 MW of Solar Power and 50 MW Small Hydro Power to the State of Meghalaya[6].

The state also introduced Renewable Purchase Obligation and the state has very ambitious RPO targets upto 2017-18

6- Report of Expert Group on 175 GW renewable energy by 2022 : NITI Aayog

Table 4 - Meghalaya State RPO

Year	Solar RPO	Non Solar RPO	Total RPO
2015-16	0.41%	1.09%	1.50%
2016-17	0.42%	1.58%	2.00%
2017-18	043%	2.07%	2.50

Meghalaya Non-Conventional and Rural Energy Development Agency is also taking many other initiatives such as promotion of domestic biogas plants, improved chullas (cook stoves), village electrification, solar pumping, solar street lighting, etc. There are other agencies also such Meghalaya Basin Development Authority has also initiated other program such as Chikgitchakre and Banderkona Energy Sufficiency Project and Bhaitbari Primary Health Center Energy project

The Government of Meghalaya has taken many initiatives for promoting energy efficiency in the State.

Few energy efficiency and energy conservation measures initiated by the Meghalaya State Government are summarized below:

Energy Efficiency Meghalaya State Government with the support of Bureau of Energy Efficiency has established the Meghalaya State Designated Agency (MSDA) for effective implementation of the Energy Conservation Act and promotion of energy efficiency activities in the state. MSDA has been designated with the responsibilities of promoting awareness, capacity building, facilitating finance, facilitating the implementation & demonstration of pilot energy efficiency projects, implementation of Energy Conservation Building Codes in the State and various other functions.

Electrification

The Government of Meghalaya and the Central Government of India has initiated the project on providing 24 X 7 Power for All Meghalaya. Under this program it is envisaged to cover the entire state under programme in a phased manner and provide 24x7 power supply to all domestic, agriculture industrial and commercial consumers for all connected households from 2017 and to all un-connected households by 2019.

Investment Grade Energy Audit for Government Buildings

Investment Grade Energy Audit (IGEA) study has been conducted by MSDA with the support of some reputed Indian organizations

IGEA Outcomes

Energy saving potential was identified for government buildings

Industries

Meghalaya State has 3 designated consumers under the 2nd Cycle of PAT scheme in various sectors such as cement and iron and steel. Efforts are ongoing to meet the targets set by the scheme

Government Buildings

Energy conservation measures taken in all government buildings, offices and local bodies such as mandatory use of CFL, energy efficient air conditioners, etc.

Others

Demand Side Management Project for replacement of existing lighting with LEDs.
National energy conservation day celebrations, awareness program on energy efficiency and conservation in villages, training and workshops for industries and other stakeholders

4. CARBON FOOTPRINT STUDY

Atmospheric levels of carbon dioxide (CO2) have increased steadily since the beginning of the industrial revolution and these levels are projected to increase even more rapidly as the global economy grows. Significant climate changes are associated with increased atmospheric concentrations of certain gases, most significantly CO2. The human and ecological cost of climate change in the absence of mitigation measures is forecasted to be sufficiently large. The time scales of both intervention and resultant climate change response are sufficiently long, which warrant immediate prudent action.

A carbon footprint study facilitates understanding the current emissions and development of an action plan for emission mitigation based on the current inventorised emissions.

4.1 STATE CARBON FOOTPRINT STUDY

A state carbon footprint (or greenhouse gas inventory of a state) is an accounting of greenhouse gases (GHGs) emitted to (or removed from) the atmosphere in the baseline year. State government policy makers can use GHG inventories to establish a baseline for tracking emission trends, developing enabling policies & strategies for GHG emission mitigation, and assessing progress on a regular basis. A carbon footprint study is usually the first step taken by state governments that want to reduce their GHG emissions. An inventory can help state governments:

- Identify the GHG emissions intensive sources within their boundary
- Understand emission trends
- Quantify the benefits of measures that reduce emissions
- Establish a basis for developing policies and track progress on actions taken
- Set goals and targets for future reductions

4.2 CARBON FOOTPRINT STUDY OBJECTIVE

- Identify major sources of GHG emissions
- Understand historic emission trends
- Quantify benefits of activities that reduce emissions
- Establish basis for developing a local action plan
- Track progress in reducing emissions
- Set goals and targets for future reduction

4.3 BENEFITS TO MEGHALAYA STATE

The benefits of developing a GHG inventory are numerous and varied, and include:

- **Increasing preference from foreign investors**

  With increasing international awareness & demand for green investment designations, the carbon footprint exercise and long term vision of a low carbon state would put Meghalaya on the green investment map. This will also facilitate increased investment opportunities from investors and developmental organizations looking at climate conscious destinations.

- **Direction for future investments**

  The carbon footprint study aims to highlight not only the emission intensive sectors, but also provides a holistic understanding of the carbon distribution across sectors. This study will serve as a tool to identify and direct future investments. It will also highlight opportunities for carbon intensity reduction in different sectors and facilitate in directing investments in these sectors.

- **Efficient Risk Management**

  Inventorizing GHG emissions would help governments manage climate risk by documenting and taking early actions to reduce GHG emissions intensity. Such information will help the state be better prepared for any environmental risk.

- **Recognition as an environmental leader**

  Accounting GHG emissions and developing a low carbon strategy provides governments with a roadmap to recognize, publicize, and promote their environmental stewardship. Meghalaya would be one among the first few states in the country to have its carbon footprint.

- **Preparedness for a carbon constrained future**

  Identifying emissions sources to develop a GHG profile and management strategies that will help the government be better prepared to respond to a carbon constrained future.

- **Opportunity to address Inefficiencies**

  Accounting for emissions has helped several corporates gain better insights into the relationship between improving efficiency (reducing factor inputs and waste) and reducing emissions. As a result, organizations have redesigned business operations and processes, brought in technological innovations, improved products and services and ultimately realised gains, both, monetary terms and resources savings. Similar opportunities exist for the state,, wherein the state can evaluate, identify and redesign its operations to improve efficiencies and reduce waste.

- **Stakeholder Engagement opportunities**

  Putting together the annual GHG emissions inventory can help inform state administration, management, constituents, employees, and the public in general, about the government's GHG emissions profile. This presents an excellent opportunity to involve all stakeholders in 'Greening' Meghalaya.

5. GHG EMISSION INVENTORISATION METHODOLOGY

The GHG emission inventorisation in the state of Meghalaya was carried out based on the IPCC Guidelines for National Greenhouse Gas Inventories. This includes various sources and removal sinks which fall under the provincial boundaries. The "India Greenhouse Gas Emissions Report 2007" has been taken as reference to define the GHG inventorisation boundaries for the state. This approach has been adopted to avoid uncertainties and to ensure that the report on GHG Inventorisation for Meghalaya State is aligned with the national inventory, "India Greenhouse Gas Emissions Report 2007".

5.1 GHG EMISSION ESTIMATION APPROACH

GHG emissions can be estimated by adopting two different approaches, namely absolute basis and scoping basis. Each of these methods is unique and offer specific advantages.

Absolute Basis approach covers emissions that fall within the geopolitical boundary irrespective of the influence from source outside the boundary. This method eliminates double counting of emission sources.. In addition, this method will also provide an opportunity for every state to align their emission inventory with the future national inventory. Hence, this absolute method would be the most preferred approach for a study at a National or a state level. It should be noted here that the emissions under this methodology are indicated in terms CO2 Equivalent (CO2 Eq.).

The scoping basis approach is a relatively simple one when compared to the absolute basis approach. Under scoping study, emission sources are categorized as direct (Scope 1) emissions and indirect (scope 2 and scope 3) emissions based on the control of the state on operations. This method overlooks certain emission categories when they are relatively insignificant in comparison to the total emission levels.

For the Meghalaya state study, "Absolute Approach" has been adopted. This approach provides a reasonable amount of flexibility for other states to calculate emissions from their sources without double counting. Secondly, it also enables the Nation to quantify emissions through summation of the GHG inventories of all states in the country. Finally, this approach would align the state's report with the methodology employed in the National inventory, "India Greenhouse Gas Emission Report 2007".

5.2 BASELINE YEAR

The choice of a baseline year becomes crucial for any study of this kind, since accuracy is a critical factor for estimating GHG emissions. To meticulously analyze the state's inventory, the baseline period of 2012-13 was chosen. Many of the government departments of Meghalaya were in the process of data consolidation post 2012-13 and large amount of key data required to estimate GHG emissions were not updated after 2012-13. It is also the year for which the most complete and most accurate data is available.

5.3 GREENHOUSE GASES COVERED UNDER THE STUDY

Internationally, all local government inventories assess emissions of all six greenhouse gases recognized greenhouse gases regulated under the Kyoto Protocol. For completeness of the GHG Inventory for the state of Meghalaya, all the 6 greenhouse gases have been accounted separately and emissions are reported in metric Tons of each gas and metric Tons of CO2 Eq.

Table 5 - GHG gases covered under the study

Gas	Formula
Carbon Dioxide	CO_2
Methane	CH_4
Nitrous Oxide	N_2O
Hydrofluorocarbons	HFCs
Perfluorocarbons	PFCs
Sulphur Hexafluoride	SF_6

5.4 GLOBAL WARMING POTENTIAL & CONCENTRATION LEVELS OF GHGs

For reporting purposes, the GHGs are converted and reported in a single metric, CO2 Eq. The non-CO2 gases are converted to CO2 using internationally recognized Global Warming Potential (GWP) factors. GWPs were developed by the Intergovernmental Panel on Climate Change (IPCC) to represent the heat-trapping ability of each GHG relative to that of CO2.

Table 6 - Global Warming Potential & Concentration levels of GHGs

Gas	Unit	Pre-1750 (Before industralisation)	2011	GWP
Carbon Dioxide (CO_2)	Ppm	280	392.6	1
Methane (CH_4)	Ppb	700	1874	23
Nitrous Oxide (N_2O)	Ppb	270	324	310
HydroFluorocarbons (HFCs)	Ppt	0	539	10900
Perfluorocarbons (PFCs)	Ppt	0	68	1430
Sulphur Hexafluoride (SF_6)	Ppt	0	7.47	22800

5.5 ACTIVITY DATA

Activity data, according to the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, is defined as data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time. Collection of activity data was the most challenging task during the course of this study. To ensure completeness in data collection, key source points have been categorized into two major areas:

1

Primary sources are Meghalaya Department of Agriculture, Department of Industries, Department of Animal Husbandry and Veterinary Science, Meghalaya State Pollution Control, Meghalaya State PCCF, Forest & environment department etc.

2

Secondary sources are nationally available data published by the Planning Commission, Reserve Bank of India, Ministry of Power, Ministry of Finance, sustainability reports of industries etc.

To increase accuracy of data collected, primary and secondary data were matched with one another. If any deviations occurred, it was discussed with government officials and experts for normalization. Data pertaining to population, gross domestic product (GDP) and compound annual growth rate (CAGR) were obtained from publicly available national data.

Following the data collection process, activity data was cross verified with several government department officials and industry experts. Additionally, data was also verified against secondary sources like data published by Central Electricity Authority (CEA), India Census report and GDP forecast etc. Similarly, orders of magnitude of the final emission figures was cross verified with macro-economic indicators of the state.

5.6 CHOICE OF EMISSION FACTORS

The emission factors used in this study were a mix of country specific factors and default factors from IPCC. Default factors were used only in the absence of country specific emission factors.

IPCC has outlined a three-tier system for estimating GHG emissions from various sources. These tiers are described in the Table 7. Tier I is the simplest approach, while Tier III provides the most accurate emissions estimates.

Table 7 - Choice of Emission Factors

Tiers	Description	Ease of Availability
Tier I	Tier I 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	Easily available (IPCC database)
Tier II	Tier II uses the same methodological approach as Tier 1 but applies emission factors and activity data that are defined by the country	Selected emission factors are available
Tier III	Tier III approach uses higher order methods including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by disaggregated levels	-

5.3 APPROACH FOR CALCULATING STATE CARBON FOOTPRINT

While carrying out carbon footprint studies for entities, one of the two approaches for collecting activity related data could be adopted: top down approach or bottom up approach.

In the top-down approach, inventories rely on data collected and aggregated by state, national and international agencies. This would take into account all data collected at state level and in many cases, several data would be available at a single source (eg., statistics department, etc). Bottom-up approach involves collecting and aggregating data from local end users, such as utilities, pollution control board, industry, etc. Depending on the size of state & data available, the approach should be chosen.

While estimating the carbon footprint for Meghalaya State, a hybrid approach was adopted. This approach involved a combination of top-down and bottom-up approach wherein all macro level data were collected at state level and industry/emission specific data were collected from individual/local end users.

Figure 1 - Carbon footprint study process

Step 1 Setting Boundaries	Defining physical, organisation and operational boundaries	Odisha Geopolitical boundary was considered for GHG estimation
Step 2 Defining Emmission Basis	Scoping basis or Absolute basis for estimating Carbon footprint	Absolute basis in line with India GHG report was adopted for study
Step 3 Quantification Approach	Choice of Top-down, Bottom-up or Hybrid Approch for Quantification	Hybrid approach was adopted for study
Step 4 Setting Baseline	Choosing a baseline year for estimating inventory	The year of 2011-12 was considered for the study
Step 5 Calculating Emmissions for five sectors (Energy, Agriculture, LULUCF, Waste and Industry)	**Step 6** Identification of Migration Opportunities	**Step 7** Strategies for low Carbon Enonomy for the state

6. CARBON FOOTPRINT STUDY

The GHG emission inventorisation study in Meghalaya was carried out based on the IPCC Guidelines for National Greenhouse Gas Inventories from various sources and removal sinks which fall under the provincial boundaries. The India Greenhouse Gas Emissions Report 2007 has been taken as reference to define the GHG inventorisation boundaries for the state. This approach has been adopted to avoid uncertainties and to ensure that the report on GHG inventorisation for the Meghalaya state is aligned with the India Greenhouse Gas Emissions report. The emission factors used in this study are a mix of country specific emission factors and default factors from IPCC. Default factors have been used only in the absence of country specific factors.

Table 8 illustrates the total emissions inventorised in this study for the state of Meghalaya. The contributions from each of the sectors, namely, energy, agriculture, waste, industry and land use to the total emissions are described. The table also shows the significant contribution (%) by each of the sub-categories to the major sectors.

