Estimation of

ODISHA'S CARBON FOOTPRINT

Submitted to

Department of Forest and Environment
Government of Odisha

December 2015

CII

Confederation of Indian Industry

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ODISHA'S CARBON FOOTPRINT

(2011-12)

Submitted to

DEPARTMENT OF FOREST AND ENVIRONMENT
GOVERNMENT OF ODISHA

Prepared by

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Survey No. 64, Kothaguda Post, Hyderabad 500064

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1. EXECUTIVE SUMMARY

The Prime Minister of India released India's National Action Plan on Climate Change in June 2008 (NAPCC, 2008) addressing India's climate change concerns, areas of priority and a specific & well defined action plan for addressing the same. While the NAPCC provides a roadmap that can guide states toward prioritizing a set of strategies for the state, the Ministry of Environment and Forests (MoEF) has also developed a common framework that can facilitate states to prepare their State Action Plans in line with the broad objectives of the NAPCC.

Odisha, the ninth largest state in India in terms of area, is an industrialized and fast growing state. Odisha is notable as one of the first Indian states to have tackled its structural problems during the post-1994 Indian economic reforms. Odisha was also the first state in India to begin to privatise its electricity transmission and distribution businesses. Odisha has abundant natural resources and a large coastline. It contains a fifth of India's coal, a quarter of its iron ore, a third of its bauxite reserves and significant reserves of chromite.

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 from the state's resources and operations, 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.

The GHG Emission Inventorisation in the state of Odisha 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 Odisha state is aligned with the "India Greenhouse Gas Emissions Report 2007". The emission factors used in this study were a mix of country specific emission factors and default factors from IPCC. Default factors were used only in the absence of country specific factors.

The Carbon Footprint study for the Odisha state indicates that the total GHG emissions in the baseline year of 2011-12 were 98.5 million Tons CO_2 Eq. The contributions from energy, agriculture, waste, industry and land use to the total emissions are described in Table 1. The table also shows the significant contribution (in %) of each of the sub-categories to the major sectors.

Table 1 - Contribution of each sector to total emissions

Emission Source	CO_2 Eq. (MT)	%
Energy	**61,307,420**	**62%**
a) Power Generation	50,770,105	83%
b) Transport	6,077,759	10%
c) Residential/Commercial	1,573,317	3%
d) Other Energy	907,641	1%
e) Fugitive Emissions	1,978,598	3%
Agriculture	**25,067,055**	**25%**
a) Enteric Fermentation	10,112,319	41%
b) Manure Management	543373	2%

Emission Source	CO_2 Eq. (MT)	%
c) Rice Cultivation	9,359,552	38%
d) Agricultural Soils	4,896,181	20%
e) Burning of crop residue	155,629	1%
Waste	**659,016**	**1%**
a) Municipal Solid Waste	170,375	26%
b) Domestic Waste Water	224,450	34%
c) Industrial Waste Water	264,191	40%
LULUCF	**-36,969,070**	**-38%**
a) Forest Land	-28,289,723	77%
b) Crop Land	-7,621,879	21%
c) Grass Land	520,533.481	-1%
d) Wet Land	-1,867,770.9	5%
e) Fuel wood usage	289,769.357	-1%
Industrial Sector	**48,461,456**	**49%**
a) Cement Industry	2,683,800	5.5%
b) Ceramic Industry	83,839	0.2%
c) Chemical Industry	93,954	0.2%
d) Iron & Steel Industry	11,759,561	24.3%
e) Aluminium Industry (Smelter & Refinery)	29,751,739	61.4%
f) Ferro Alloys Industry	1,792,365	3.7%
g) Pulp & Paper	989,232	2.0%
h) Other Energy Usage	1,306,967	2.7%
Total Emissions in baseline year 2011-12 (MT)	98,525,876	

The overall approach for emission reduction strategy of Odisha should be to pursue an aggressive emission reduction target. In line with the national commitment of reducing emission intensity by 20-25% of 2005 levels by 2020[1], this study explored all possible options to help the state of Odisha achieve similar emission intensity reduction. Based on the mitigation options identified, an emission intensity reduction of 20-25% by 2020 for the state of Odisha looks feasible.

1 NAPCC – under the Copenhagen Accord

Some of the key recommendations:

1. Adopting voluntary Renewable Power Obligation (RPO) targets, significantly exceeding any mandatory values that central government may impose. RPO should be gradually increased from the current levels of 6%[2] to 25% by 2020.
2. Creation of 'Green Fund' and supporting the state's climate mitigation efforts through funds raised from larger emission sources could be a viable alternate to resolve environmental concerns to a certain extent without compromising on the citizen's fundamental requirements.
3. 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.
4. Investments in renewable energy should be aggressively pursued and results achieved to aid significant reduction in carbon emission intensity.
5. Establishing a 'Power Plant Refurbishment Fund' to create a fund source for the Odisha electricity board to gradually refurbish and modernize its power stations.
6. Charging a fuel cess of Rs 0.50/Litre on both diesel and petrol, with the funds generated from it utilized for funding bio fuel research and supporting technology absorption. Based on baseline year data, proposed fuel cess (at the rate of Rs 0.50/Litre) will result in substantial funding towards research and implementation of low carbon fuels.
7. Consider a '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.
8. Consider clean energy cess to non fossil fuel based energy such as energy plantations, bio mass, waste to energy, etc.
9. Co-processing of industrial, municipal and other combustible wastes in cement kilns could be another viable alternate for meeting dual needs of meeting partially cement industries energy requirements and addressing the waste management issues of the state.
10. 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).
11. Promoting adoption of green buildings in residential & commercial space. Government Odisha to lead by example. Providing 8-10% extra FAR for Green Buildings
12. Demand side management in agricultural pumpsets, water & crop management and Systemic Rice Intensification (SRI) technique to be explored as potential emission reduction opportunities in agricultural sector.

Disclaimer: The above mentioned points are recommendations to the State Government of Odisha.

This carbon footprint study would assist the Odisha 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 Odisha for the year of 2011-12 and has highlighted broad opportunities for emission reduction and achieving low carbon growth for the state.

2 RPO target of Odisha 2013-14 : 1.6% from Non-Solar, 4.2% from cogeneration & 0.2% from Solar http://www.indianenergysector.com/

2. NAPCC AND INDIA GHG EMISSION

The Prime Minister of India released India's National Action Plan on Climate Change (NAPCC) in June 2008 (NAPCC, 2008) addressing India's climate change concerns, areas of priority and a specific, well defined action plan for addressing the same. The objective of the mission is to reduce the GHG intensity by 5% by 2020 (base year 2005). The Action Plan outlined eight missions that are envisaged to mitigate climate change and undertake adaptation actions without compromising on the economic growth required to meet the developmental aspirations of its population. 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 annual fuel savings in excess of 23 Million Tons of Oil Equivalent (MTOE) and cumulative avoided 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.

While the NAPCC provides a roadmap that can guide states prioritize a set of strategies for the state, the Ministry of Environment and Forests (MoEF) has also developed a common framework that can facilitate states to prepare their state action plans in line with the broad objectives of the NAPCC, and this 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).

Odisha state government in 2010, released its state action plan on climate change "Odisha (Orissa) Climate Change Action Plan". It is one of the first States in India, to release a comprehensive action plan to address the climate changes issues while recognising the development imperatives. 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.

1. Agriculture
2. Coasts & Disasters
3. Energy
4. Animal & Fishery Resources
5. Forestry
6. Health
7. Industry
8. Mining
9. Transport
10. Urban Planning
11. Water Resources
12. Cross Sectoral issues

3. ODISHA AT A GLANCE

Odisha, "The Soul of Incredible India" is located on the south east coast of India, by the Bay of Bengal. It is bounded by the states of West Bengal, Bihar, Andhra Pradesh and Chhattisgarh.

Odisha is blessed with abundant natural resources – minerals, marine, forest and agricultural land and sea coast line of 480 km along the Bay of Bengal. Odisha possesses varied topography from extensive hill ranges, to rolling uplands, coastal plains to extensive river & brackish water systems and 5th highest (220 Sq Km) mangrove cover in India along the coast.

Because of the favorable geographic location, mineral resources and availability of skilled manpower, the state has attracted massive investment in industrial and service sectors. The Government of Odisha is engaged in creating a conducive investment climate with a number of pro- industrial policies and institutional support. The Government of Odisha is also focused on the development of infrastructure through building new ports, roads, highways and educational institutions in order to increase the foreign direct investment (FDI) inflow.