Table 8 Summary of Emissions in Meghalaya, 2012-13

Sr. No	Emission Source	T CO_2 (eq)	% of Source	% of overall
A	**Energy**	**1594871**	**100**	
A-1	Power	56238	3.53	**23.59**
A-2	Transport	1004106	62.96	
A-3	Residential	119278	7.48	
A-4	Other	311115	19.51	
A-5	Fugitive	104133	6.53	
B	**Agriculture**	**1233194**	**100**	**18.25**
B-1	Enteric fermentation	538913	43.70	
B-2	Manure Management	46937	3.81	
B-3	Field burning of agriculture residues	7157	0.58	
B-4	Direct N_2O emissions from agriculture soils	329994	26.76	
B-5	Indirect N_2O emissions from agriculture soils	116250	9.43	
B-6	Rice Cultivation	193942	15.73	
C	**Industry**	**3800543**	**100**	**56.23**
C-1	Cement Industry	3450461	90.79	
C-2	Ferro Alloys Industry	293202	7.71	
C-3	Other Industry	56879	1.50	
E	**Waste**	**129766**		1.92
E-1	Municipal Solid Waste (MSW)	23975	18.48	
E-2	Domestic Water	19103	14.72	
E-3	Industrial Water	86688	66.80	
	Gross Emissions	**6758374**		100.00
D	**LULUCF**	**-3798040**	-	
D-1	Forest land & Fuel Wood	-3389993	-	
D-2	Crop Land	-565335	-	
D-3	Grass Land	157289	-	
	Net Emissions	**2960334**		

In 2012-13, the energy sector in Meghalaya was the second largest source of emissions in the state with over 1.59 million Tons of CO2 Eq. Of these emissions, 62% was emitted from transport sector, 19% wasemitted from other energy consumption, 7.48 % from residential/commercial and 6.53% was fugitive emissions. Unlike other states, the state of Meghalaya does not have Thermal Power Plants and thus has relatively lesser emissions from the power generation sector. (Note: The power generation in state is mostly dominated by Hydro Power; emissions are considered as zero from Hydro Power)

Agriculture sector emitted 1.23 million Tons of CO2 Eq. emissions. Enteric Fermentation and Direct N2O emissions were the largest contributors, collectively amounting to about 77% of emissions from agriculture. Emissions generated through manure management and crop residue burning formed a smaller 12%, in addition to the emissions from agriculture. The emissions are relatively higher as compared to the other states because of large population of livestock.

Emissions from Waste sector amounted to 0.12 million Tons of CO2 Eq. The largest contributor to these emissions was waste generated by industries and accounted for 66% of the total waste emissions. Domestic waste water contributed 14% while municipal solid waste's share was 18% of the total emissions from waste.

Land Use Land Use Change and Forestry (LULUCF) by estimation of carbon stock changes, CO2 emissions and removals and Non-CO2 GHG emission was estimated to be about 3.79 million Tons of CO2 sequestrated. Total sequestration from Crop Land was estimated to be 0.56 million Tons of CO2 & that from forest land was 3.3 million Tons of CO2. Grass land emissions was 0.15 million Tons of CO2 respectively.

Emissions from the Industry sector is among the highest in the state, which included emissions generated from cement production, iron and steel industries and other industry related energy consumption that amounted to 3.8 million Tons of CO2 Eq. These emissions account for 56% of the total emissions generated in the state of Meghalaya. Among these the cement is highest and is equivalent to 1.2 Tons of CO2/per capita

The overall GHG emission overview for the state of Meghalaya during 2012-13 is shown in the figure below

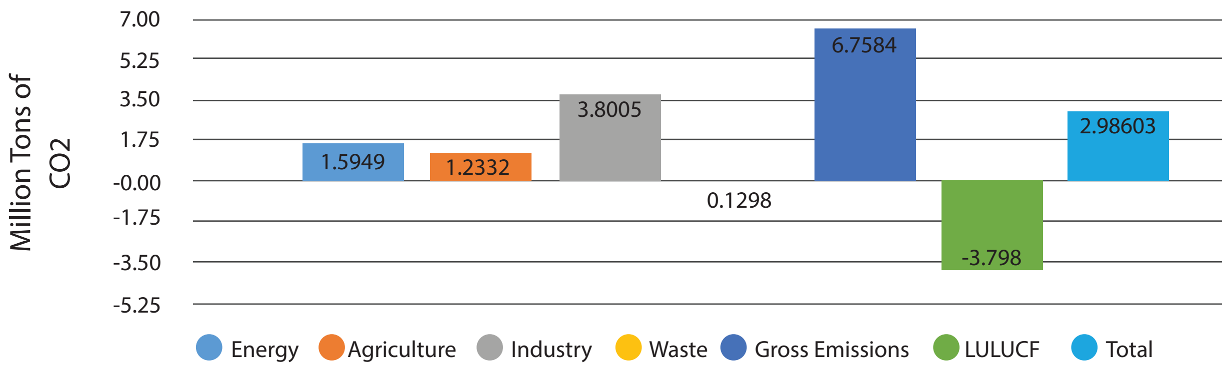


Table 9

A schematic representation of the sectors, source categories and gases included in

Sector	Source	Gas
Energy	Electricity Generation	CO_2, CH_4 & N_2O
	Other Energy Industries	CO_2, CH_4 & N_2O
	Transport	CO_2, CH_4 & N_2O
	Residential/Commercial	CO_2, CH_4 & N_2O
	Commercial/ Institutional	CO_2, CH_4 & N_2O
	Fugitive	CH_4
Agriculture	Enteric Fermentation	CO_2, CH_4 & N_2O
	Manure Management	CO_2, CH_4 & N_2O
	Rice Cultivation	CH_4
	Agricultural Soils	N_2O
	Burning of Crop Residue	CH4 & N_2O
Industries	Minerals	CO_2, CH_4 & N_2O
	Metals	CO_2, CH_4 & N_2O
	Chemicals	CO_2, CH_4 & N_2O
	Other Industries	CO_2, CH_4 & N_2O
Land Use, Land Change & Forestry	Forest Land	CO2
	Crop Land	CO2
	Grass Land	CO2
	Settlements	CO2
Waste	Municipal Solid Waste	CH_4 & N_2O
	Waste Water	CH_4 & N_2O

Figure 3 - % Contribution of CO2, CH4, N2O to the total emissions

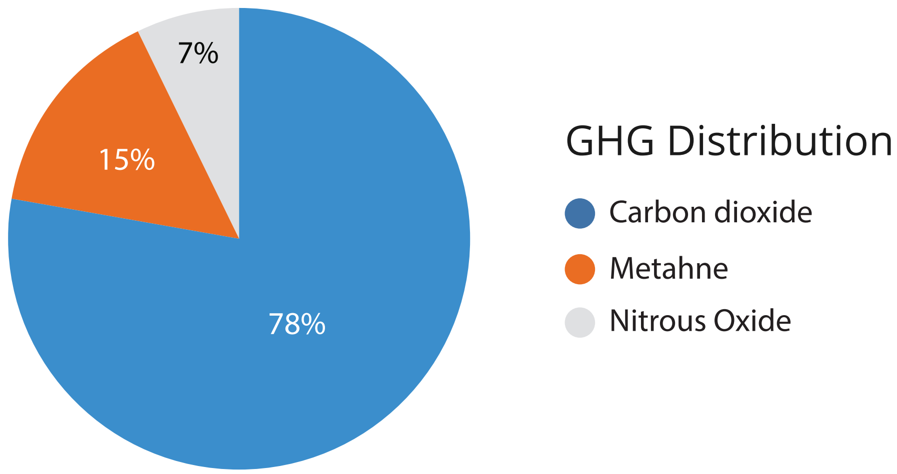


Figure 3 shows the contribution of the different Greenhouse Gases (CO2, CH4 and N2O) to the total state emissions. Direct CO2 emissions account for about 72% of the total emissions inventorised in this study. Methane emissions account for 23% of the emissions and N2O contributes about 5%. The break-up of emissions from each of the sectors is illustrated in Table 10

Table 10

Contribution of the different GHGs to the total state emissions

GHG in Tons				
Sector	CO_2	CH_4	N_2O	CO_2 Eq
Energy	1485730	5017	13	1595162.51
Agriculture	0	37638.48	1447.62	1239171.86
Industry	3798852.22	67.45	0	3800268.87
Waste	0	5270	13.21899	114760.85
Forest	-3798040			-3798040

The per capita emission for Meghalaya state in the year 2012-13 is estimated to be 0.99 tons of CO2. The reported per capita emission for India in year 2007 was 1.518 tons of CO2 (MOEF, 2009). CII was involved in similar Carbon Footprint studies for the states of Tamil Nadu (TN), Andhra Pradesh (United) and Odisha. The reported per capita emission for Tamil Nadu was 1.59 tons of CO2 (2009, CII) and that for AP was 1.77 tons of CO2 (2010, CII). For the purpose of comparative analysis, the per capita emissions for the Nation and the other states have been extrapolated for the year 2012-13, as shownin Table 11.

Table 11

Comparative analyses of per capita emissions

Country/State	Total Emissions (million T CO2 eq)	Per Capita Emission (T CO2 percapita)
India (2010)	1884.39	1.6
Tamil Nadu (2009)	133.0	1.6
Andhra Pradesh (2010)	150.3	1.8
Odisha (2011)	98.0	2.3
Meghalaya (2012)	2.96	1.0

It can be clearly observed that the per capita emissions for the Meghalaya State is on the lower side as compared to the other states. The lower emissions are due to hydro power generation and nature of the industrial sectors situated in the state. The economy of Meghalaya is highly dependent on agriculture and not on the industry. Some of the carbon emission intensive industries with a significant contribution to the Meghalaya state's GHG emissions are Cement and Ferro Alloys (56% of overall emissions). These sectors utilize high amount fossil fuel and also have process emissions and thus have contributed to higher per capita emission for the state.

7. ENERGY

7.1 ENERGY SECTOR IN MEGHALAYA

Energy Sector is one the important sectors for any state to progress on the path of economic development. From the Carbon footprint perspective, under the energy sector, following sources are covered:

- Thermal Power Generation
- Transportation – Road, Rail and Aviation
- Residential and Commercial Sector
- Other Sector Emission – Energy Consumption in agriculture, mobile towers
- Fugitive Emissions – Emissions associated with coal mining

Meghalaya is one of the few states in India which despite having surplus availability, have lower per capita consumption than the national average of 1000 kWh. (Per capital consumption of the state has marginally grown from 456 kWh in FY 12 to 499 kWh in FY 15)[7]

Many factors play vital role in deciding the emissions profile from the energy sector for a State or Country. Energy is the core foundation upon which the economy of the state depends. Meghalaya State Government has been taking many initiatives for ensuring economical and reliable power to the citizens of the state. One of the recently launched initiatives by the government is to provide 24 X 7 power for all of Meghalaya – A joint initiative by Government of India and Government of Meghalaya.

As a part of the State government's reforms in power sector, the Meghalaya government unbundled the Meghalaya State Electricity Board (MSEB) into four corporations under the Meghalaya Power Sector Reforms Transfer Scheme 2010. The newly-formed corporations are the Meghalaya Energy Corporation Limited (MeECL) - the holding company, Meghalaya Power Distribution Corporation Limited (MePDCL) - the distribution utility arm, Meghalaya Power Generation Corporation Limited (MePGCL) - the generation utility arm and the Meghalaya Power Transmission Corporation Limited (MEPTCL) - the transmission utility arm.

7- 24 X 7 Power for all Meghalaya – A Joint initiative by Government of India and Government of Meghalaya

Following table indicates the growth of power sector in the state of Meghalaya

Table 12 - Growth of Power sector in Meghalaya

No.	Particulars	1975-76	2013-14	Unit
1	Installed Generation capacity	65.20	314.70	MW
2	Energy Generation	176.08	861.79	MU
3	Connected load within the State	20.96	630.043	MW
4	Energy consumption within the State	33.346	1072.53	MU
5	Number of consumer within the State	7377	350306	Nos.
6	Number of Grid Sub-Station	2	13	Nos
7	Number of Electrified Villages	261	5462	Nos
8	Per capita consumption	-	499	kWh

The energy requirements in the state are met by the state owned hydro power plants and central allocated power generation. The total installed capacity in Meghalaya including firm share of CGS as on 31st March 2015 (allocated capacity in State, Private, joint and CGS) is 492.47 MW as detailed in table below (Table 13).

The majority of the power generation in the state is from hydro power with the installed capacity amounting to 388 MW (State Hydro- 314.70 MW and Central Hydro 73.30 MW). The state hydro power is managed by the Meghalaya State Energy Corporation Limited.

Table 13- Installed Capacity

Source	Installed Capacity (MW)	% of Overall
Within State		
Hydro	282	57.26
Small Hydro	32.70	6.63
Total	**314.70**	**63.9**
Outside State		
Gas	104.47	21.2
Hydro	73.30	14.9
Total	**177.77**	**36.1**
Grand Total	**492.47**	**100**

The state's total distribution to 3.5 lakh electrical consumers amounts to a connected load of 630 MW (2011-12). The per capita consumption of electricity (2014-15) in the state was 499 kWh/per annum (overall)[8]. Following table indicates the overall scenario of the power availability in the state.

Table 14- Power scenario In Meghalaya

Year	Unrestricted Peak Demand (MW)*	State Generation (MU)	Power Purchase (MU)	Total Availability (MU)
2004-05	220	635.35	757.96	1393.31
2005-06	280	514.44	871.66	1386.10
2006-07	350	389.09	929.30	1318.39
2007-08	385	663.06	924.15	1587.21
2008-09	352	552.84	968.92	1521.76
2009-10	339	534.79	947.29	1482.08
2010-11	289	507.90	1129.15	1637.05
2011-12	373	517.54	1170.54	1688.08
2012-13	381	704.55	1056.78	1761.33
2013-14	396	861.79	1028.76	1890.55

8- Ministry of Power/Press Information Bureau of India -http://pib.nic.in/newsite/erelease.aspx?relid=74497

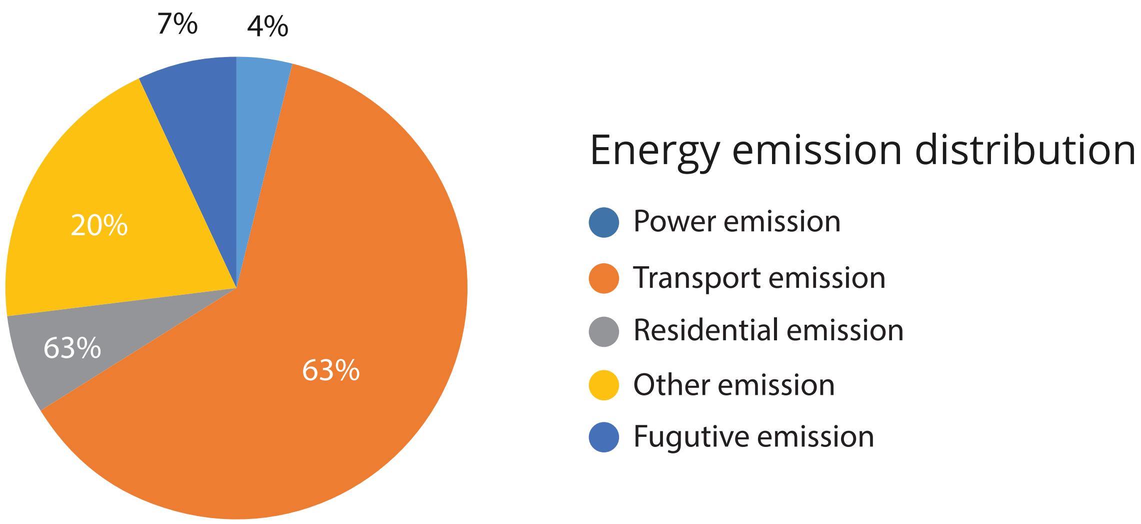
7.2 OVERVIEW OF GHG EMISSIONS FROM ENERGY SECTOR

In 2012-13, the emissions from the energy sector in Meghalaya was estimated to be 1.59 million Tons of CO2 Eq. The energy sector includes emissions from

- Power Generation (IPP)
- Transport Sector (Road, and Air)
- Residential/Commercial Sector (LPG , Coal & SKO)
- Other Energy (Agriculture implements, Mobile Towers and others)
- Fugitive Emissions (Coal Mining)

Figure 4 –GHG Emission distribution of Energy Sector

In 2012-13, the emissions from the energy sector in Meghalaya was estimated to be 1.59 million Tons of CO2 Eq. The energy sector includes emissions from



7.3 ELECTRICITY EMISSIONS

The power sector emissions are relatively low in the State of Meghalaya as the State has majorly Hydro Based power generation and the emissions are considered zero for hydro power.

For estimating the GHG emissions, the power generating stations within the state's geographical boundary are accounted. Presently, all the power plants are hydro based in the state. The table below provides details of Hydro Power Plants in the State.

Table 15 – Power Stations Meghalaya

Sr.No	Station	Type	Unit	Installed Capacity (MW)
1	Umiam Stage-I	Storage/ Pondage	4*9 MW	36
2	Umiam Stage-II		2*10 MW	20
3	Umiam Stage-III		2*30 MW	60
4	Umiam Stage-IV		2*30 MW	60
5	Umtru Power Station	Run of River (ROR)	4*2.8 MW	11.2
6	Sonapani HEP		1.5 MW	1.5
7	Leshka HEP		3*42 MW	126
Total				**314.7**

In addition to the Hydro Power Plants in the State, the Meghalaya state has some allocation of power from Central Government Owned Power Plants in other neighboring states.

There are a few coal based captive power plant and independent Power Producers (8 MW). The emissions from captive power plants are not considered since it is already accounted in industrial emissions. Thus, emissions from the power sector is estimated to be 0.0563 Million tons of CO2.

Hydro power stations account for almost 100% of Meghalaya state's power generation. The energy made available from hydro power in the year 2012-13 was 704.5 MU. Thus hydro power has resulted in elimination of producing 6194 MU from thermal power plants which would have resulted in 0.5 million Tons of CO2 Eq.

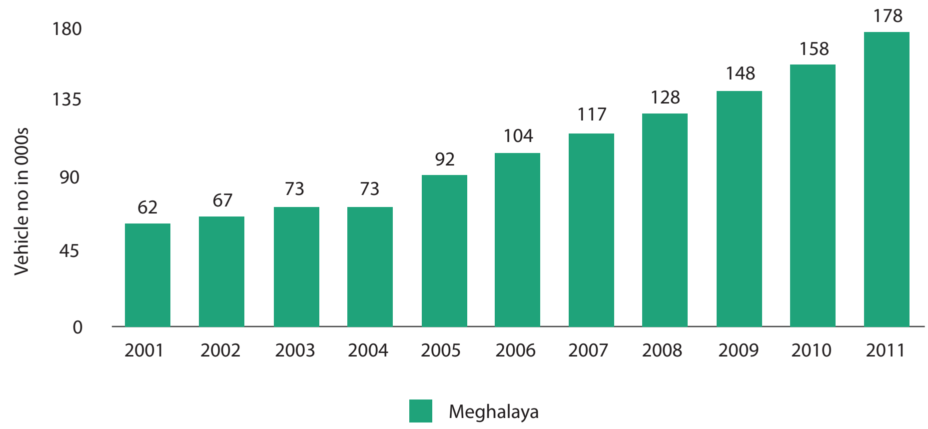
7.4 Transport Emmisions

The development of roads, highways and railways plays an important role in overall development of the state and especially industrial development. For a state, emissions from transport sector considers emissions from road, rail and aviation sectors. Since there is no railway infrastructure in the Meghalaya state, the emissions from railways are zero. Due to the lack of railway infrastructure, there is an increased use of vehicles in the state and thus road emissions are relatively higher.

The state has a total road length of 12,317 km (2012-13), out of which, 1171 km belongs to National Highways and the rest is of state highways, major/district roads and village/rural roads.

The total vehicle population on road has increased substantially between 2001 and 2012 as shown in Figure 5:

Figure 5 -Growth in Vehicles



In 2012-13, the emissions from the transport sector was estimated to be 1 million Tons of CO2 Eq. The road sector contributed to almost 100% of the transport emissions. The Aviation sector contributed to less than 100 Tons of CO2.

7.5 Residential Emmisions

The major source of emissions from the residential sector is LPG and kerosene oil usage. In addition to these, there is use of Coal/Coke in both rural and urban areas. These fuels are majorly used for cooking, heating and lighting purposes. Activities of the residential sector resulted in 0.11 million Tons of CO2 Eq.

Table 16 – Emissions from residential sector

Energy Source	Quantity (MT)	Tons of CO_2 Eq.
Liquefied Petroleum Gas (LPG)	14000	**41,820**
Super Kerosene Oil (SKO)	20000	**63204**
Coal/Coke	**7555**	**14253**

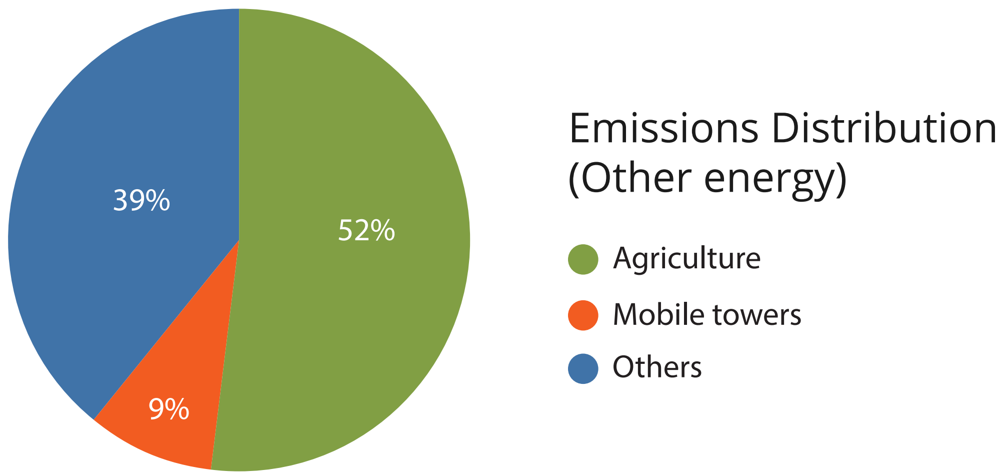
7.6 Other Emmisions

The emissions from other energy usage are included under this category of emissions. The emissions from energy consumption in agriculture sector, mobile towers and other diesel consumption which has not been included elsewhere (data from Petroleum Planning & analysis cell) are included under this sector. The energy usage in agriculture sector is majorly diesel consumption in agricultural pump sets and other uses.

The total emissions for other usage of energy was estimated to be 0.3 million Tons of CO2 Eq. The emissions from agriculture sector's energy consumption was 0.16 million Tons of CO2 Eq. Emissions. Diesel usage in mobile towers was 0.029 million Tons of CO2 Eq. and other diesel usage was 0.12 million Tons of CO2 Eq.

Breakup of emissions from other energy usage is shown in Figure 6:

Figure 6 - Emissions from other energy sources



7.7 Residential Emmisions

Fugitive emissions are the emissions from pressurized equipment due to leaks and other unintended or irregular releases mostly from industrial activities. The major sources of fugitive GHG emissions are oil refining, transport and coal mining. In 2012-13, the only pertinent activity in the state resulting in fugitive emissions was coal mining and handling.

Coal mining results in fugitive emissions in the form of CO2 and CH4. The geological processes of coal formation also produces methane (CH4) and carbon dioxide (CO2) and thus may also be present in some coal seams. These are collectively known as seam gas, and remain trapped in the coal seam until the coal is exposed and broken during mining. CH4 is the major greenhouse gas emitted from coal mining and handling.

The Emissions from coal mining are of two types[9]:

1

Emission during mining: These emissions result from the liberation of stored gas during the breakage of coal, and the surrounding strata, during mining operations.

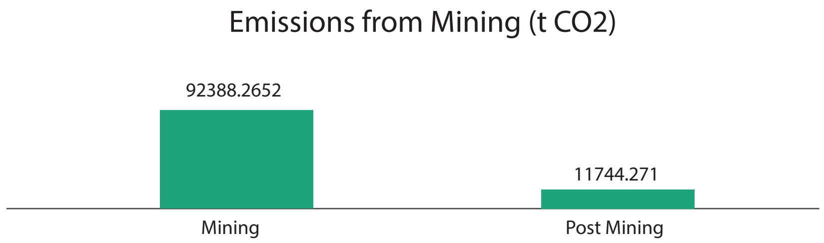
2

Emission during post mining: Emissions from subsequent handling, processing and transportation of coal are termed as post mining emissions.

These emissions are further categorised based on the type of mining i.e. Open cast mines (OCM) and Underground mines (UG). The emission factors for these mines vary depending on the type of mines and stage of emissions (mining and post-mining). The country specific emission factors used in this study are referenced from the national inventory- India GHG Report 2007.

For estimating the fugitive emissions for Meghalaya, the average of emission factors for low degree mines has been taken, since most of the mines are Open Cast Mines or shallow depth. Production of coal by OCM was 5649000 Tons. The mining activity in the Meghalaya state resulted in 4958 Tons of CH4 emissions (0.1 million Tons of CO2 Eq).

Figure 7 - Fugitive emissions breakup (million Tons CO2 Eq.)



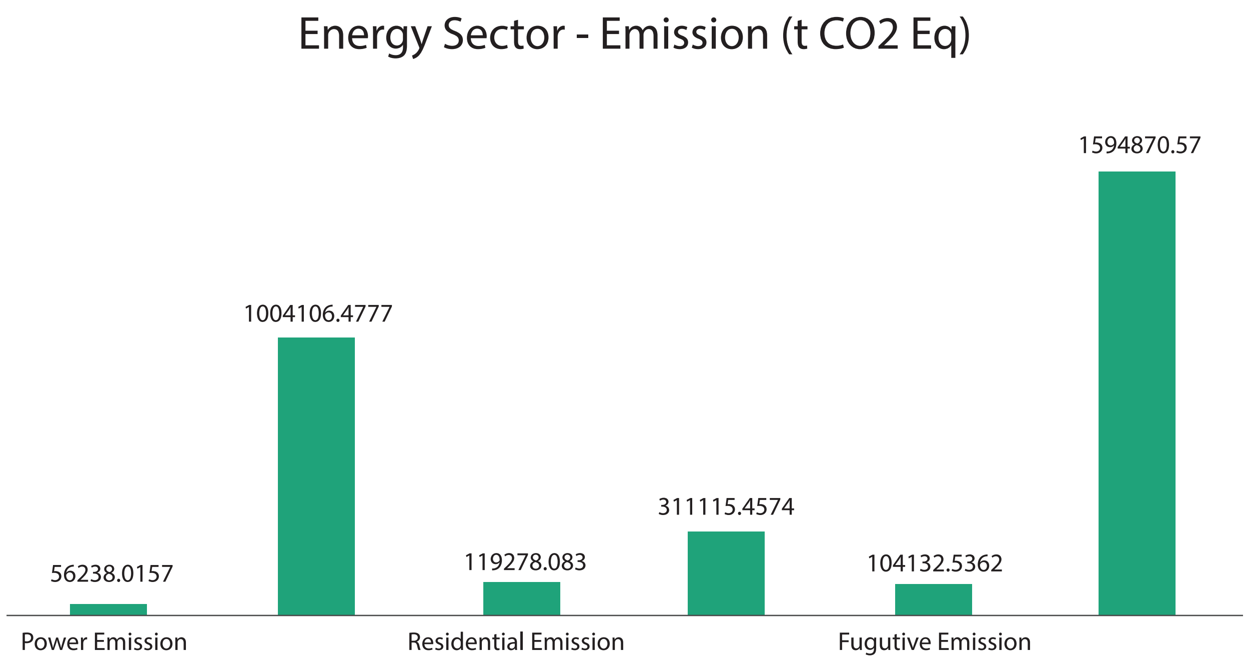
9- IPCC : 2006 IPCCC Guidelines for National GHG Inventories- Energy

7.7 GHG EMISSIONS SUMMARY - ENERGY SECTOR

Table 17: Summary of Emissions – Energy Sector

Emission Source	*Emission*	*Unit*
Power Emission	56238	Metric Tons of CO_2 (Eq)
Transport Emission	1004106	Metric Tons of CO_2 (Eq)
Residential Emission	119278	Metric Tons of CO_2 (Eq)
Other Emission	311115	Metric Tons of CO_2 (Eq)
Fugitive Emission	104133	Metric Tons of CO_2 (Eq)
Total	***1594871***	***Metric Tons of CO_2*** (Eq)
Total	***1.59***	***Million Metric Tons of CO_2*** (Eq)

Figure 8: Energy Sector Emission Profile



8. AGRICULTURE

The economy of Meghalaya is agrarian. Since nearly 81% of the state's population depends on agriculture, employment and income generation is directly related to agricultural developmental activities. The State is yet to reach National levels in economic and agricultural growth rate, even after attaining full statehood twenty-five years ago. The State is slowly and steadily progressing inspite of numerous constraints and limiting factors. Meghalaya is amongst the highest rainfall areas in the world, with an annual average rainfall of 11,000 mm during the period of 1980-91, predominantly mountainous, lying between the Brahmaputra valley in the North and the Surma valley (Bangladesh) in the South.

Practice of improved and modern methods of agriculture by the farmers, use of chemical fertilizers, plant protection measures and introduction of High Yielding Variety (HYV) seeds of Paddy, Wheat, Maize, etc. has contributed to the increase in production of food grains. Despite the fact that 81% of the population is dependent on agriculture, the net cropped area is only about 9.87% of the total geographical area of the State. The state is deficit in food grains by 1.22 lakh tonnes annually, to feed a population of 2.3 million. This is due to several reasons such as the undulating topography, transport and communication problem, population dispersal pattern, inadequate credit support, poor marketing system and so on.. To overcome these hurdles, several programmes are planned, such as increasing agricultural/horticultural production and productivity, research system on the development of economically viable and location specific technologies in rain fed, flood-prone irrigated areas, and increasing the utilisation of irrigation potential etc.

Agricultural practices release significant amounts of methane (CH4) and nitrous oxide (N2O). Methane is produced largely from microbial activity in oxygen-deprived condition, notably from fermentative digestion by ruminant livestock (enteric fermentation), through manure management practices and rice fields. N2O is produced from microbial transformation of nitrogen in the soils and manures, and this activity is enhanced further when available nitrogen exceeds the plant requirements.