Particulars	Odisha
Capital City	**Bhubaneswar**
Administrative Districts	30
Geographical area-Sq. km (9^{th})	155707
Population in millions (11^{th})	41.94
Male population	21.2
Female population	20.74
Literacy rate in % (16^{th})	73. 45
Source :http://censusindia.gov.in	

Over the last few years, the state has attracted investments across various sectors to the tune of Rs. 723986 Crores in investment proposals (1991-2009)[3]. The state is witnessing a rapid economic and industrial growth. GSDP (Gross State Domestic Product) has grown 9.72% annually between the years 2004 and 2011. Odisha state is emerging as the centre for metal businesses in India and attracting majority of the investments in iron & steel and power sectors. Listed below are a few comparative advantages Odisha state offers over other states.

- Odisha state is a power surplus state and is exporting power to other states
- Abundant natural resources (Land, Water etc.)
- Politically stable and a state Government that favors industrial growth
- Large pool of scientific & technical workforce
- Adequate, skilled and cheap labor force
- Port and road facilities
- Most investment friendly state in the country

Odisha Government has established Odisha State Energy Conservation Fund (OSECF) for effective implementation of energy conservation act in the state. Energy conservation policy of the state is also being framed to ensure implementation of energy efficiency in buildings, municipal, agricultural, industrial and domestic sector. The draft policy is being reviewed for finalization.

Few energy efficiency and energy conservation measures initiated by the Odisha Government are summarised below:

Rural Electrification

- The Government of Odisha has initiated schemes for electrification of villages and providing access to electricity to the people living in the unelectrified areas of ULBs. Two schemes initiated by the government are Biju Gram Jyoti Yojana (BGJY) and Biju Saharanchala Vidyutikiran Yojana (BSVY).

Investment Grade Energy Audit for commercial and industrial sector

- Investment Grade Energy Audit (IGEA) study has been conducted by SDA Orissa with the support of some reputed Govt. of India organizations such as National Productivity Council and Petroleum Conservation Research Association (PCRA).
- IGEA Outcomes
  - For Government buildings energy saving potential of 2 MW was identified
  - For dairy plants, energy saving potential of 4 lakhs units and saving potential of 2 lakh Litres in furnace oil consumption was identified

3 http://dipp.nic.in/English/Archive/stats/dec2009/index.htm (IEM, DILs & LOIs)

Industries

- Odisha is the first government to amend ECBC to meet it's local requirements. The ECBC was implemented as the Odisha State Energy Conservation Building Codes for adoption in the state
- Scheme for extending financial support to State PSUs, cooperatives and autonomous institutions for implementation of energy efficiency in the buildings, industries, municipality, and agriculture has been approved and notified
- Odisha State has 28 designated consumers under PAT scheme in various sectors such as iron and steel, aluminium, thermal power plant, pulp and paper and cement and 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.
- IGEA for government buildings, ULBs, etc.

Others

- Promotion of energy efficient building design
- Mandatory use of BIS marked agriculture pump sets, power capacitors, foot valves, etc.
- Mandatory use of solar water heating systems in industries, hotels, hospitals, jail barracks, canteen, etc.
- Procurement and use of energy efficient distribution transformers
- National energy conservation day celebrations, awareness program on energy efficiency and conservation in villages, training and workshops for industries and other stakeholders

Renewable Energy

- The government of Odisha formed the Green Energy Development Corporation, a fully owned subsidiary of OHPC to promote investment and to develop renewable energy projects and other green energy projects in the state.
- It has very ambitious RPO targets upto 2014-15

Year	Non Solar RPO Targets	Solar RPO Targets
2012-13	4.75%	0.75%
2013-14	5%	1%
2014-15	5.25%	1.20%

- OREDA is undertaking various other initiatives such as promotion of domestic biogas plants, improved cook stoves for rural households, village electrification, solar street lighting, solar PV plants, solar pump sets, water pumping windmills, etc.
- National biogas and manure management program and energy plantation and bio-diesel production are two other programs initiated by OREDA
- There are also a number of renewable energy and other projects (Odisha) registered under UNFCCC Clean Development Mechanism (CDM).

4. CARBON FOOTPRINT STUDY

Atmospheric levels of carbon dioxide (CO_2) 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 CO_2. The human and ecological cost of climate changes 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 a future action plan for emission mitigation based on 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 tracking 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 reductions

4.3 BENEFITS TO ODISHA 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 Odisha 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 footprinting study aims to highlight not only the emission intensive sectors, but provide a holistic understanding of the carbon distribution across sectors. This study would serve as a tool to identify and direct future investments. This study would also highlight business opportunities for carbon intensity reduction in different sectors. This would also 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 would help the state be better prepared against environmental risk.

- Recognition as an environmental leader

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

- Preparedness for a carbon constrained future

Identifying emissions sources to develop a GHG profile and management strategies would help 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, implemented technological innovations, improved products and services, and ultimately realised gains, both monetary and in resources. Similar opportunities exist for the state also, wherein the state can evaluate, identify and redesign its operations to improve efficiencies and reduce waste.

- Stakeholder Engagement opportunities

Assembling an 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' Odisha.

5. GHG EMISSION INVENTORISATION METHODOLOGY

The GHG emission inventorisation in the state of Odisha 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 Odisha 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 all possible ways. In addition, this method provides opportunity for every state to align their emission inventory with the future national inventory. Hence, this absolute method would be the preferred approach for a study at national or state level. It should be noted here that emissions under this methodology are indicated in terms CO_2 Equivalent (CO_2 Eq.).

The scoping basis approach is relatively simple 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 total emission levels.

For this study, "Absolute Approach" has been adopted to estimate GHG. This approach provides reasonable amount of flexibility for other states to calculate emissions from their sources without double counting. Secondly, it 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 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 2011-12 was chosen. Many of the government departments of Odisha were in the process of data consolidation post 2011-12 and vast amounts of key data required to estimate GHG emissions were not updated after 2011-12. 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 Odisha, all the 6 greenhouse gases have been accounted separately and emissions have been reported in metric Tons of each gas and metric Tons of CO_2 Eq.

Table 2 - 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 into a single metric of CO_2 Eq. These non-CO_2 gases are converted to CO_2 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 CO_2.

Table 3 - Global Warming Potential & Concentration levels of GHGs

Gas	Unit	Pre-1750 (Before industralisation)	2011	GWP[4]
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

4 India GHG Report 2007 - INCCA

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. Activity data collection 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:

Primary sources are Odisha State Designated Agency, Odisha Pollution Control Board, Department of agriculture, Centre of Environmental Studies, Odisha State PCCF, Forest & Environment Department etc.

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

To increase accuracy of data collected in GHG data, 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 were 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 4. Tier I is the simplest approach, while Tier III provides the most accurate emissions estimates.

Table 4 - 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 are used including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by disaggregated levels	-

5.7 APPROACH FOR CALCULATING STATE CARBON FOOTPRINT

While carrying out carbon footprint studies for entities, either 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 Odisha 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.

The process that was used for carrying out GHG inventorisation study for Odisha is described in the Figure 1:

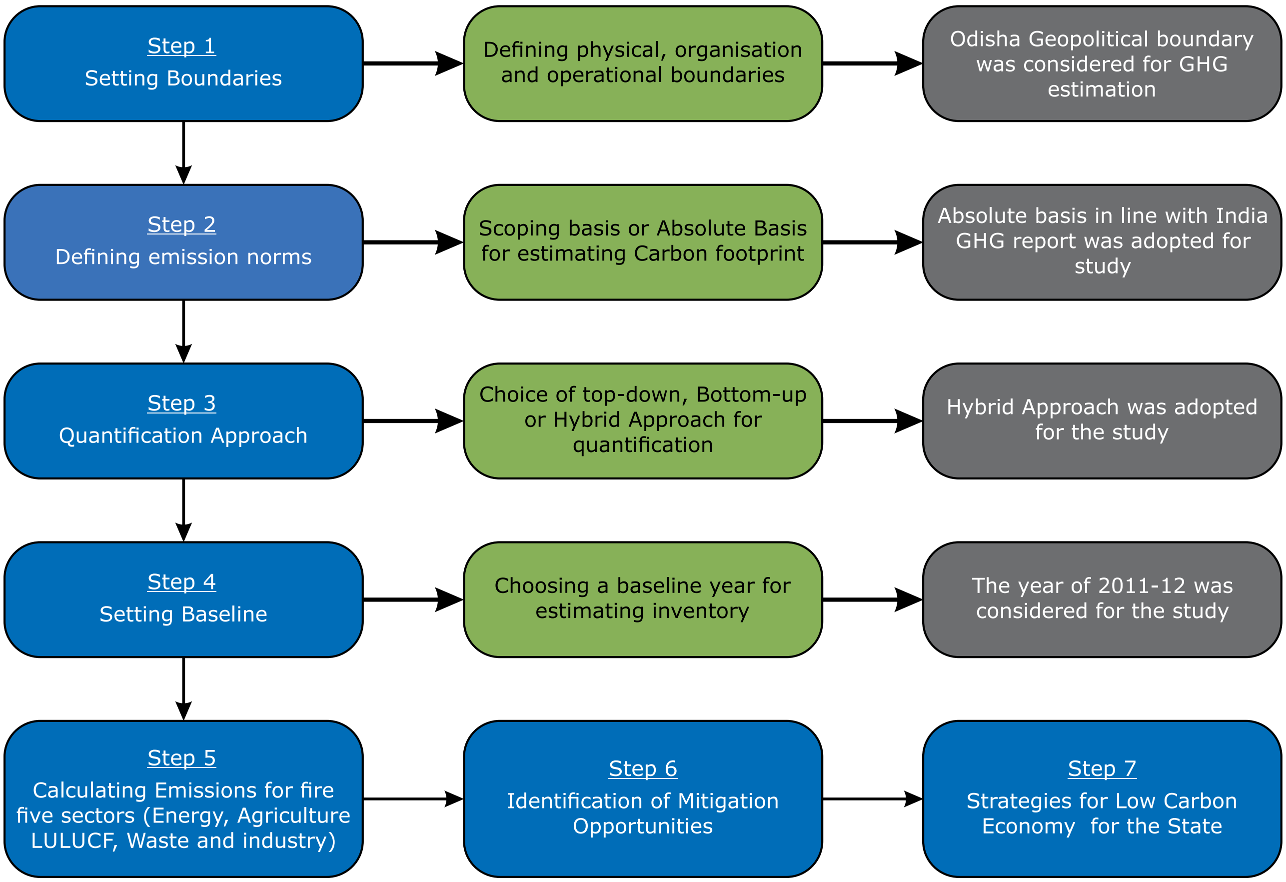

Figure 1 - Carbon footprint study process

6. ODISHA GHG EMISSIONS OVERVIEW

The GHG emission inventorisation study in Odisha 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 Odisha 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 5 - Summary of Emissions in Odisha, 2011-12

Emission Source	Total Emissions (MT)	Per Capita Emission	Share of Emissions, %
Energy	61,307,420	1.46	62%
Agriculture	25,067,054.5	0.6	25%
Waste	659,016	0.02	1%
Industry Sector	48,461,456	1.16	49%
Gross	**135,494,946**	**3.23**	
LULUCF	-36,969,070	-0.88	-38%
Total	**98,525,876**	**2.35**	
Population	41,940,000*		
* India census report			

Table 6 below illustrates the total emissions inventorised in this study for the state of Odisha. The contributions from each energy, agriculture, waste, industry and land use to the total emissions are described. The table also shows the significant contribution (%) of each of the sub-categories to the major sectors.

Table 6 - Emission Profile of Odisha, 2011-12

Emission Source	CO_2 Eq. (MT)	%
Energy	**61,307,420**	**62%**
a) Power Generation	50,770,105	83%
b) Transport	6,077,759	10%
c) Residential/Commercial	1,573,317	3%
d) Other Energy	907,641	1%
e) Fugitive Emissions	1,978,598	3%
Agriculture	**25,067,054.5**	**25%**
a) Enteric Fermentation	10,112,319	41%
b) Manure Management	543373	2%
c) Rice Cultivation	9,359,552	38%
d) Agricultural Soils	4,896,181	20%
e) Burning of crop residue	155,629	1%
Waste	**659,016**	**1%**
a) Municipal Solid Waste	170,375	26%
b) Domestic Waste Water	224,450	34%
c) Industrial Waste Water	264,191	40%

Emission Source	CO_2 Eq. (MT)	%
LULUCF	**-36,969,070**	**-38%**
a) Forest Land	-28,289,723	77%
b) Crop Land	-7,621,879	21%
c) Grass Land	520,533.481	-1%
d) Wet Land	-1,867,770.9	5%
e) Fuel wood usage	289,769.357	-1%
Industrial Sector	**48,461,456**	**49%**
a) Cement Industry	2,683,800	5.5%
b) Ceramic Industry	83,839	0.2%
c) Chemical Industry	93,954	0.2%
d) Iron & Steel Industry	11,759,561	24.3%
e) Aluminium Industry (Smelter & Refinery)	29,751,739	61.4%
f) Ferro Alloys Industry	1,792,365	3.7%
g) Pulp & Paper	989,232	2.0%
h) Other Energy Usage	1,306,967	2.7%
Total Emissions in baseline year 2011-12 (MT)	**98,525,876**	

Study on estimating carbon footprint for Odisha state calculated the emissions of carbon dioxide, methane, nitrous oxide and small amounts of tetraflouromethane, a fluorocarbon generated in Aluminium production. The sectors covered under this study are energy, agriculture, industry, waste, land use-land use change & forestry.

In 2011-12, the **Energy sector** was the largest source of emissions with over 61.3 million Tons of CO_2 Eq. Of these emissions, 83% were emitted from power generation, 10% were emitted from transport, 3% from residential/commercial, 1% from other energy and 3% from fugitive emissions.

Agriculture sector emitted 25 million Tons of CO_2 Eq. emissions. Rice cultivation and enteric fermentation emissions were the largest contributors, collectively amounting to about 77% of emissions from agriculture. Emissions (both direct and indirect) from agricultural soils accounted to another 20%. Emissions generated through manure management and crop residue burning formed a smaller 3% addition to the emissions from agriculture.

Emissions from **Waste sector** amounted to 0.7 million Tons of CO_2 Eq. The largest contributor to these emissions was waste generated by industries and accounted for 40% of the total waste emissions. Domestic waste water contributed another 34% while municipal solid waste's share was 26% of the total emissions from waste.

Land Use Land Use Change and Forestry (LULUCF); by estimation of carbon stock changes, CO_2 emissions and removals and Non-CO_2 GHG emission were estimated to be about 37 million Tons of CO_2 sequestrated. Total sequestration from Crop Land was estimated to be 7.6 million Tons of CO_2 & that from forest land was 28.28 million Tons of CO_2. Sequestration from wetlands was relatively small accounting to 1.87million Tons of CO_2. Emissions from fuel wood usage and grass land emissions were 2.9 and 0.52 million Tons of CO_2 respectively.

Emissions from the **Industry sector,** which included emissions generated from cement production, chemical industries, iron and steel industries, aluminium industries, ceramic industries, chemical industries, ferro-alloy industries, pulp and paper industries and other industry related energy consumption; amounted to 48.4 million Tons of CO_2 Eq. These emissions account for 49% of the total emissions generated in the state of Odisha.

The overall GHG emission overview for the state of Odisha during 2011-12 can be seen in figure 2 below:

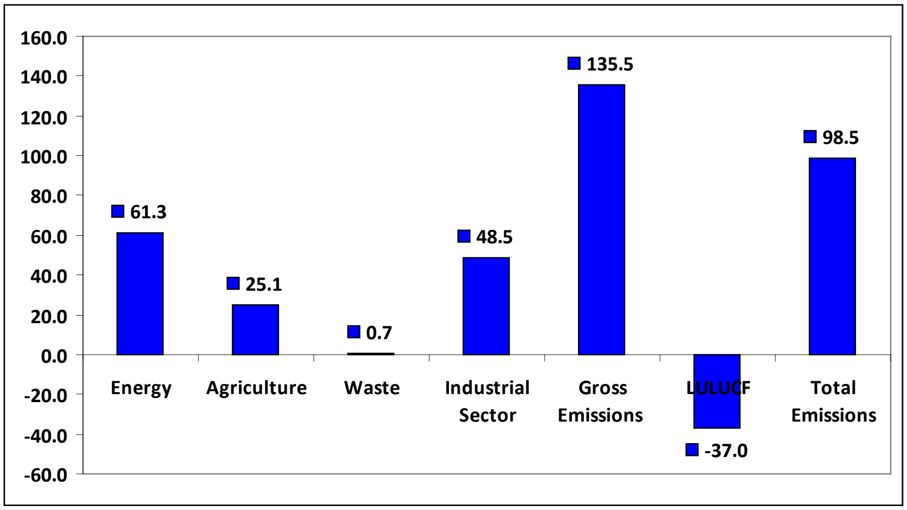

Figure 2 - GHG Emissions Overview

A schematic representation of the sectors, source categories and gases included in Table 7

Table 7 - Gases included under each sector

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	CH_4 & 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	CO_2
	Crop Land	CO_2
	Grass Land	CO_2
	Settlements	CO_2
Waste	Municipal Solid Waste	CH_4 & N_2O
	Waste Water	CH_4 & N_2O