This section discusses the emissions from agriculture sector. Sources analyzed in this discussion are

Livestock

- Enteric fermentation
- Animal manure

Rice cultivation

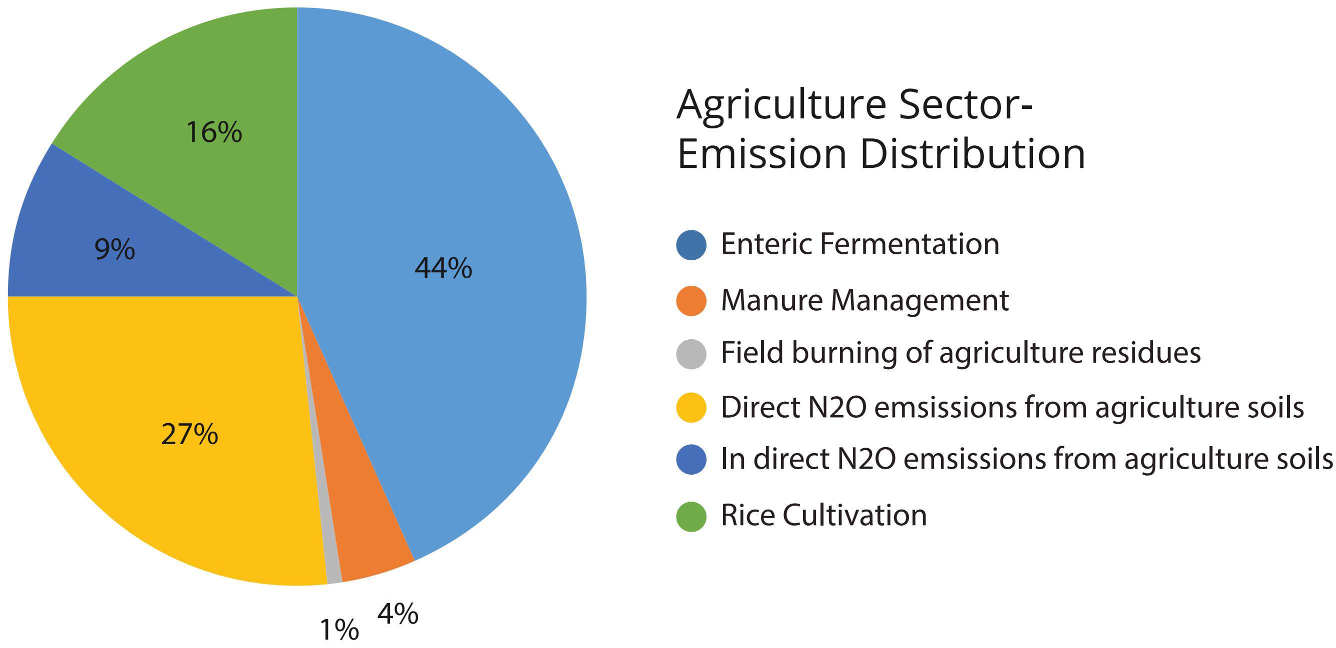
- Irrigated – continuously flooded, single and multiple aeration
- Rain fed – drought prone and flood prone

Agriculture soils – direct emissions and indirect emissions

Field burning of agriculture crop residues

8.1 OVERVIEW OF GHG EMISSIONS FROM AGRICULTURE SECTOR

Agricultural sector emits nearly 1.23 million Tons of CO2 Eq. emissions.
Enteric fermentation accounted to 44% of the total CO2 equivalent followed by direct emissions from soil which was 27%. Rice cultivation in the state contributed to 14% of the emissions and 10% of the emissions was from the indirect emission from the soil. Remaining 5% was attributed to manure management and burning of crop residues.



8.2 AGRICULTURAL SOILS

Nitrous oxide emissions occur directly and indirectly. Direct emissions include addition of organic nitrogen, inorganic nitrogen, manure deposition and nitrogen fixation by crops. Indirect emissions comprise the following: i) Volatilization of Ammonia (NH3) and oxides of nitrogen (NOx) from managed soils, manure depositions, fossil fuel combustion, and biomass burning and ii) Leaching of soil, manure depositions and runoffs. Direct N20 emissions generated from agricultural soils was estimated to be 0.33 million Tons of CO2 Eq. and the indirect emissions was estimated to be 0.116 million Tons of CO2 Eq.

8.3 BURNING OF CROP RESIDUE

Usually, crops such as rice, maize, cotton, millet, sugarcane and groundnut are burnt in fields.

Emission from burning crop residues is calculated using the formula given below:

$$\text{Emissions} = \sum \text{crops} \, (a \times b \times c \times d \times e \times f)$$

Where,
a - Crop production
b - Residue to crop ratio
c – Dry matter fraction of the residue burnt
d – Fraction burnt
e – Fraction actually oxidized
f – Emission factor

This estimation is in line with the IPCC revised inventory preparation guideline (IPCC, 1996).

Dry matter fraction of crop residue = 0.8 (Bhattacharya and Mitra, 1998)
Fraction oxidized = 0.9 (IPCC, 1997)
Fraction burned = 0.25 (IPCC, 1997)

IPCC default values were used for crop specific values of carbon fraction and N/C ratios. Values from the revised IPCC 1996 Guidelines for National Greenhouse Gas Inventories were used for the ratios of residue to crop product and emission factors. Applying this methodology, it was estimated that 0.007 million Tons of CO_2 Eq. was emitted due to burning, which comprised of 220.84 Tons of CH_4 and 8.13 Tons of N_2O.

8.4 ENTERIC FERMENTATION

Meghalaya is endowed with large rivers and dense forest that have been instrumental in the development of a strong agricultural and livestock base. Livestock reared include cattle, buffalo, sheep, goat, horses, pigs, and poultry. Many of these animals, specifically rumens, through enteric fermentation, produce massive amounts of methane. To estimate the emissions, population of each of these livestock categories was taken. Livestock census is done every five years and the last census available is 2012. The livestock population for 2012 was taken as reference for calculation of the emissions.

In order to estimate the enteric fermentation emissions, tier I approach - which uses the population of each species and their respective international emission factors (IPCC), has been adopted. For cattle and buffalo, the pollution was categorized into dairy and non-dairy species. Dairy includes all lactating breeds, both indigenous and cross breeds and non-dairy category comprising of calves below one year, adults beyond calving age, and those within one and two years of age.

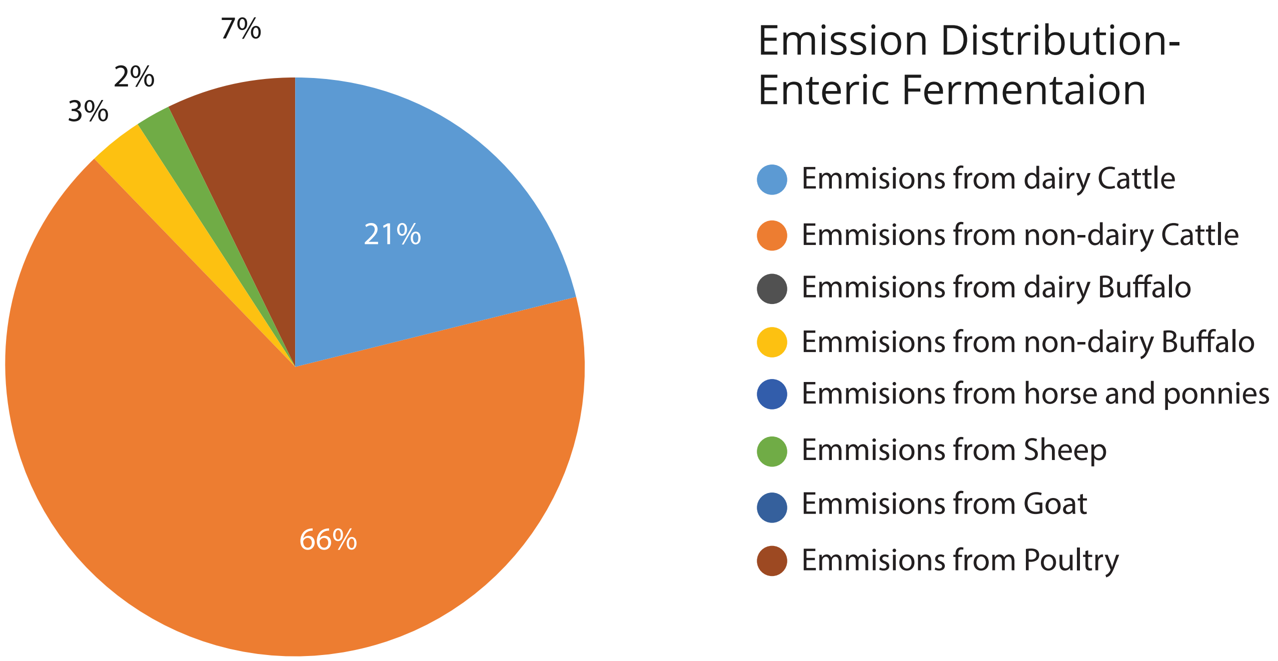
Table 18 - Livestock population for 2012[10]

Sr No	Species	Population (Numbers)			Total	Growth Rate (%)
1	Catlle	Crossbred	Male	5602	26458	-1.45
			Female	20856		
		Indigenous	Male	355705	879295	2.2
			Female	523590		
2	Buffalo	Indigenous	Male	16363	24894	10.02
			Female	8531		
3	Goat	Indigenous	Male	179502	472325	29.23
			Female	292823		
4	Pig	Exotic/ Crossbred	Male	72834	137984	96.68
			Female	65150		
		Indigenous	Male	224672	431317	-5.04
			Female	206645		
5	Sheep	Exotic/ Crossbred	Male	299	805	232.64
			Female	506		
		Indigenous	Male	7434	20186	-2.95
			Female	12752		
6	Poultry	Fowl	Improved	344157	3541716	25.84
			Desi	3197559		16.15
		Duck	Improved	514	22845	-93.56
			Desi	22331		-61.76
		Others	Turkey	498	498	2271.43

In 2012-13, enteric emissions accounted for a release of 25,662 Tons of CH4 (0.5 million Tons of CO2). Of these, non-dairy cattle was the single largest contributor with enteric emissions amounting to 0.26 million Tons of CO2. The enteric methane emissions from other species was relatively smaller when compared to the bovines.

10- Department of Animal Husbandry & Veterinary, Government of Meghalaya

Figure 10: Emission Distribution – Enteric Fermentation

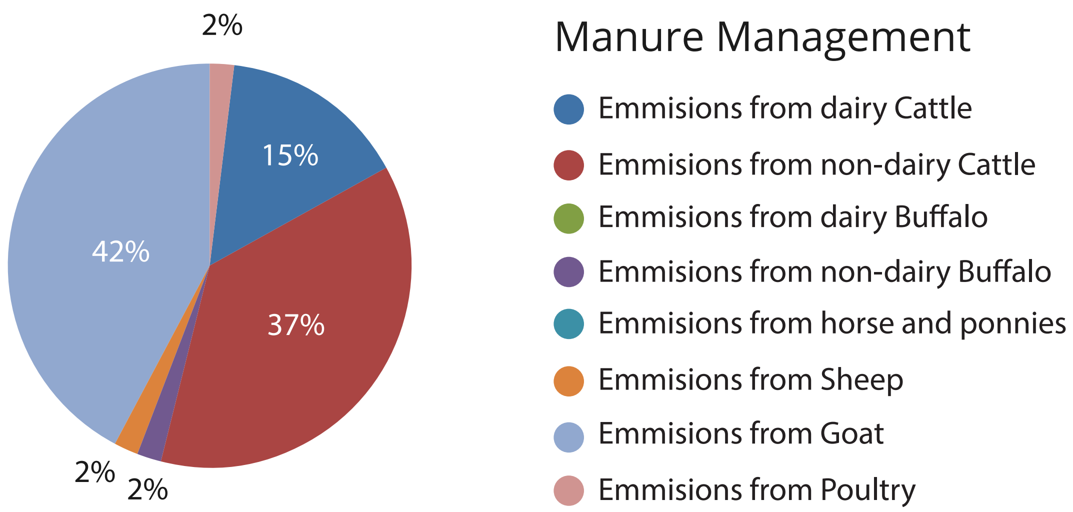


8.5 MANURE MANAGEMENT

The decomposition of manure under anaerobic conditions, during storage and treatment, produces CH4. The main factors affecting CH4 emissions include the amount of manure produced and the portion of the manure that decomposes under anaerobic conditions. The former depends on the rate of waste production per animal and the number of animals, and the latter depends on how the manure is managed. When manure is stored or treated as liquids (e.g., in lagoons, ponds, tanks, or pits), it decomposes anaerobically and can produce a significant quantity of CH4. The temperature and the retention time of the storage unit also affect the amount of methane produced. When manure is handled as solids (e.g., in stacks or piles) or when it is deposited on pastures and rangelands, it tends to decompose under more aerobic conditions and a relatively lower quantity of CH4 is generated.

In this study, it was assumed that 50% of the manure produced is managed for reuse (in line with India GHG Program) and about 50% is added to land directly. In order to estimate the manure management emissions, tier I approach - which uses the population of each species and their respective international emission factors (IPCC). For cattle and buffalo, the population was categorized into dairy and non-dairy species.

Figure 11: Emission Distribution – Manure Management



8.6 Rice Cultivation

Methane is generated in anaerobic conditions and is naturally produced and emitted from wetlands and other natural situations. Paddy fields are one of the largest man-made sources of methane. Rice is grown in flooded rice paddies, mainly because the floodwater has no adverse effects on the rice plants but controls most weeds and pest insects. The flood water creates an anaerobic environment that is ideal for methane production.

Rice dominates the crop area and is also the main crop in Meghalaya. Rice fields thus produce signification amount of emissions. Following is the distribution of rice cultivation area under different rice ecosystems.

Figure 12 – Rice cultivation area (hectares)

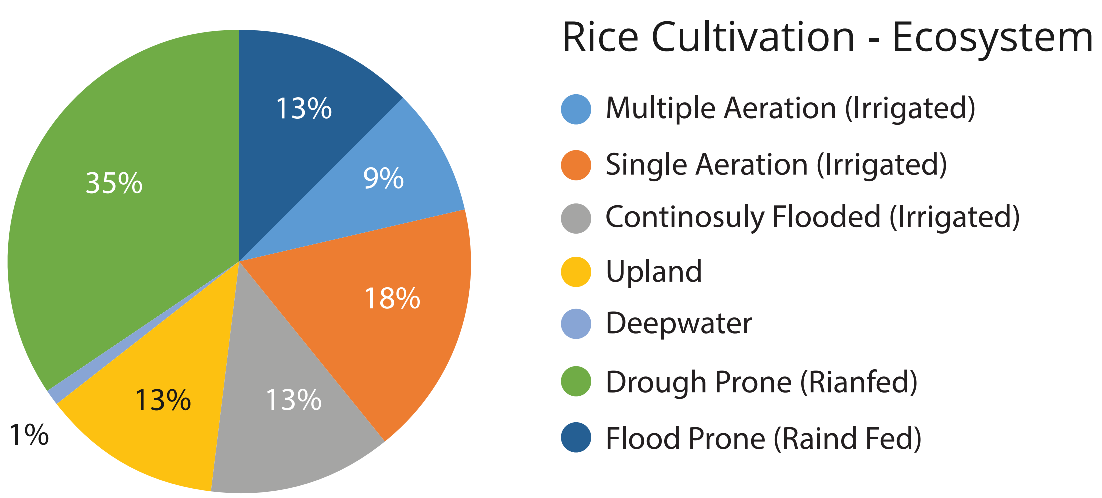
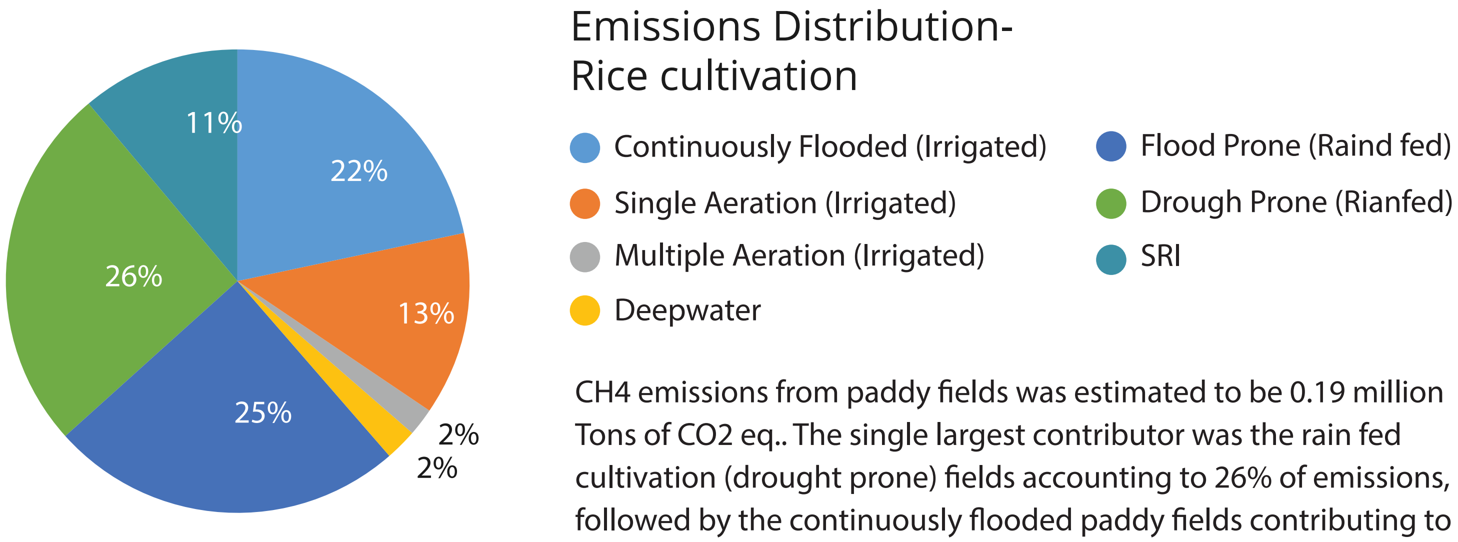


Figure 13 - Emissions from rice cultivation

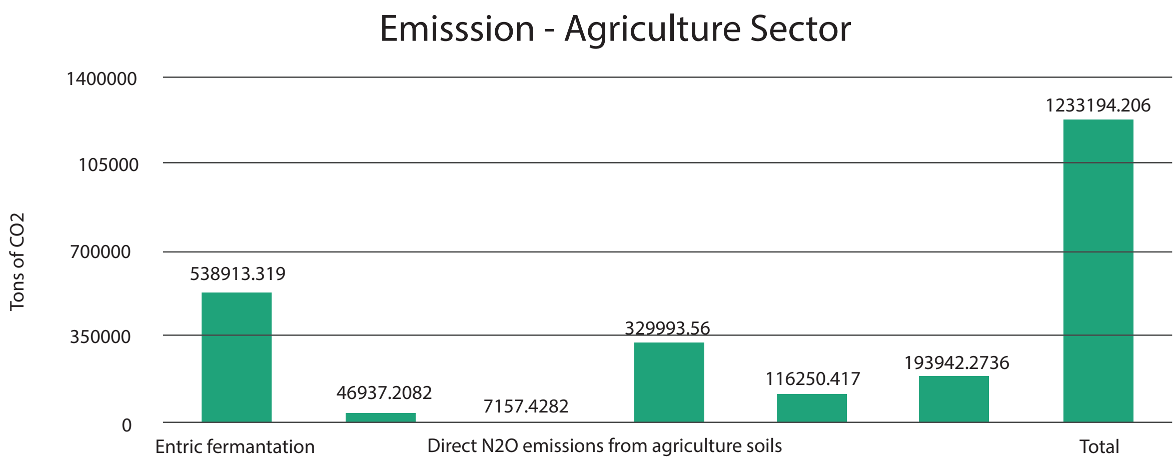


CH4 emissions from paddy fields was estimated to be 0.19 million Tons of CO2 eq.. The single largest contributor was the rain fed cultivation (drought prone) fields accounting to 26% of emissions, followed by the continuously flooded paddy fields contributing to 28% of the emissions and multiple aeration regions accounting to 21% of the total emissions.

8.7 GHG EMISSIONS SUMMARY - AGRICULTURE SECTOR

Table 19 – GHG emission summary - Agriculture Sector

Emission Source	CO_2 Eq. (MT)
Enteric fermentation	538913
Manure Management	46937
Field burning of agriculture residue	7157
Direct N2O emissions from agricultural soil	329994
Indirect N2O emissions from agricultural soil	116250
Rice cultivation	193942
Total	**1233194**



9. LAND USE, LAND USE CHANGE AND FORESTRY

In the context of global climate change and sustainable development, forest management activities play a major role in alleviating the effects of climate change. Socio-economically, forests are of prime importance as they provide both tangible and intangible resources. Hence, its preservation becomes an activity of prime importance. However, forests are also affected by climate change and their contribution to mitigation strategies are in turn under stress.

This chapter discusses the emissions from land use, land use change and forestry. Sources analyzed in this discussion include:

Forest land	Crop land	Grass land	Fuel Wood Usage

9.1 GHG ESTIMATION METHODOLOGY – GPG APPROACH

The IPCC has developed three exhaustive guidelines to inventorize GHG emissions from LULUCF sector:

Revised 1996 guidelines for LULUCF (IPCC, 1997)
Good Practice Guidelines (GPG) for LULUCF (IPCC, 2003)
Agriculture forest and Other Land Use category Guidelines, AFLOU 2006

The widely covered land use categories, the sub-categories and carbon pools in GPG 2003 include:

- Land Categories
- Forest Land, grassland, crop land, wetland, settlements and others
- Land remaining in the same category (E.g. Grassland remaining grassland)
- Land converted into other category (E.g. Forest land converted into cropland)

CO2 emissions and removals from carbon pools :

- Above Ground Biomass (AGB) – namely stem, leaves, and branches etc.
- Below Ground Biomass (BCB) – roots having thickness of 2mm and above.
- Soil carbon.
- Dead Organic Matter (DOM) and woody litter.

9.2 GHG ESTIMATION – CARBON STOCK CHANGES

Greenhouse gas inventory for Forest Land Remaining Forest Land (FF) involves estimation of changes in carbon stock from five carbon pools (i.e., above-ground biomass, belowground biomass, dead wood, litter, and soil organic matter), as well as emissions of non-CO2 gases.

Dominant GHG emissions in the LULUCF sector are mainly attributed to CO2 emissions and removals. Emissions and removals are estimated by calculating the sum of changes in stock over a period of time, which can be averaged further to yield annual stock change.

The changes in the carbon stock can be estimated using two approaches: "Carbon Gain-Loss method" and "Carbon Stock-Change or Stock-Difference method" (IPCC 2003 and 2006). However, for Meghalaya "Gain Loss" method has been used to derive the carbon removal and emission figures. The GHG Estimation from Forest can be estimated by any of the following methods:

1. **Gain Loss Method:**

   The method involves, based on estimates of annual change in biomass from estimates of biomass gain and loss

2. **Stock Change:**

   The method estimates the difference in total biomass carbon stock at time t^2 and time t^1

The biomass gain-loss method is applicable for all tiers although the stock-difference method is more suitable for Tiers 2 and 3. However, the Stock –Change method provides more reliable information if accurate forest inventory is carried out.

9.2.1 Gain Loss Method

The default methodology (Gain – Loss Method) was adopted for estimating the GHG emissions from the forest sector and following is the summary of methodology:

Greenhouse gas inventory for the land-use category 'Forest land Remaining Forest land (FF)' involves estimation of changes in carbon stock from five carbon pools (i.e. aboveground biomass, belowground biomass, dead wood, litter, and soil organic matter), as well as emissions of non-CO2 gases from such pools. The summary equation, which estimates the annual emissions or removals from FF with respect to changes in carbon pools is given as follows (IPCC)

ANNUAL EMISSIONS OR REMOVALS FROM FOREST LAND REMAINING FOREST LAND

$\Delta CFF = (\Delta CFF\ LB + \Delta CFF\ DOM + \Delta CFF\ Soils)$

ΔCFF = annual change in carbon stocks from forest land remaining forest land, tons C/year

$\Delta CFF\ LB$ = annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land remaining forest land; tons C/ year

$\Delta CFF\ DOM$ = annual change in carbon stocks in dead organic matter (includes dead wood and litter) in forest land remaining forest land; tons C /year

$\Delta CFF\ Soils$ = annual change in carbon stocks in soils in forest land remaining forest land; tons C /year

9.2.1.1 Forest Land Remaining Forest Land

The Emissions/Sequestration from Forest Land Remaining Forest Land is calculated based on Default Method. This method requires subtraction of biomass loss from the biomass increment for the reporting year.

ANNUAL CHANGE IN CARBON STOCKS IN LIVING BIOMASS IN FOREST LAND REMAINING FOREST LAND (DEFAULT METHOD)

$$\Delta CFF\ LB = (\Delta CFF\ G - \Delta CFF\ L)$$

$\Delta CFF\ LB$ = annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land remaining forest land, tons C /year

$\Delta CFF\ G$ = annual increase in carbon stocks due to biomass growth, tons C /year

$\Delta CFF\ L$ = annual decrease in carbon stocks due to biomass loss, tons C/year

Estimation of annual increase in carbon stocks due to biomass increment in forest land remaining forest land requires estimates of area and annual increment of total biomass, for each forest type and climatic zone in the country. The carbon fraction of biomass has a default value of 0.5, although higher tier methods may allow for variation with different species, different components of a tree or a stand (stem, roots and leaves) and age of the stand.

Annual increase in carbon stocks due to biomass increment in forest land remaining forest land

ΔCFF G = Σij (Aij   GTOTALij)   CF

Where:

ΔCFFG = annual increase in carbon stocks due to biomass increment in forest land remaining forest land by forest type and climatic zone, tonnes C yr-1

Aij = area of forest land remaining forest land, by forest type (i = 1 to n) and climatic zone (j = 1 to m), ha

GTOTAL ij = average annual increment rate in total biomass in units of dry matter, by forest type (i=1 to n) and climatic zone (j = 1 to m), tonnes d.m. ha-1 yr-1

CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)-1

Average annual increment in biomass (GTOTAL)

GTOTAL is the expansion of annual increment rate of above ground biomass (Gw) to include its below ground part, involving multiplication by the ratio of below ground biomass to aboveground biomass that applies to increments. This may be achieved directly where Gw data are available as in the case of naturally regenerated forests or broad category of plantation. In case Gw data is not available, the increment in volume (Iv) can be used with biomass expansion factor for conversion of annual net increment to aboveground biomass increment.

Average annual increment in biomass

GTOTAL = GW   (1 + R) In case aboveground biomass increment (dry matter) data are used directly

GW = IV   D   BEF1   In case net volume increment data are used to estimate GW

Where:

GTOTAL = average annual biomass increment above and belowground, Tons d.m. ha-1 yr-1

GW = average annual aboveground biomass increment, Tons s d.m. ha-1 yr-1

R = root-to-shoot ratio appropriate to increments, dimensionless

IV =average annual net increment in volume suitable for industrial processing, m3 ha-1 yr-1

D = basic wood density, Tons d.m. m-3

BEF1 = biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless

These factors have been specifically taken for Meghalaya State and Emissions has been calculated.

Table 20 - State Level Parameter for estimating C emissions for land use change

State	Mean Biomass expansion factor	Wood Density (Mg cu.m)	Ratio of below ground biomass to above ground biomass	Average above ground biomass growth (tons d.m.ha^{-1}yr^{-1}	Soil organic carbon (tons ha^{-1})
Meghalaya	1.53	0.76	0.27	1,69	111.60

Annual biomass loss is the sum of losses from commercial roundwood fellings, fuelwood gathering, and other losses. Following equation is used to estimate the emissions from Forest Land Remaining Forest Land

ANNUAL DECREASE IN CARBON STOCKS DUE TO BIOMASS LOSS IN FOREST LAND REMAINING FOREST LAND

$$\Delta CFFL = L_{fellings} + L_{fuelwood} + L_{other\ losses}$$

ΔCFFL = annual decrease in carbon stocks due to biomass loss in forest land remaining forest land, tonnes C/year

Lfellings = annual carbon loss due to commercial fellings, tons C /year

Lfuelwood = annual carbon loss due to fuelwood gathering, tons C / year

Lother losses = annual other losses of carbon, tons C /year

Following equations were used for estimation of carbon loss due to commercial fellings

ANNUAL CARBON LOSS DUE TO COMMERCIAL FELLINGS

$$Lfellings = H \bullet D \bullet BEF \bullet (1 - fBL) \bullet CF$$

Lfellings = annual carbon loss due to commercial fellings, tons C yr-1

H = annually extracted volume, roundwood, m3 yr-1

D = basic wood density, tons d.m. m-3;

BEF= biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark),

fBL = fraction of biomass left to decay in forest (transferred to dead organic matter)

CF = carbon fraction of dry matter (default = 0.5), tons C (tons d.m.)-1

ANNUAL CARBON LOSS DUE TO FUELWOOD GATHERING

$$Lfuelwood = FG \bullet D \bullet BEF \bullet CF$$

Lfuelwood = annual carbon loss due to fuelwood gathering, tonnes C. yr-1

FG = annual volume of fuelwood gathering, m3 yr-1

D = basic wood density, tonnes d.m. m-3;

BEF = biomass expansion factor for converting volumes of extracted fuelwood to total aboveground biomass (including bark), dimensionless;

CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)-1

The other losses have not been included in the calculation since the data availability is a challenge.. In line with the Tier 1 methodology, carbon change in dead wood and litter is not significant and thus can be assumed as zero.

Based on the methodology, it was estimated that 3.38 million Tons of CO2 Eq. was sequestered during 2012-13 from forests. Sequestration from living biomass in forest land contributed to highest emissions of 3.46 million Tons of CO2 and Forest Land Converted to other land resulted in 0.07 million Tons of CO2

9.3 INVENTORY ESTIMATION

Inventorizing the emissions requires careful study of land area and the approach methodology. A broad classification of land area is given in Table 21. The approach used to quantify LULUCF emissions in Meghalaya is as per IPCC's Tier II approach.

Table 21 Land area classification for inventorisation

Main categories	Sub-categories	C-pools
Forest	Forest land remaining forest land	AGB, BGB and Soil carbon
	Lands converted into forest land	
Crop land	Crop land remaining crop land	Soil and Biomass
	Lands converted into crop land	
Grassland	Grassland remaining grassland	
	Lands converted into grassland	
Wetland	Wetland remaining wetland	
	Lands converted into wetland	
Settlements	Settlements remaining settlements	
	Lands converted into settlements	

9.4 LAND USE MATRIX

GHG emissions are estimated for land remaining in the same category and for lands converted into other lands, especially in the case of forest. For non-forest land categories, estimation is carried out for land remaining in the same categories. Table 22 illustrates land use pattern in Meghalaya state.