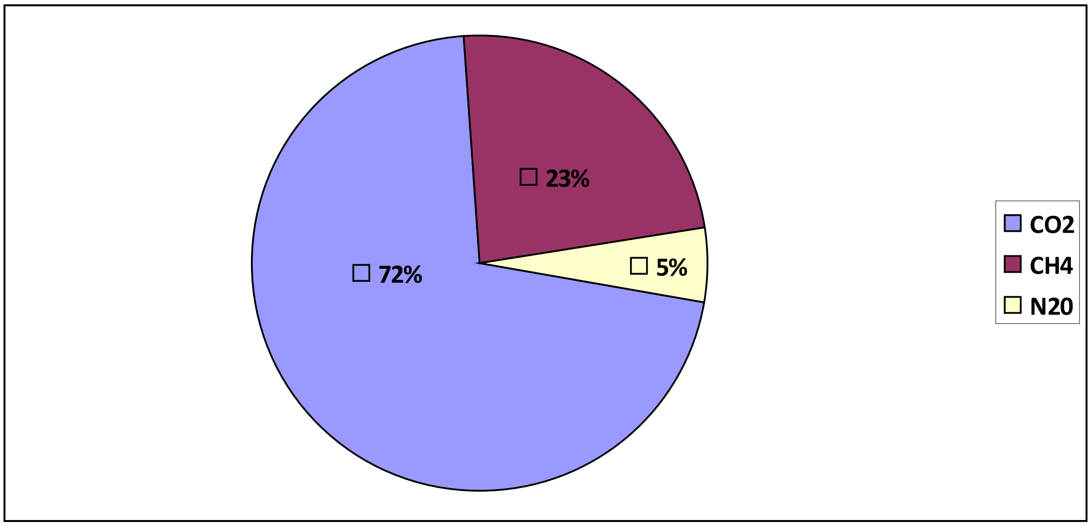

Figure 3 - % Contribution of CO_2, CH_4, N_2O to the total emissions

Figure 3 shows the contribution of the different Greenhouse Gases (CO_2, CH_4 and N_2O) to the total state emissions. Direct CO_2 emissions account for about 72% of the total emissions inventorised in this study. Methane emissions account for another 23% of the emissions while N_2O contribute about 5%. The break up of emission from each of the sectors is illustrated in Table 8.

Table 8 - Contribution of the different GHGs to the total state emissions

Emission Source	CO_2	CH_4	N_20	CO_2 Eq.
Energy	59046056	95080	854	61307420
Agriculture	0	957580.871	15993.085	25067055
Waste	0	29088.9668	155.31395	659016
LULUCF	-36969070	0	0	-36969070
Industry[5]	48109401	16485	34	48466221

5 CF4 & C2F6 emissions from aluminum (smelting & refineries) have been included in terms of CO_2 Eq. directly since they account for less than 1% of Odisha's overall CO_2 emissions. Emissions from aluminum industries have been directly sourced from sustainability reports which are in terms of CO_2 Eq.

The per capita emission for Odisha state in the year 2011-12 is estimated to be 2.34 tons of CO_2. The reported per capita emission for India in year 2007 was 1.518 tons of CO_2 (MOEF, 2009). CII was involved for a similar Carbon Footprinting study for the states of Tamil Nadu and Andhra Pradesh, the reported per capita emission for TN was 1.59 tons of CO_2 (2009,CII) and for AP it was 1.77 tons of CO_2 (2010,CII). For the purpose of comparative analyses, the per capita emissions for the nation and the other states have been extrapolated for the year 2011-12, as seen in Table 9.

Table 9 - comparative analyses of per capita emissions

GHG Emissions 2011-12				
	Emission (Million Tons CO_2)	GDP (INR Billion)	Per Capita Emissions	GDP Intensity (Million Tons/INR Billion)
India*	2308.91	52475.30	1.92	0.0440
Tamil Nadu*	135.28	3865.08	1.87	0.0350
Andhra Pradesh*	161.25	3628.08	1.90	0.0444
Odisha	98.30	1019.8	2.34	0.0964

* For India, Tamil Nadu and Andhra Pradesh the emission has been estimated.

* For States, Net Domestic Product has been refered

It can be clearly observed that the per capita emissions are significantly higher for Odisha. The higher emission can be attributed to power generation and nature of industrial sectors situated in the state. Some of the carbon emission intensive industries with a significant contribution to the Odisha state's industrial economy include power plants, aluminum, iron and steel, ferro-alloys and cement sector. These sectors utitlise high amount of fossil fuel and also have process emissions, which have contributed to higher per capita emission for the state.

7. ENERGY

7.1 ENERGY SECTOR IN ODISHA

Odisha is a major industrial state and is a favoured investment destination. Many factors play a vital role in this high standing achievement including a pro-industrial government, abundant natural resources, abundant availability of power, investment friendly policies and structure, etc.

Energy is the core foundation upon which the economy of Odisha depends and the state has been a front runner in introducing reforms in electricity sector. It was the very first state in the country to tier the structure of State Electricity Board into generation, transmission and distribution categories. The state was also first to form the State Electricity Regulatory Commission (SERC).

The energy requirements in the state are met by the state owned thermal power plants, hydro power plants, independent power producers, captive power plants and renewable energy resources. The state also has central stations which contribute to the state capacity. The total installed capacity of power plants owned by state sector is around 4780 MW and the breakup is shown in Figure 4:

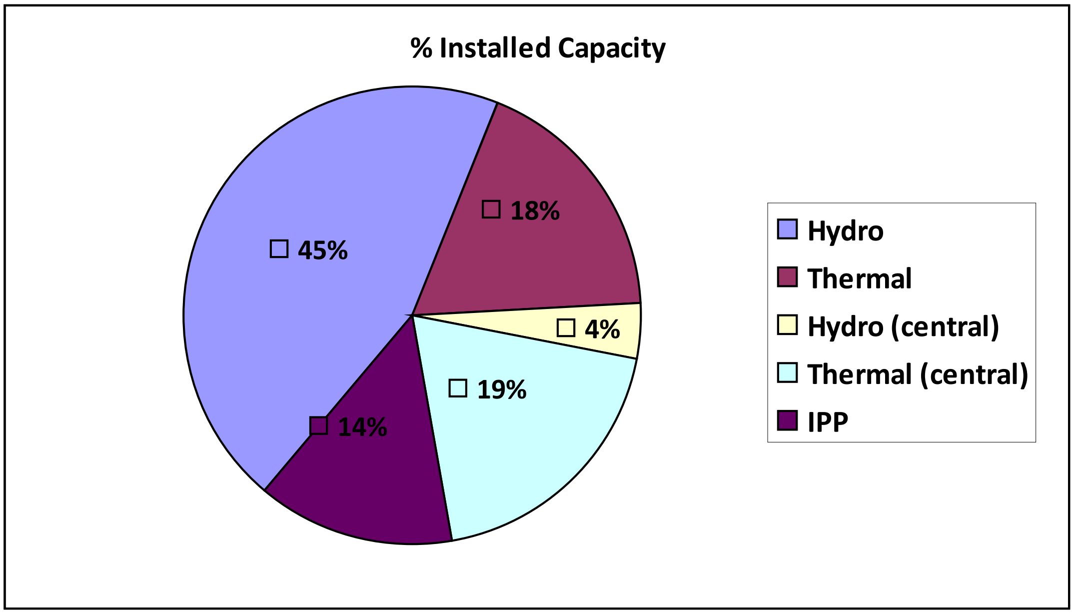

Figure 4 – Installed Capacity of Power Plants (%)

The majority of the power generation in the state is from hydro power with the installed capacity amounting to 2330 MW (State Hydro- 2142 MW and Central Hydro 189 MW). The state hydro power is managed by Odisha Hydro Power Company (OHPC) and it functions to acquire, establish, operate, maintain, renovate, modernize hydro-electric generating stations, thermal and nuclear electric generating stations and any other electric generating stations based on any non-conventional sources of energy in the state of Orissa.

Odisha state also boasts of a large contribution from captive power plants- 5360.5 MW[6]. These plants are usually grid connected and thus supply surplus power to state power companies.

Abundant supply of coal led to the establishment of a large number of thermal power plants. Power plants are established in proximity to the coal mines to reduce transportation costs. Most of this power is exported to other states and these states have certain share in the overall installed capacity. The overall installed capacity in Odisha including state, central, IPP and captive power plants is 10144 MW[7].

List of all power plants with their installed capacities can be found in Annexure 1.

The state's total distribution to around 40 lakh electrical consumers amounts to 2674 MW (2011-12). The power consumption in the state was 22423 million units. Although the state has a relatively higher installed capacity, it experiences cycles of power deficit and surplus. The per capita consumption of electricity (2009-10) in the state was 874.26 kWh/per annum (overall).[8]

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6 Odisha Power Sector at Glance – 2011, OERC & Individual published plant data

7 Economic Survey of Odisha 2012-13.

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 2011-12, the emissions from the energy sector in Odisha were estimated to amount to 61.3 million Tons of CO_2 Eq. The energy sector includes emissions from:

1. Power Generation (State owned, Center Owned, IPP and Captive Power Generation)
2. Transport Sector (Road, Rail and Air)
3. Residential/Commercial Sector (LPG & SKO)
4. Other Energy (Agriculture, Mobile Towers, Bitumen and others)
5. Fugitive Emissions (Coal Mining)

The power and electricity generation sector was the major source of GHG emissions. The emissions from the electricity sector were estimated to be 50.7 million Tons of CO_2 Eq.The transport sector was the second major source of emissions with emissions amounting to 6 million Tons of CO_2 Eq.Contribution of emissions generated from other energy source was 0.9 million Tons of CO_2 Eq.and that from fugitive emissions from coal mining resulted in 1.98 million Tons of CO_2 Eq. Residential/Commercial use of LPG & SKO contributed to 1.57million Tons of CO_2 Eq. emissions.The GHG emission distribution for energy sector is described in Figure 5:

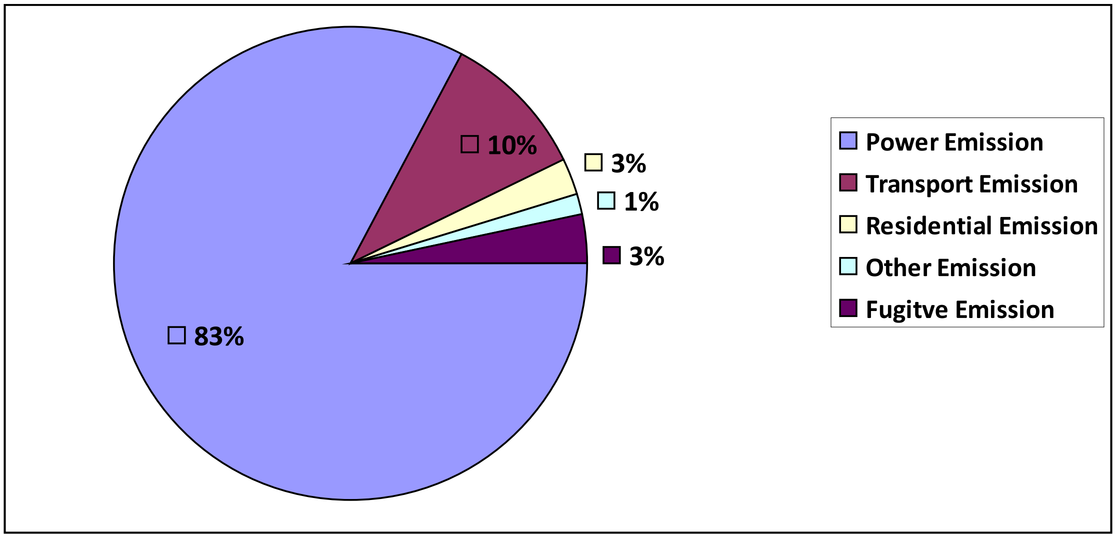

Figure 5 –GHG Emission distribution of Energy Sector

7.3 ELECTRICITY EMISSIONS

The power sector emissions were the major source of emission from energy sector contributing to 83% of overall energy emissions.

For estimating the GHG emissions, the power generating stations within the state geographical boundary are accounted. Presently, all the thermal power plants in the state are using coal as fuel for producing power. Table 10 shows the plants considered for calculating the power GHG emissions in the state.

Table 10 – Power Plants Considered for Calculating GHG Emissions

Sr. No	Thermal Power Plant	Capacity (MW)	Heat Rate (kCal/kWh)
1	IB Thermal Power Plant	420	2,423
2	Talcher (TTPS)	460	2,360
3	Talcher (STPS-I)	1,000	2,425
4	Talcher (STPS-II)	2,000	2,600
5	Arati Steel	50	3,220
6	Sterlite Energy	600	2,429
7	Captive Power (CGP)	5,360.5	As per capacity from CEA data base
8	Captive Power (Co gen)	1,221.5	

Coal based power plants have contributed the highest to the emissions from power sector. 28.9 million Tons of CO_2 Eq. is emitted from these plants, followed by captive power plants which contributed to 15.85 million Tons of CO_2 Eq. Emissions from captive plants in Aluminum manufacturing companies has not been included under this section. These emissions are considered under emission from industrial sector. Independent power producers contributed to 6 million Tons of CO_2 Eq.

Hydro power stations form about 45% of Odisha state's power mix. Power generation from hydro has no fossil fuel consumption, thus resulting in zero GHG emissions. The energy made available from hydro power in the year 2011 was 6194 MU. Thus hydro power resulted in avoided emissions from thermal power plants from producing 6194 MU which would result in 6.8 million Tons of CO_2 Eq.

A list of all power plants with their capacities has been included in Annexure 1.

Many of the power plants in Odisha including thermal and hydro export power to other states. The carbon Footprinting methodology, however, considers the state's geographical boundary for the estimation of emissions and the emissions from export of the power are also included in this inventory.

One of the major thermal power plants established in Odisha is the Talcher Super Thermal Power Plant. The power plant includes two units of 1000 MW (Unit-I) and 2000 MW (Unit-2), however the state share in the installed capacity is 31.8% and 10% only. These power plant accounts for almost 30% of the state installed capacity. Table 11 is an indication of the impact of Talcher power plant on the state GHG emissions.

Table 11 – Impact of Talcher Power Plant on the State GHG Emissions

Particulars	Value	Unit
Total Emission for Talcher Super TP unit 1 and 2	22.45	Million Tons CO_2
Odisha Share Emission (based on purchase by GRIDCO)	3.42	Million Tons CO_2
Difference in Emissions	19.03	Million Tons CO_2
Per Capita Excess Emissions	0.45	Tons/Per Capita
Actual Per Capita Emissions	2.34	Tons/Per Capita
Net Per Capita Emissions	1.89	Tons/Per Capita

The GHG emissions form Talcher power plant is estimated to be 22.45 million tons of CO_2 and based on state share capacity, the emissions are estimated to be 3.42 million tons of CO_2. The per capita GHG emissions for the state is estimated to be 2.34 tons of CO_2 and excess per capita emission due to export of power is 0.45 tons of CO_2. Thus, the net per capita emission was 1.89 tons CO_2 by adjusting the excess emissions from the actual per capita emission of the state as seen in Figure 6.

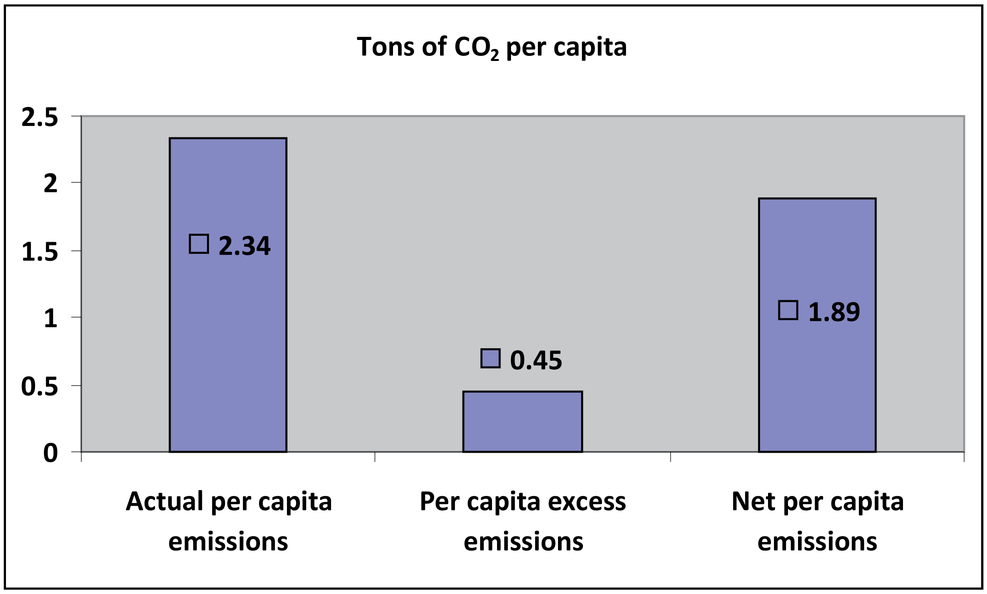

Figure 6 - Net per capita emission

7.4 TRANSPORT EMISSIONS

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 accounts for emissions from road, rail and aviation sectors.