Table 22 - Land Use matrix (Area in Hectares)

Sr. No	Particulars	2011-12	2012-13
1	Geographical Area	2242900	2242900
2	Reporting Area	2240837	2241254
3	Forests	946089	946127
4	Area not Available for Cultivation		
	(i) Area under non-agricultural uses		
A	a. Water Logged Land	1028	1022
B	b. Social forestry	19198	19203
C	c. Land Under Still Water	28959	28973
D	d. Other Land	58265	58416
	Total (a to d)	107450	107614
	(ii) Barren and Uncultivable Land	131744	131734
	Total (i and ii)	**239194**	**239348**
5	Other Cultivate Land		
A	Permanent Pastures and Other grazing Land	0	0
B	Land under Misc. tree Crops and Grooves, etc.	164215	164295
C	Cultivable Wastelands	390889	390744
	Total (a+b+c)	**555104**	**222039**
6	Fallow Land		
A	Fallow land and other current Fallows	115180	155193
B	Current Fallow	60093	60048
	Total (a + b)	215273	215241
7	Net Area Sown	285177	285499
8	Area Sown more than once	54040	54226
9	Total Cropped Area	339217	339725

12- Department of Agriculture, Government of Meghalaya

9. 5 MEGHALAYA FOREST AT A GLANCE

The total forest and tree cover in the state of Meghalaya is 17,956 Sq. km which constitutes nearly 80.05% of overall geographical area of the state. Out of the total, 9,496 Sq. km falls under recorded forest area and comprises of the reserved forests (11.7%), unclassed forests (88%) and remaining under protected forests.

Forest biodiversity in Meghalaya is classified into six major groups:

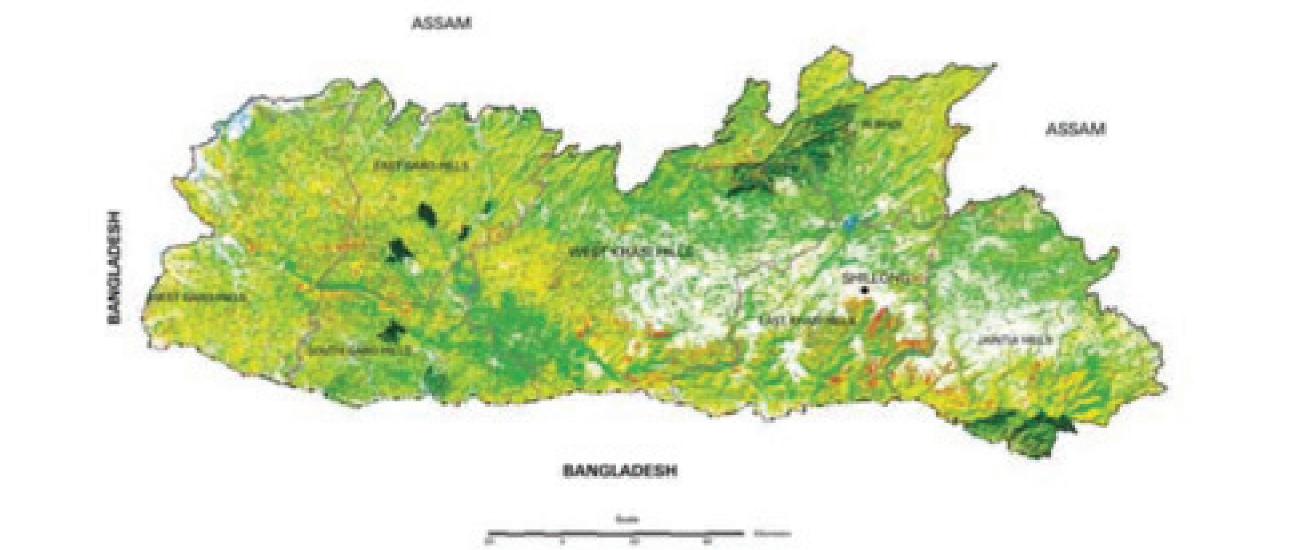
- Tropical Evergreen Forests
- Tropical Semi-Evergreen Forests
- Tropical Moist and Dry Deciduous Forests
- Grasslands and Savannas
- Temperate Forests
- Sub-tropical Pine Forests

These major categories are further subdivided into different categories as illustrated in the Figure 14. Table 23 shows the change in area of different types of forest in Meghalaya between 2011 and 2013 (FSI 2011 & 2013).

Table 23 - Forest Cover change matrix of Meghalaya (Sq.km)

Categories	2011 Total	2013 Total	Net change
Very dense forest	449	449	0
Moderately dense forest	9,689	9,584	-105
Open forest	7,150	7,184	34
Scrub	372	348	-24
Non forest	4,769	4,864	95
Total	22,429	22,429	0

Figure 14: Forest Map of Meghalaya



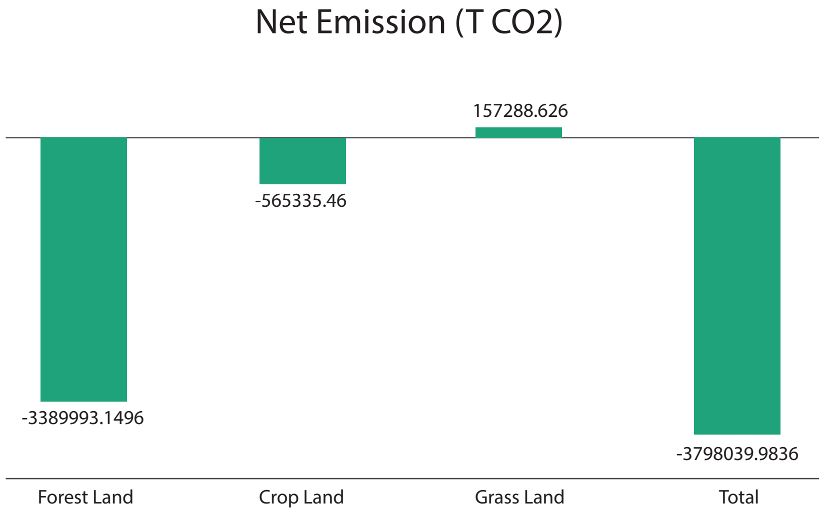
9. 7 EMISSIONS AND REMOVAL FROM NON-FOREST CATEGORIES

The three non-forest categories included in this study are cropland, grassland and wet land. The net emissions/removals from non-forest land categories: grasslands and croplands has been estimated using Tier II approach. This involved incorporating the total area (in hectares) of each subcategory with their respective country specific emission factors (INCCA report). In order to estimate the emissions from wetlands, net carbon stock change method has been used and is as outlined in Table.

Table 24 - GHG emission and removals from non-forest land categories: Grassland & Cropland

Land use	Annual Average Sequestration (Tons of CO_2/ha/Year)	Area in 2012-13 (ha)	Net CO_2 Emissions and removals]
Grassland			
Grazing land	0.198	0	0
Scrubland	0.198	1,64,295	32530
Land put to Non-agricultural uses	0.198	2,39,348	47391
Culturable waste	0.198	3,90,744	77367
Total Grassland	**0.198**	**7,94,387**	
Cropland			
Net sown area	1.13	2,85,499	-322328.371
Current fallow	1.13	60,048	-67794.192
Other fallow	1.13	1,55,193	-175212.897
Total Cropland	**1.13**	**5,00,740**	**-565335.46**

Figure 15 – Emissions & Removal from LULUCF



Net GHG emissions and removals are shown in the table 24. Removal from forest land during base year was about 3.38 million Tons of CO2 and removal from crop land was 0.56 million Tons of CO2, while emissions from non-forest land was around 0.15 million Tons of CO2 specifically from removal of grasslands during the year 2012-13.

The net sink constituted 3.88 million Tons of CO2 Eq. while net emissions was 0.15 million Tons of CO2 Eq. In totality, around 3.79 million Tons of CO2 Eq. emissions was sequestered during 2012-13 from land use, land use change & forestry.

9.8 GHG EMISSIONS SUMMARY – LAND USE, LAND USE CHANGE & FORESTRY

Table 25 - GHG Emissions Summary – Land Use, Land Use Change & Forestry

Emission Source	CO_2 emissions/removals (MT) [-removals and + sequestration]
Forest land	-33,89,993
Corp Land	-5,65,335
Grass Land	1,57,289
Total	***-37,98,040***

10. WASTE

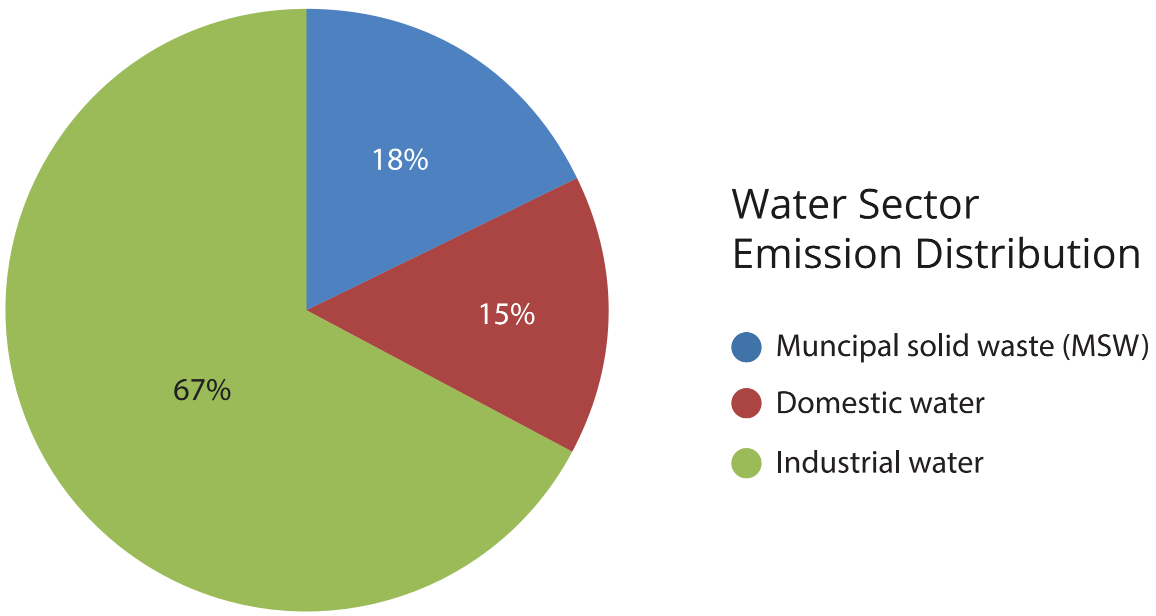
Waste generation is closely associated with population, urbanization and affluence. Sustainable waste collection, recycling and treatment is a major challenge faced by the local municipalities. A core requirement for sustainable development is to establish affordable and effective management practices.

Waste is one of the major sources of methane emissions. It is generated as a result of anaerobic decomposition by methanogenic bacteria of organic matter. In addition, it is also a source for N_2O emissions in the case of domestically generated wastewater.

Sources of greenhouse gases from waste discussed in this document are classified into three categories including:

Municipal solid waste disposal resulting in CH_4 emissions	Domestic waste water disposal culminating in CH_4 and N_2O emission	Industrial waste water disposal resulting CH_4 emissions

Figure 16 - GHG Emission distribution by waste sector (% CO2 Eq.)



10.1 MUNICIPAL SOLID WASTE

In Meghalaya, waste is periodically collected and disposed at waste disposal sites in cities. A majority of the MSW is discarded in landfills by means of open dumping and a small fraction of the waste finds its way into composting practices.
To estimate the emissions from landfills, first order decay methodology has been used (IPCC, 2002).

CH_4 generated from disposal site is calculated using the following formula:

Methane Emitted = (∑CH4 generated - RT) * (1 - OXT)
RT = Methane recovered in year T, Tons
OXT = Oxidation factor in year T (fraction)
CH4 generated from the landfill depends on the amount and composition of waste and waste management practices as well.
CH4 generated in year T is represented as
CH4 = DDOCm decompoT * F * 16/12

Where,
F = Fraction of CH4 by volume
16/2 = Molecular weight ration, CH4/C
DDOC m is the Decomposable degradable organic carbon that degrades under the anaerobic condition in landfill site.

This component is calculated using the formula

DDOCm = W*DOC*DOCf* MCF

W = Mass of waste deposited, tones
DOC = Degradable organic carbon in the deposition year
DOCf = Fraction of DOC that can possibly decompose (fraction)
MCF = Methane correction factor in the year of deposition (fraction)
Average value used for per capita waste generation was 0.55 kg/day. There are seven municipal boards in Meghalaya and according to the discussions with CPCB, almost 133MT of the MSW was collected every day. Three municipal boards had composting facilities for treating the bio degradable waste and the non-bio degradable waste was discarded in landfills. Various values considered –
Degradable organic carbon fraction = 0.11 (NEERI, 2005)
Methane correction factor = 0.4
Fraction of degradable organic carbon that decomposes (DOCf) = 0.5
Fraction of methane in the landfill = 0.5
Rate constant = 0.17/year (as per IPCC guidelines (IPCC, 2002)).

Treated waste accounted for only 100 TPD (composting, vermicomposting, biogas plant, RDF etc), which is assumed to have insignificant or nil emissions.

On applying this methodology, the methane emissions from municipal solid waste was estimated to be 1142 Tons (i.e 23975 Tons of CO2 Eq.)

10.2.1 DOMESTIC WASTE WATER

Emissions from domestic wastewater handling are estimated only for urban centers. This is because the characteristics of the municipal wastewater vary from place to place and depend on factors, such as economic status, food habits of the community, water supply status and climatic conditions of the area. In most rural areas the amount of waste generated is low. Also, most of the waste is subjected to open dumping. Thus, waste from the rural regions is degraded aerobically with insignificant or nil emissions.

CH_4 Emissions:

In this report CH4 emissions estimates has been made using Tier II approach – which uses the urban population and relevant country specific emission factor. This country specific emission factor has been derived from the INCCA report (2007)[15].

The INCCA report estimated CH4 emissions of India using Tier II approach, which uses country specific emission factors and country specific data. Emission estimates has been arrived at by using reliable and accepted secondary data generated by various Government and private agencies working in these respective areas in the country.

The annual methane emissions from domestic wastewater can be expressed as (IPCC, 2002):

$$Td = \{\Sigma (Ui \times Tij \times EFi)\} (TOW - S) - R$$

Where,
Td – Total domestic methane emission
Ui – Fraction of population in income group i in inventory year
Tij – Degree of utilization of treatment/discharge pathway or system
i – Income group: rural, urban high income and urban low income.
j – Each treatment/discharge pathway or system
EFi – Emission factor, kg CH4 / kg BOD
TOW–Total organics in wastewater in inventory year, kg BOD/yr
S – Organic component removed as sludge inventory year, kg BOD/yr
R – Amount of CH4 recovered in inventory year, kg CH4/yr
Using this methodology for urban population, the methane emissions was estimated to be around 19103.2 Tons.