The state has a total road length of 250,328 km (2011-12). The road networks of the state consist of national highways, state highways, major/district roads and village/rural roads. The total vehicle population on road has increased substantially between the years 2004 and 2012as seen in Figure 7 below:

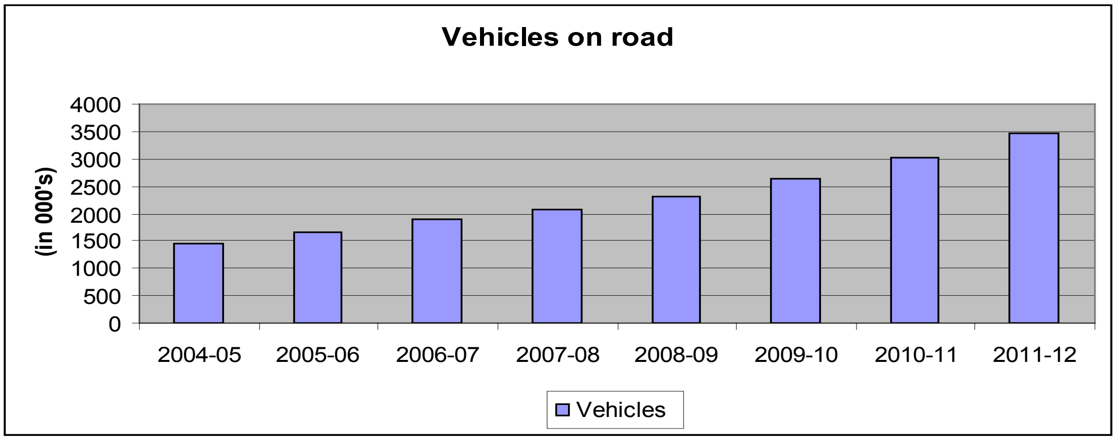

Figure 7 - Growth in vehicles

In 2011-12, the emissions from the transport sector were estimated to be 6 million Tons of CO_2 Eq. The road sector contributed almost 97% of transport emissions with 5.9 million Tons of CO_2 Eq., aviation contributed 0.1 million Tons of CO_2 Eq. and railways contributed 0.06 million Tons of CO_2 Eq., accounting for 2% and 1% of emission from transport respectively. For railways, only the emissions from diesel and coal consumption have been accounted since emissions from electricity usage gets accounted under power sector emissions.

7.5 RESIDENTIAL EMISSIONS

The major source of emissions from residential sector is LPG and kerosene oil usage. These fuels are majorly used for cooking and lighting purposes. These activities in the residential sector resulted in 1.57 million Tons of CO_2 Eq.

Table 12 – Emissions from residential sector

Energy Source	Quantity (MT)	Tons of CO_2 Eq.
Liquefied Petroleum Gas (LPG)	197,690	590,518
Super Kerosene Oil (SKO)	311,000	982,799

7.6 OTHER EMISSIONS

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 comprised of diesel consumption in tractors, agricultural pump sets and other agriculture usage. The total emissions for other usage of energy were estimated to be 0.9 million Tons of CO_2 Eq. The emissions from agriculture sector energy consumption was 0.35 million Tons of CO_2 Eq. Emissions from diesel usage in mobile towers was 0.065 million Tons of CO_2 Eq. and other diesel usages accounted for 0.48 million Tons of CO_2 Eq. Breakup of emissions from other energy usage is shown in Figure 8:

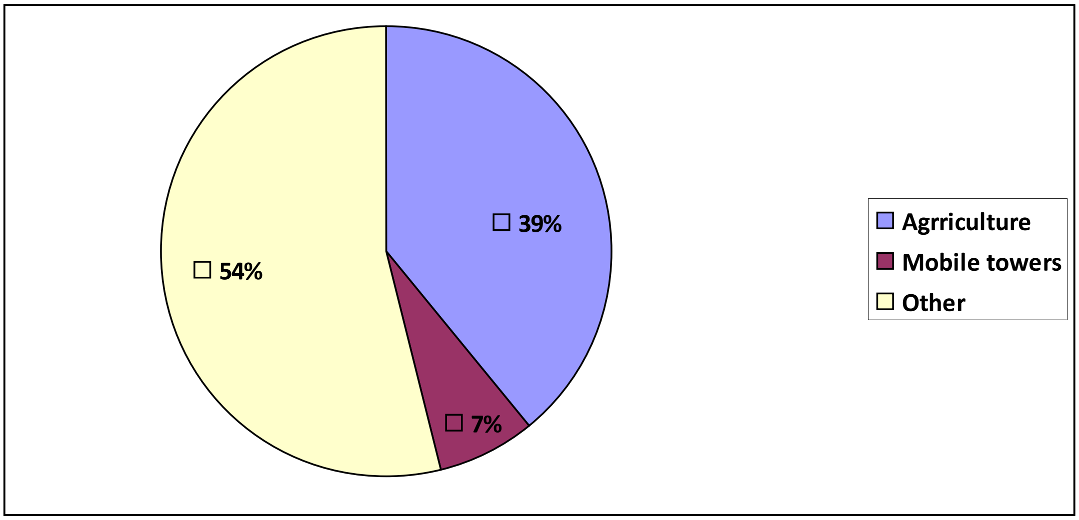

Figure 8 - Emissions from other energy sources

7.7 FUGITIVE EMISSIONS

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 2011-12, 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 CO_2 and CH_4. The geological processes of coal formation also produces methane (CH_4) and carbon dioxide (CO_2) 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. CH_4 is the major greenhouse gas emitted from coal mining and handling.

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

- Emission during mining: These emissions result from the liberation of stored gas during the breakage of coal, and the surrounding strata, during mining operations.
- 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 Odisha, the average of emission factors for low, medium and high degree mines has been taken. Production of coal by OCM and UG was 100,930,000 Tons and 2,190,000 Tons respectively in Odisha during 2011-12.[10] The emission factors used depend on the depth of these mines which was available with Odisha Pollution Control Board (PCB). The mining activity in the Odisha state resulted in 94,219 Tons of CH_4 emissions (1.97 million Tons of CO_2 Eq). The breakup of these emissions (million Tons of CO_2 Eq.) is shown in Figure 9:

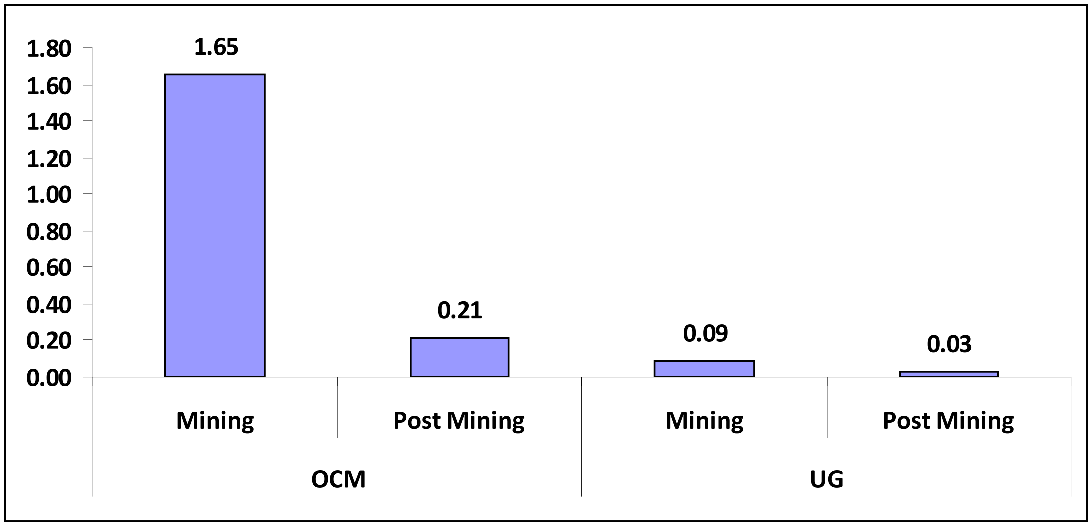

Figure 9 - Fugitive emissions breakup (million Tons CO_2 Eq.)

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

10 Mahanadi Coalfields Limited

7.8 GHG EMISSIONS SUMMARY - ENERGY SECTOR

Table 13 – Summary of emission – Energy Sector

Emission Source	CO_2 Eq. (MT)
Power Emissions	50,770,105
Transport Emission	6,077,759
Residential Emission	1,573,317
Other Emission	907,641
Fugitive Emission	1,978,598
Total	**61,307,420**

8. AGRICULTURE

Odisha is primarily an agrarian economy having nearly 21.11% contribution to the net state domestic product (NSDP) with 73% of the work force engaged in this sector. The cropped area is about 87.46 lakh hectares, out of which 18.79 lakh hectares are irrigated. Climate and soil play a vital role in Odisha's agriculture economy. The total cultivable land used for cropping is about 40% of the total geographical area and the utilization is comparatively more in the coastal districts of Odisha.

Odisha is one of the largest producers of rice in India. The state grows almost one tenth of the total rice production of the country. Favorable climate and presence of rich soils accounts for the flourishing agriculture of Orissa. The main crops cultivated in the state are: rice, jute, oil seeds, pulses, coconut, mesta, roselle, sugarcane, tea, turmeric, rubber, cotton, gram, mustard, maize, sesame, ragi, potato and soybean. With almost 60 % of land under rain fed agriculture and with water-dependent rice, as its main crop, the agriculture sector is particularly vulnerable to climate change.

Agricultural practices release significant amounts of methane (CH_4) and nitrous oxide (N_2O). 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. N_2O 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
  - Rainfed – 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 emitted 25 million Tons of CO_2 Eq. emissions.

Enteric fermentation emitted 40% of total CO_2 equivalent followed by rice cultivation, which emitted 37% of the total CO_2 equivalent emissions. Direct Emissions from soil resulted in 14% of the emissions, while indirect emissions from soil resulted in 6% of the CO_2 Eq. emissions. Remaining 3% were attributed to manure management and burning of crop residues.

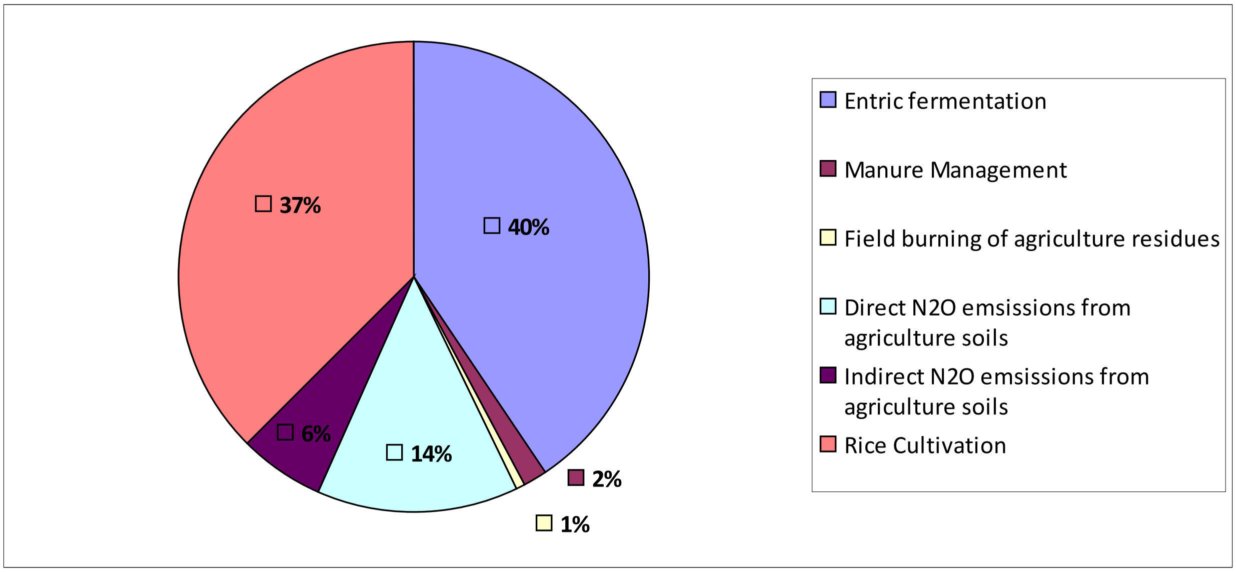

Figure 10 - GHG emission distribution of agriculture sector (% CO_2 Eq.)

8.2 AGRICULTURAL SOILS

Nitrous oxide emissions occur through direct and indirect ways. Direct pathway includes addition of organic nitrogen, inorganic nitrogen, manure deposition and nitrogen fixation by crops. Indirect pathways follow two methods: i) Volatilization of Ammonia (NH_3) and oxides of nitrogen (NO_x) from managed soils, manure depositions, fossil fuel combustion, and biomass burning and ii) Leaching of soil, manure depositions and runoffs. Direct N_20 emissions generated from agricultural soils were estimated to be 3.5 million Tons of CO_2 Eq. and the indirect emissions were estimated to be 1.4 million Tons of CO_2 Eq.

8.3 BURNING OF CROP RESIDUE

Usually, crops that are burnt in the field are rice, maize, cotton, millet, sugarcane and groundnut.

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

Emissions = ∑ crops (a x b x c x d x e x 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 used was 0.8 (Bhattacharya and Mitra, 1998). Fraction oxidized used was 0.9 (IPCC, 1997) and fraction burned was 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 0.15 million Tons of CO_2 Eq. was emitted due to burning, which comprised of 4474 Tons of CH_4 and 199 Tons of N_2O.

8.4 ENTERIC FERMENTATION

Odisha state is endowed with large rivers and dense forests that have been instrumental in the development of a strong agricultural and livestock base rich in biodiversity. Livestock reared include cattle, buffalo, sheep, goats, 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 were quantified. Livestock census is done every five years and the last census data available for use was published in 2007. The livestock population for 2011-12 was estimated using compounded annual growth rate from 2003 and 2007 as shown Table 14 (as per data published by Department of Animal Husbandry, Ministry of Agriculture, Government of India).

Table 14 - Livestock population estimates for 2011-12[11]

Sr. No.	Species	Livestock population in '000			
		2003	2007	CAGR	2011-12
1	Cattle	13,903,000	12,310,000	-2.3	11,181,620
a)	Dairy	3,621,000	2,709,000	-5.0	2,163,160
b)	Non-dairy	10,282,000	9,601,000	-1.3	9,092,283
2	Buffalo	1,394,000	1,190,000	-2.9	1,050,683
a)	Dairy	358,000	281,000	-4.3	232,649
b)	Non-dairy	1,036,000	909,000	-2.5	819,855
3	Sheep	1,620,000	1,818,000	2.4	1,995,760
4	Goat	5,803,000	7,127,000	4.6	8,427,865
5	Pigs	662,000	612,000	-1.5	575,021
6	Donkeys	9,000	410	-19.1	97
7	Horses & Ponies	380	200	-9.5	124

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 from both indigenous and cross breeds and non-dairy category comprises of calves below one year, adults beyond calving age, and those within one and two years of age.

11 Department of Animal Husbandry, GoI

In 2011-12, enteric emissions accounted for a release of 481,539 Tons of CH_4 (10.1 million Tons of CO_2) Cattle and buffalo populations were estimated to be 7.8 million Tons and 1.2 million Tons of CO_2 respectively. Of these, non-dairy cattle were the single largest contributor with enteric emissions amounting to 5.2 million Tons of CO_2. The enteric methane emissions from other species were relatively smaller when compared to the bovines

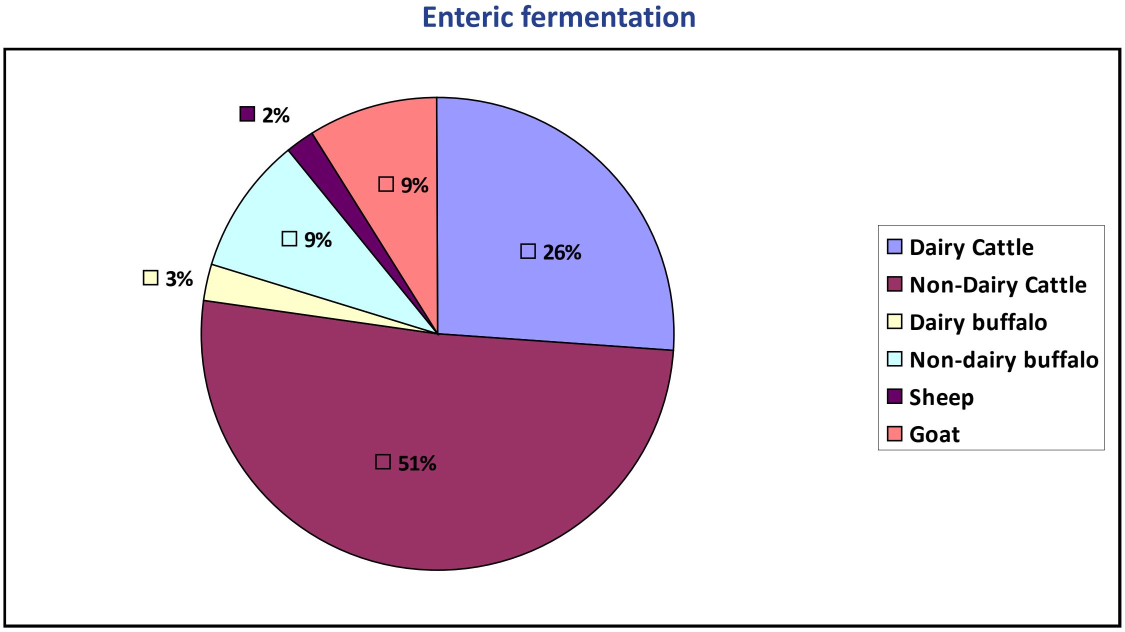

Figure 11 - Emissions from enteric fermentation

8.5 MANURE MANAGEMENT

The decomposition of manure under anaerobic conditions, during storage and treatment, produces CH_4. The main factors affecting CH_4 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 on how the manure is managed. When manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits), it decomposes anaerobically and can produce a significant quantity of CH_4. The temperature and the retention time of the storage unit also affect the amount of methane produced. When manure is handled as a solid (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 CH_4 is generated.