N_2O emissions:

N2O emissions occur irrespective of the handling method due to the presence of protein in wastewater. The simplified equation to determine N2O from wastewater is:

$$N_2O Emissions = NEffluents * EFEffluents * 44/28$$

Where,
N2OEmissions – N2O emissions in inventory year, Tons N2O/year
NEffluent – Nitrogen in the effluent, Tons N/year
EFEffluent – Emission factor for N2O emissions from wastewater, Tons N2O-N/Tons N
44/28 - Conversion factor for Tons N2O-N into Tons N2O

NEffluent is calculated using the following formula:

$$NEffluent = P * Pr * FNPR * FNON\text{-}CON * FIND\text{-}COM * NSludge$$

Where,
P – Human population
Pr – Annual per capita protein consumption, ton/per/yr
FNPR - Fraction of nitrogen in the protein (Default = 0.00016 ton N/ ton of protein)
FNON-CON - Factor denoting non-consumed protein addition to the wastewater (Default – 1.4)
FIND-COM - Factor representing the addition of industrial and commercial discharged protein into the sewer system (Default – 1.25)
NSludge – Nitrogen detached along with the sludge (Default = 0), Tons N/yr
Annual per capita protein consumption of 57 g/day during 2005-2008 was taken for calculation (Ministry of Statistics and Programme Implementation).
Using this methodology for urban population, the N2O emissions was estimated to amount to 13.2 Tons and that of methane to be 714.5 Tons.

The overall emissions from domestic waste water was estimated to be 129766 Tons of CO2 Eq.

10.2.2 INDUSTRIAL WASTE WATER

The only major industry which was generating waste water was distillery and the emissions are quantified.

Methodology: The equation to estimate emission from industrial sector is given by

$$Ti = \sum(TOWi - Si) * EFi - Ri$$

Where,
Ti - CH4 emission during the quantification year, Tons CH4/yr; i – Industrial sector
TOWi – Total organically degradable waste in wastewater for industrial sector I, Tons COD/yr
Si – Organic component removed as sludge during the quantification year, Tons COD/yr (Default: 0.35)
EFi – Emission factor for industry i, Tons CH4/COD for treatment/discharge pathway
Ri – Methane recovered in the inventory year, Tons CH4/yr
In order to estimate emissions from industrial waste water, tier I approach was used. The emission factors for each of industries has been taken from INCCA and IPCC reports.
Industries which recover and reuse their waste water have also been taken into consideration during estimations. Distillery sectors reuses 75 percentage of the water it uses.
In 2012-13, emission due to industrial waste water was estimated to be 86,688 Tons of CO2 Eq.

10.3 GHG EMISSION SUMMARY - WASTE SECTOR

The total GHG emitted from waste sector in 2012, in Meghalaya, was 0.13 million Tons of CO2 Eq. Industrial waste water has been the dominant source of CH4 emission in Meghalaya and amounts to 67% of the total CO2 Eq. from waste. Domestic wastewater and municipal solid waste constituted to be 15% & 18% of the emissions respectively.

Table 26 - GHG Emission Summary - Waste Sector

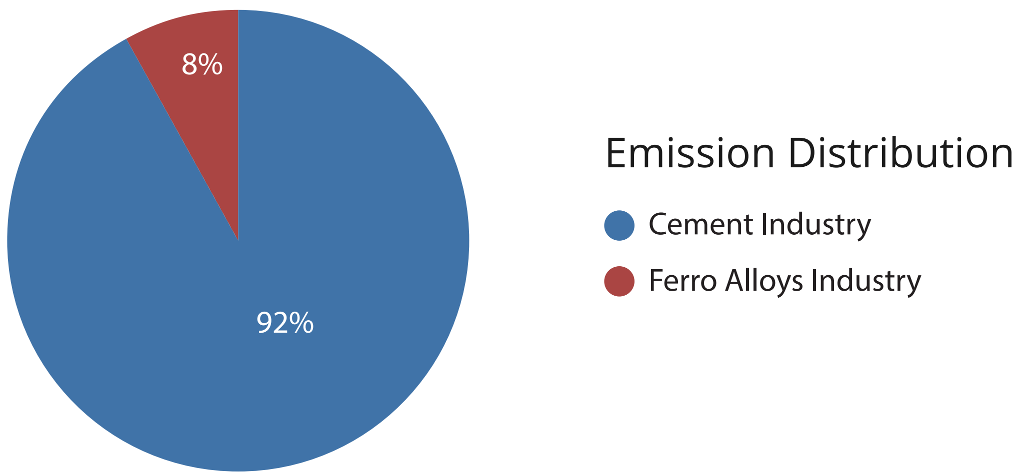
Emission Source	CO_2 Eq. (MT)
Municipal Solid Waste	23975.0
Domestic Waste Water	19103.2
Industrial Waste Water	86688.0
Total	**129,766**

11. INDUSTRIES

Meghalaya's industrial sector contributes to 26 percent of Meghalaya's GSDP. Industrial sectors included in this study are cement, ferro alloys and other miscellaneous industries.
Of these, the cement industry contributes to a big 92% of Meghalaya's total emissions followed by ferro alloys with 8% of total CO2 Eq. emissions of the industrial sector (Figure 17).

Estimation for the industry sector has been made based on Tier II approach, by utilizing the production data of constituent industries (from published data) and country specific emission factors (CMA, INCCA etc.). Tier 2 has been used only in the case of ferro chrome, where emission factor from India GHG Report 2007 has been used for estimation.

Figure 17 - GHG emission distribution by industrial sector (% CO2 Eq.)



Cement production contributes maximum to industrial emissions. There are 19 plants in Meghalaya with an installed capacity of 6 million TPA. The total emissions estimated from the cement industry was 3.45 million Tons of CO2 Eq. emissions during the year 2012-13. This accounts to more than 90% of Meghalaya's overall GHG emissions and includes both process and fuel emissions.

Other major industry in Meghalaya was ferro alloys industries and other miscellaneous industries such as distilleries, food processing, etc.

11.1 GHG EMISSIONS SUMMARY - INDUSTRIAL SECTOR

Emission Source	CO_2 Eq. (MT)
Cement Industry	3,450,461
Ferro Alloys Industry	293,202
Other Industries	56,879
Total	**3,800,543**

12. LOW CARBON GROWTH IN MEGHALAYA STATE

The overall approach for the emission reduction strategy of Meghalaya should be to pursue an aggressive emissions reduction target. In line with the national commitment of reducing emissions intensity by 30-33% of 2005 levels by 2030, this study explored possible options to help the state of Meghalaya achieve similar emissions intensity reduction. Based on the mitigation options identified, an emissions intensity reduction of 30-33% by 2030 for Meghalaya is achievable since Meghalaya has a large potential of sequestration through Land Use Land Use Change and Forestry (LULUCF).

Typically, for states, the emissions intensity could either be on emissions per capita basis or on emissions per unit GSDP. While the intensity reduction on emissions per capita basis would call for a very strong effort from the state, requiring significant investments & technology interventions, addressing the reduction initiatives in emissions per unit GSDP appears to be relatively simple and also in line with the National targets.

With over 80% of emissions in Meghalaya arising out of energy, power and industry related sources, it is imperative for the state to continue to focus on strategies on renewable energy to maintain low carbon intensity and lower its overall emission footprint. With per capita energy consumption in the state bound to rise with increasing urbanization, improved standard of living, increased industrial growth, it is essential for the state to embark on a low carbon power supply to achieve its overall reduction targets. Meghalaya's commitment in this direction will be explicit if the state can adopt an implementation plan for the voluntary Renewable Power Obligation (RPO) requirement which will significantly exceed any mandatory values that the central government may impose. Implementing such an ambitious yet achievable RPO targets, will align the state's action towards this direction and portray favorably for investors as well.

Research & development play a key role in helping the state understand its emissions portfolio and identify suitable mitigation options. These R&D initiatives should also be adequately supported to convert into deployment and widespread adoption, thereby achieving the results foreseen. In these efforts, significant financial support is one of the key criteria for effective implementation of the state's low carbon strategies. For a transition economy like India, and anattractive investment destination such as the state of Meghalaya, it becomes unviable for the state to fund such climate mitigation measures through its fiscal budgets. Basic competing needs such as eradicating poverty, increasing power availability for creating livelihood opportunities, increasing literacy etc. will prevail over the state's environmental concerns. Creation of a 'Green Fund' and supporting the state's climate mitigation efforts through funds raised from larger emission sources, could be a viable alternative to meet environmental concerns without compromising on the citizen's fundamental requirements.

Land Use, Land Use Change and Forestry (LULUCF) can significantly act as a carbon sink in the state's efforts to minimize its overall carbon footprint. LULUCF currently sequesters 56% of the total carbon emissions. Increasing urbanization and greater demand of land for industrial, agricultural and residential purposes is resulting in rapid deforestation and land use change issues. Carbon sinks in various states are gradually depleting and increasing the overall environmental concerns with respect to water, soil and climate. States pursuing low carbon growth should provide undivided focus on LULUCF, not only from the standpoint of carbon mitigation, but also to address other relevant environmental concerns such as biodiversity preservation, prevention of soil erosion, maintaining water balance and the overall green image of the state.

12.1 ENERGY

Energy consumption in a society, is closely linked with all key contemporary challenges – poverty alleviation, food scarcity, environmental degradation and therefore its efficient use attains paramount importance.

In the baseline year of this study, 2012-13, energy related emissions was estimated to be approximately 1.594 million Tons of CO2 equivalents, about 24% of overall Meghalaya's gross emissions. To address such a large share of the emissions, and a significantly increasing share of overall emissions, a combination of regulatory, fiscal and technological measures are essential to meet the upcoming challenge. While a few policy measures from a regulatory standpoint could address emission from sources, a combination of technological and financial measures is essential for reducing the overall emissions profile of the state in FY 2030.

Renewable energy (RE), internationally and nationally, promises to be an excellent alternative to address the serious issues of meeting increased energy demand andincreasing emissions intensity. There is a total estimated potential of 6185 MW of Renewable Energy in the State of Meghalaya which is currently utilizes at less than 1%. 31.03 MW grid interactive small hydro power and various off grid solar photovoltaic, biomass gasifiers (rural and industrial) etc[19]. are installed in Meghalaya.

Table 28 - Renewable Energy Potential

Renewable Energy Potential (MW)						
State	**Wind Power**	**Small Hydro Power**	**Bio-mass power**	**Waste to Energy**	**Solar**	**Total**
Meghalaya	82	230	11	2	5860	6185

19 - http://mospi.nic.in/Mospi_New/upload/Energy_stats_2015_26mar15.pdf

India, as per its commitment in NAPCC, aims to derive 15% of its energy requirements from renewable energy sources by the year 2022. Under this, Meghalaya state government has been allocated 212 MW of Renewable Energy Installation. Renewable Purchase Obligation (RPO) is one of the tools adopted by the Government of India in achieving this ambitious goal. Under these rules, distribution companies, open access consumers and captive power consumers are obligated to substitute a certain percentage of their overall energy consumption from renewable energy sources. RPO should be gradually increased from current levels to 25% by 2020. Clear policies and communication would prepare distribution companies, open access consumers and captive power consumers to plan their investments accordingly and assist in meeting the state's overall emission targets.

The Meghalaya Electricity Regulatory Commission has implemented Renewable Purchase Obligations in the state to promote the generation and use of renewable energy. Meghalaya has also released a notification indicating the % RPO for the obligated entities as seen in Table 26

Table 29 - %RPO for the obligated entities

RPO- Minimum quantum of purchase (%) from renewable energy sources (in kWh)	2015-16	2016-17	2017-18
Solar	0.41	0.42	0.43
Non Solar	1.09	1.58	2.07
Total	1.5	2	2.5

Based on the above table, the RPO obligation is expected to increase to 2.5 % by the year 2017-18. Among the obligated entities under RPO are captive power generators and distribution companies. As there are not many captive power plants or other entities, the Meghalaya State Government should also explore other avenues for promoting Renewable Energy in the State.

It is suggested that the Government of Meghalaya should prepare the Renewable Energy Roadmap with a target of adding atleast 1000 MW by 2022 and it should highlight the areas or location with RE potential so as to facilitate fast track implementation of such projects. The government should explore implementing projects in PPP model. At 1000 MW of renewable energy, the state would be able to mitigate yearly emissions of atleast 3 million tons of CO2.

The transmission and distribution losses policy describes that the state government would prepare a five year plan with annual milestone to bring down the transmission and distribution losses expeditiously. The Meghalaya State Electricity Regulatory Commission has already framed a trajectory for reduction of losses for next three years and accordingly allowed distribution loss at 23% for 2015-16.[20] Continuation of present level of losses not only owes a threat to the power sector but also jeopardizes the growth of the economy as a whole. Similarly, the electricity policy envisages encouragement of energy conservation and demand site management. Periodic energy audits are mandated for power intensive industries.

20- http://www.mserc.gov.in/orders/2015-16/Tariff_Order_MePDCL_2015-16.pdf

12.2 TRANSPORT

Transportation is an integral part of our national economy. India's transport sector is also very large and diverse, catering to the needs of over 1.1 billion people. Good logistics connectivity across the country is essential for robust economic growth. Since the early 1990s, India's growing economy has witnessed a rise in demand for transport infrastructure and services. Roads are the dominant mode of transportation in India today. They carry almost 90% of the country's passenger traffic and 65% of its freight. The density of India's highway network - at 0.66 km of highway per square kilometer of land – is similar to that of the United States (0.65) and much greater than China's (0.16) or Brazil's (0.20)[21]. Motor vehicle penetration in the country is still one among the least in the world.

Meghalaya transport related emissions was estimated to be 1.004 million Tonnes of CO2 equivalent and this contributed to 63% of the emissions from various energy sources. With a fast growing automobile market, growing disposable incomes and increased need for transportation, India is bound to witness significant increase in transportation related activities in the years ahead. The road length at the time of creation of Meghalaya in 1970, was only 2786.68 km which has been increased to 7633.00 Km by 31st March 2003. The road density increased from 12.35 km per 100 square kilometer to 7633 kms, out of which 3691 km is black topped and remaining 3942 km is graveled. To attenuate the increasing emission levels, key strategies need to be in place.

Attempts to reduce transport related carbon emissions globally have focused on increased mass transport systems, improving fuel efficiency of vehicles and promoting low carbon intensity fuels (e.g., bio fuels).

While the central government is working on improving fuel efficiency of motor vehicles[22], states can explore the opportunity of increased mass transport systems and promoting low carbon intensity fuels. In this regard, fuel cess has been recognized in many European nations and in a few Indian states (E.g.: Delhi) to reduce the carbon footprint of fossil fuels. In Delhi, a cess of Rs 0.25/litre is levied on diesel and the funds are diverted for green initiatives. A similar strategy can be implemented in Meghalaya as well. It is proposed to charge a fuel cess of Rs 0.50/litre on both diesel and petrol, and the tax generated from it can be utilized for funding bio fuel research and supporting technology absorption.

The major industry in Meghalaya is Cement which contributes to over 90% of the industrial emissions which is followed by the Ferro alloys industry. Various policies developed over the last couple of decades, meet the dual objectives of generating increased employment opportunities and achieving higher growth. Past trend on industrial energy consumption shows increasing growth rate and is expected to grow predominantly in the future as well. Industry related greenhouse gas emission in the baseline yearwas estimated to be about 3.801 million Tons of CO2 equivalent.

21 - World Bank, http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/EXTSARREGTOPTRANSPORT/0,,contentMDK:20703625~menuPK:868822~pagePK:34004173~piPK:34003707~theSitePK:579598,00.html

22 - http://www.hindustantimes.com/business-news/WorldEconomy/India-to-introduce-new-fuel-efficiency-standards/Article1-693452.aspx

12.3 INDUSTRY

The major industry in Meghalaya is Cement which contributes to over 90% of the industrial emissions which is followed by the Ferro alloys industry. Various policies developed over the last couple of decades, meet the dual objectives of generating increased employment opportunities and achieving higher growth. Past trend on industrial energy consumption shows increasing growth rate and is expected to grow predominantly in the future as well. Industry related greenhouse gas emission in the baseline yearwas estimated to be about 3.801 million Tons of CO2 equivalent.

Cement industries and ferro alloys industries are the major emitters in the industrial sector. Total cement production was 4.85 million metric tonnes and 60791 metric tonnes of ferro silicon.

Energy efficiency has been adopted by the Indian industry over the last several years as one of the effective competitiveness building measure due to very high energy costs[23]. Several mandatory energy efficiency improvement measures have also resulted in significant capacity building and awareness among the industrial fraternity. Under the NAPCC, National Mission on Enhanced Energy Efficiency (NMEEE) has embarked on a new initiative, first-of-its-kind in the world initiative, called Perform, Achieve and Trade (PAT) scheme. PAT is a market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy intensive large industries and facilities, through certification of energy savings, which can be traded.

This mandatory scheme, under the Energy Conservation Act 2001, will certainly give a major boost to the energy conservation activities in the state, thereby resulting in significant energy related greenhouse gas emissions reduction. If all the designated consumers meet their PAT targets, anticipated energy reduction is approximately 300 million kWh in two years' time period. At present, in the second cycle of Perform Achieve and Trade, three industrial units from the State are designated to participate in the scheme which focuses on specific energy consumption (SEC) reduction.

Low Carbon Technology Roadmap:

Considering that the cement sector is contributing to more than 55% of the overall emissions, it is recommended that the State Government formulates a Low Carbon Technology Roadmap for the Cement Sector in the State. The roadmap should be aligned with India's Low Carbon Technology Roadmap for Cement Sector (Voluntary initiative). The objective of the roadmap is to reduce the GHG emission intensity of the Indian cement sector by 48% by 2050 in comparison to the 2010 levels. Since the cement sector is the major contributor of the State's industrial emissions, it is suggested to have a special focus on this sector. It is also expected that, with more cement plants planned to be commissioned in the state, the emission reduction initiatives in the sector will have significant impact on the State's GHG Profile.

23 - Energy costs in India being among the highest in the world.

Another lever to encourage industries to adopt non-fossil fuel based energy sources to meet their power and fuel demand, would be to introduce a carbon tax on fossil fuel purchases. Currently, government of India levies a clean energy cess of Rs. 50 per ton of coal used. A few states have increased this cess to Rs. 100 per ton of coal used to fund non-fossil fuel based energy development. This is a measure that the government of Meghalaya could consider to promote non fossil fuel based energy such as renewable energy, energy plantations, bio mass, waste to energy, etc. Co-processing of industrial, municipal and other combustible wastes in cement kilns could be another viable alternate for meeting dual needs of meeting the energy requirements of cement industries partially and addressing the waste management issues of the state.

Promotion of Low Carbon Sectors:

All sectors are vital for growth & development of the state. Each sector has a varying impact on GHG emissions. For example, IT industry emits less CO_2 for per unit of revenue when compared to cement sector. Thus, states should also promote and encourage low carbon sectors with favorable policies and regulation. This will result in direct new investments in low carbon sectors. The State Government of Meghalaya should promote the other sectors which are less energy intensive and carbon intensive,

Small and Medium Enterprises (SMEs) across India typically operate in the context of industrial clusters, or geographic concentrations of firms contributing to production of similar goods. These clusters can count over one thousand enterprises, including hundreds of industrial manufacturing plants and provide employment to tens of thousands of workers. They collectively deliver a substantial share of industrial employment, output and exports. SME clusters are impeded in their development due to several constraints, including access to factors such as technology, finance, skills and supporting management resources and access to markets. As the Government of Meghalaya is planning to develop industrial parks, Cleaner Production and Industry Symbiosis can improve the productive use of energy, materials and water, reduce the generation of waste and emissions (including GHGs) and strengthen the sound management of chemicals.

This enhances productivity and contributes to competitiveness, supporting the following overall objectives:

- Reduced pollution intensity and increased resource efficiency of target SME industry clusters
- Reduced exposure of employees and communities to risks from industrial clusters and improved employee and community well-being
- Enhanced public-private partnership in SME clusters with improved ability to innovate. A multi-pronged approach should be deployed for promotion and awareness creation, assessment and coaching support, recognition and rating of performance, and strengthening public-private partnerships at the cluster-level

Implementation of Demand Side Management program in Domestic Sector:

In 2012 there was a sale of 1.2 million units of Incandescent Lamps (ICL). If they are replaced with LEDs which uses 85% less energy, it will result in savings of 79 million units of electricity which is equivalent to 64,780 tons of CO_2

Domestic: In the State of Meghalaya, more than 80% of the population is dependent on fire wood to meet the energy requirements for cooking and heating. This method of cooking is coupled with inefficient stoves which results in more consumption of fire wood and high amount of generation of pollutants which affects the health of people. In many countries, Program of Activities under UNFCCC has been focused on promoting Energy Efficient Stoves (Ex. Kenya, Rwanda, Bangladesh). The State of Meghalaya should also explore introducing such programs with the aim of improving the efficiency of stoves in households.

12.4 BUILDINGS

Buildings are responsible for large amounts of energy consumption and GHG emissions (primarily through electrical energy consumption). Buildings are a key area of focus since 70% of the floor space in India in 2030 is yet to be built. Building sector has a vast potential to reduce the GHG intensity through proven technological and architectural interventions. To deploy the breakthroughs and achieve maximal reductions, holistic actions are required. Following are the mitigation opportunities available for Meghalaya state to reduce the emissions footprint from infrastructure. For green buildings, the government can provide 8-10% extra FAR to encourage adoption of Green Buildings. State governments such as that of West Bengal (Kolkata) is providing an incentive for Green Buildings.

Table 30 - Green Buildings

Commercial Buildings	Residential buildings	Government buildings
Regulatory Measures > Compulsory Green buildings for spaces greater than 20,000 square foot > Provision of (marginally) higher floor space index as an incentive for adopting green buildings > Elimination of excessive bureaucracies on green building approval	**Regulatory Measures** > Construction of green homes for complexes having greater than 100 dwelling units or when built up space is greater than 50,000 square foot > Prioritization of rain water harvesting programmes for residential blocks in tier II & tier III cities > Creation of fast track approval channel for construction	**Regulatory Measures** > Green procurement for all activities > Green building certification for all upcoming buildings (Mandatory) > Adopting BEE's 5 star rating for all government buildings (Energy efficiency) > Mandatory energy audits of all existing buildings and improving energy efficiency
Technological interventions > Emphasis on renewable energy use for certain purposes (e.g. Solar Water heating) > Reduce heating, cooling and lighting loads through climate responsive design and conservation practices	**Technological interventions** > Deploy the use of photovoltaics and Solar water heating system for all dwelling units > Transition to energy efficient lighting from energy consuming lighting fixtures	**Technological interventions** > Transition to energy efficient lighting from energy consuming lighting fixtures > adopt building integrated renewable energy systems by design
Information dissemination measure > Capacity building on green concepts	**Information dissemination measure** > Capacity building on green concepts	**Information dissemination measure** > Capacity building on green concepts > Develop capacity for State's Public Works Department pertaining green specifications

Green Village:

Today, major challenges faced in villages are use of firewood, open defecation, drinking water scarcity, lack of adequate health care, access to basic amenities & school and power shortage. In the above context, converting existing villages to green and self-sustainable is of paramount importance to the Nation. IGBC Green Village rating is designed to address many of the rural challenges. The green concepts and techniques in the villages can help address National concerns such as water availability, energy availability, reduction in fossil fuel use, handling of waste and conserving natural resources. Most importantly, these concepts can enhance health and well-being in villages, which is assuming greater importance.

> "A Green Village is one which offers access to clean energy, adequate water, basic education, good healthcare, hygienic sanitation, leading to economic prosperity and enhanced quality of life, in a manner that is environmentally sustainable."

Benefits of Green Villages:

The green villages will adopt a holistic approach to sustainability and will set an example for the villages in the country to adopt green principles. The conversion of existing villages to green villages would result in multifold benefits.

Tangible Benefits

- Reduced water demand (20-30% Water savings)
- Reduced power demand (30-40% Energy savings)
- Better handling of municipal waste

Intangible Benefits

- Access to basic facilities like healthcare, schools, transport, recreation
- Hygiene, access to safe drinking water & sanitation

As part of the National Urban Mission launched by the Hon'ble Prime Minister, 100 clusters of villages have been selected in Phase 1 out of the total 300 rural growth clusters which are to be developed by 2020. Thirty villages of Meghalaya in East Garo Hills District (Chisim Apal Cluster) have been identified in the Phase 1 of the Urban Mission. It is recommended that the Meghalaya State Government should adopt Green Village Rating system for the selected 30 village and built Green Villages.

12.1 ENERGY

Agriculture is one of the predominant sectors for the economy of Meghalaya. Agriculture is, a sector of enormous value, but it emits mammoth quantities of GHG into the atmosphere and 44% of the emission is from enteric fermentation. Although it is impossible to completely eliminate these emissions, it is possible to reduce the externalities of agricultural practices that lead to increased emissions by embracing sustainable cultivation practices and technology.

Since Meghalaya is an agrarian economy, the focus should be on increasing the energy efficiency of the sector as a whole. One such energy efficiency measure can be the installation of energy efficient pumps or solar pumps for agriculture. Government can play a significant role by providing pumps at a subsidized cost (50% of the total cost). Supplementing the pumps, government can encourage Energy Savings Company (ESCO) model of project implementation, considering the growth of agriculture sector. Financial savings from the projects can be funneled into research projects to make the agriculture sector an instigating model for the world.

Water and Crop Management can play a decisive role in emissions reduction efforts. Efficient water management can be achieved with the government's support activities, which could include financial assistance and subsidies for procuring and installing efficient irrigation equipment and promoting solar pumps, so the usage of electricity will also reduce. On the crop management front, polices focusing on crop insurance can be provided to farmers who cultivate crops in the most sustainable manner. In addition to crop insurance, incentives can be given to farmers who use best available cultivation practices.

Systemic Rice Intensification (SRI) technique of rice cultivation, which involves less fertilizer usage and seeds, has been known to produce higher yields per hectare. The average yield obtained by using SRI (46.53 q/ha) is more than double when compared to traditional method of cultivation. These systems are gradually attracting attention and more farmers are open to SRI. The SRI technique of rice cultivation helps to cope with natural calamities like water stress, terminal drought due to climatic variability. Government can provide financial incentives and crop insurance to encourage farmers to adopt this cultivation practice. Government of Meghalaya has already initiated the pilot on SRI in certain sites in the State. The State should aim at implementing the SRI techniques in 50% of rice cultivation area in next five years.

12.6 LAND USE AND LAND USE CHANGE AND FORESTRY (LULUCF)

LULUCF management plays a vital role in regulating the environmental parameters of the earth. But presently, its very existence is being threatened by over-exploitation by human beings. Meghalaya however, has seen a continuous rise in afforestation activity over the past 10 years. The afforestation activity in the base year alone accounted to 3.7 million Tons of CO2 of sequestration. To regulate the environmental conditions, land and forest management becomes crucial.

Successful management can be achieved through the strategies described below.

GIS studies:

Effective forestry management requires information. Pertinent details on forestry can be gathered through GIS studies.

Capacity building and social forestry:

Effective management depends on capacity building with specific focus on community based development and protection measures. Community involvement will improve not only the economics status of people involved but also provide ecosystem services and environmental benefits for generations to come. The Meghalaya Government can play a stimulating role by initiating community based projects either by providing financial incentives to local forest community or by galvanizing corporate organizations to indulge in creating social forestry involving local community.

GLOSSARY OF KEY TERMS

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

CAGR: The compound annual growth rate is calculated by taking the nth root of the total percentage growth rate, where n is the number of years in the period being considered

CO2 Equivalent: It is the sum total of all Greenhouse Gases in terms of their global warming potential

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 (electricity generation, petroleum refining, manufacturing of solid fuel), transport, commercial/ institutional, residential, agriculture / forestry /and fugitive emissions from coal mining and handling and from oil and natural gas

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

Fugitive Emission: Emission that are not emitted through an intentional release through stack or vent. This can include leaks from plants, pipelines and during mining

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 CO2 over a period of time (e.g. 100 years)

Industry: This includes emissions from industrial processes and emissions due to fossil fuelcombustion in manufacturing industries. The emissions are estimated from mineral industry(cement, lime, glass, ceramics, soda ash use), chemical industries (ammonia, nitric acid, adipic acid, caprolactam, carbide, titanium dioxide, petrochemicals and black carbon, methanol, ethylene, etc.), metal industry (iron and steel, ferroalloys, aluminium, magnesium, lead, sink, 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 10,00,000 Tons

Per Capita Emissions: GHG emissions in CO2 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

Uncertainty: Lack of knowledge of the true 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

ABBREVIATIONS

GB – Above Ground Biomass
AFLOU – Agriculture Forest and Other Land Use Category
BGB – Below Ground Biomass
C - Carbon
CAGR – Compound Annual Growth Rate
CDM – Clean Development Mechanism
CFL - Compact Fluorescent Lamp
CH4 - Methane
CO2 – Carbon dioxide Equivalent
CO2 Eq. – Carbon dioxide Equivalent
DOM – Dead Organic Matter
DSM – Demand Side Management
ECBC – Energy Conservation Building Codes
EIP – Eco-Industrial Parks
ESCO - Energy Savings Company
FDI – Foreign Direct Investment
FY – Financial Year
GDP – Gross Domestic Product
GHG – Greenhouse Gas
GPG – Good Practice Guidelines
GSDP – Gross State Domestic Product
GWP – Global Warming Potential
HT - High Transmission
HFC – Hydro Fluorocarbons
IGEA - Investment Grade Energy Audit
INCCA - Indian Network for Climate Change Assessment
IPCC – Intergovernmental Panel on Climate Change
INR - Indian National Rupees
Km – Kilometer
LED – Light Emitting Diodes
LPG – Liquefied Petroleum Gas
LULUCF – Land Use Land Use Change & Forestry
MAI – Mean Annual Increment
MoA – Ministry Of Agriculture
MoEF – Ministry of Environment and Forests
MW – Mega Watt
MT – Metric Ton
MTOE – Metric Ton Oil Equivalent
N20 – Nitrous Oxide
NAPCC – National Action Plan on Climate Change
NH3 – Ammonia
NMEEE- National Mission on Enhanced Energy Efficiency

PAT – Perform, Achieve and Trade
PCRA - Petroleum Conservation Research Association
PFC – Per Fluro Carbon
PLCC – Power Line Carrier Communication
POA – Program of Activities
Ppb - Part per billion
Ppm - Part per million
PPP – Public Private Partnership
Ppt – Part per trillion
RBI – Reserve Bank Of India
RE – Renewable Energy
RPO – Renewable Power Obligation
SAPCC – State Action Plan on Climate Change
SERC - State Electricity Regulatory Commission
SEZ – Special Economic Zone
SF6 – Sulphur Hexafluoride
SKO – Super Kerosene Oil
SME – Small and Medium Enterprises
SRI - Systemic Rice Intensification
T&D – Transmission & Distribution
ULB – Urban Local Body