In this study, it was assumed that 70% of the manure produced is managed and about 30% 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. Dairy includes all lactating breeds from both indigenous and cross breeds and non-dairy category comprises of calves below one year, adults beyond calving age, and those within one and two years of age.

Methane emissions from manure management practices was estimated to be 0.54 million Tons of CO_2 Eq. emission. Similar to enteric emissions, non-dairy cattle were the single largest contributor to emissions from manure management with emissions of 0.27 million Tons. Methane emissions from other species like buffalo and poultry were relatively smaller when compared to cattle.

8.6 RICE CULTIVATION

Methane is generated in anaerobic conditions and is naturally produced and emitted from wetlands and other natural situations. Rice paddies 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 (about 75%) and is also the main kharif crop in Odisha. Rice fields thus produce signification amount of emissions.

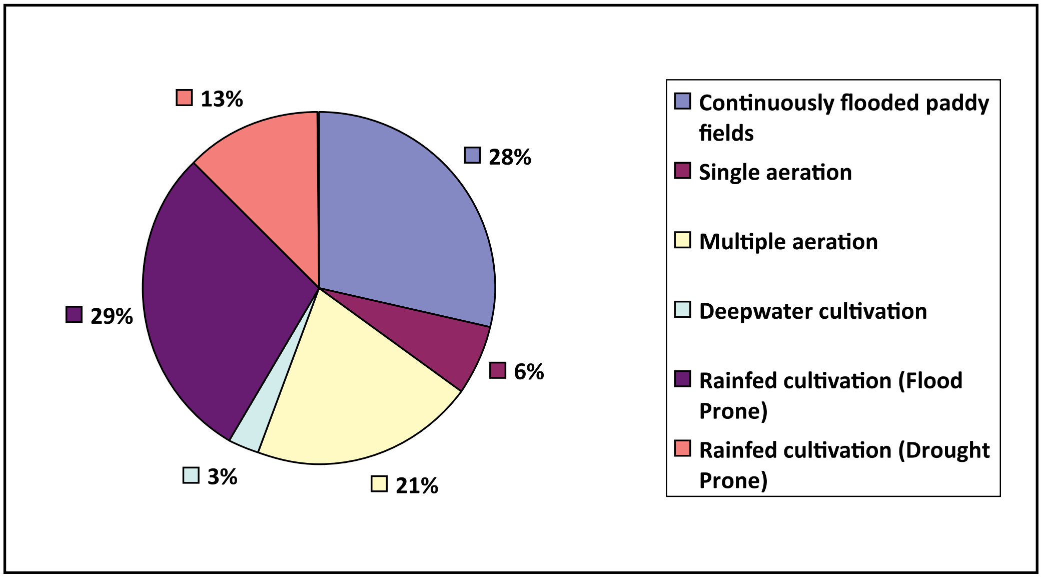

Figure 12 – Rice cultivation area (hectares)

CH_4 Emissions from paddy field were estimated to be 0.45 million Tons (9.36 million Tons of CO_2 eq.). The single largest contributor were the rain fed cultivation (flood prone) fields accounting to 29% of emissions, closely followed by the continuously flooded paddy fields that contribute 28% to the emissions and multiple aeration regions generating 21% of the total emissions.

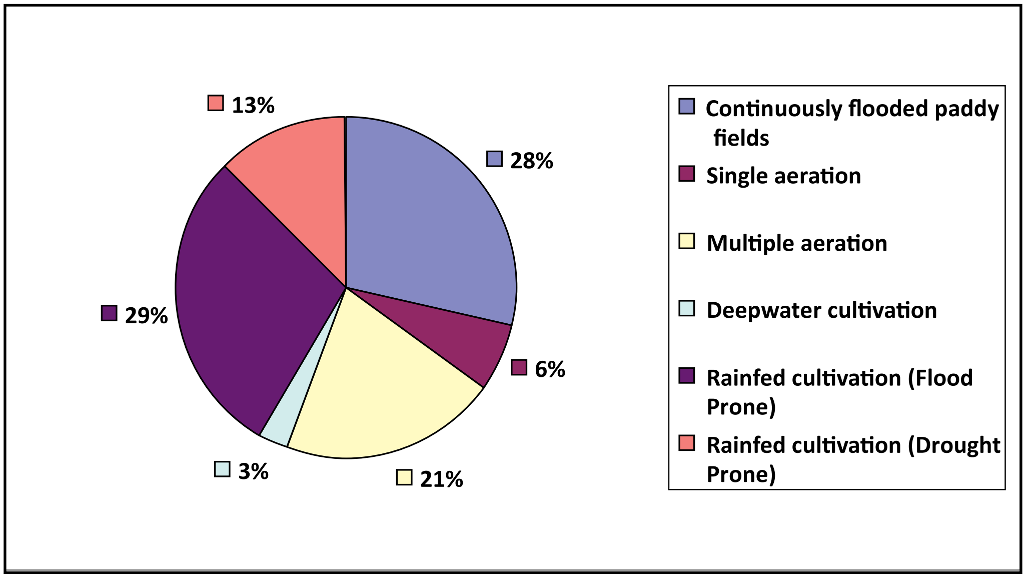

Figure 13 - Emissions from rice cultivation

8.7 GHG EMISSIONS SUMMARY - AGRICULTURE SECTOR

Table 15 – GHG emission summary - Agriculture Sector

Emission Source	CO_2 Eq. (MT)
Enteric fermentation	10,112,319
Manure Management	543,373
Field burning of agriculture residue	155,630
Direct N_2O emissions from agricultural soil	3,479,731
Indirect N_2O emissions from agricultural soil	1,416,449
Rice cultivation	9,359,552
Total	**2,506,7055**

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
- Settlements
- 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)
- CO_2 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

Dominant GHG emissions in the LULUCF sector are mainly attributed to CO_2 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. Annual stock change in the LULUCF category is given by

ΔCLU = ΔCAB + ΔCBB+ ΔCDW + ΔCSC

Where,

ΔCLU is the stock change in land use

ΔCAB = changes above ground biomass

ΔCBB = changes below ground biomass

ΔCDW = changes as a result of dead wood

ΔCSC = changes result from soil carbon

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 Odisha "Stock Change" method has been used to derive the carbon removal and emission figures, so as to be inline with the India GHG Emissions 2007(INCCA report).

Carbon stock-change or stock-difference method:

ΔC = (Ct2 – Ct1)/ (t2-t1)

Where:

ΔC is the carbon stock change

Ct1 – carbon stock at time t1

Ct2 – carbon stock at time t2

9.3 INVENTORY ESTIMATION

Inventorizing the emissions requires careful study of land area and the approach methodology as well. A broad classification of land area is given in Table 16. The approach used to quantify LULUCF emissions in Odisha is as per IPCC's Tier II approach.

Table 16 - 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, specially in the case of forest. For non-forest land categories estimation is carried out for land remaining in the same categories. Table 17 illustrates land use pattern in Odisha state.

Table 17 - Land Use matrix[12] (Area in Sq. km)

Land-use	Sub-category	2009	2011	Change in area
Forest	Protected forest	15,522	15,525	3
	Reserved forest	26,330	26,329	-1
	Unclassified forest	16,284	16,282	-2
Grassland	Grazing land	494	494	0
	Wasteland	375	-	
Cropland	Net area sown	5,604	5,292	-312
	Fallow	805	888	83

9. 5 ODISHA FOREST AT A GLANCE

The recorded forest area of Odisha is 58,136 Sq. km. The reserved forests constitute around 45%, protected forests 27% and unclassified forests constitute around 28%.

Forest biodiversity in Odisha is classified into four major groups: tropical semi evergreen, tropical moist deciduous, littoral & swamp and tropical dry deciduous forests. These major categories are further subdivided into nine categories as illustrated in the Figure 16. Table 18 shows the change in area of different types of forest in Odisha between 2009 and 2011 (FSI 2011 & 2013).

12 Department of Economics & Statistics & State forest report 2009 & 2011

Table 18 - Forest Cover Change Matrix of Odisha (Sq.km)

Categories	2009[13]	2011[14]	Net
Very dense forest	7,060	7,042	-18
Moderately dense forest	21,366	21,298	-68
Open forest	20,477	22,007	1530
Scrub	4,734	4424	-310
Non forest	102,070	100,936	-1,134
Total	**155,707**	**155,707**	**0**

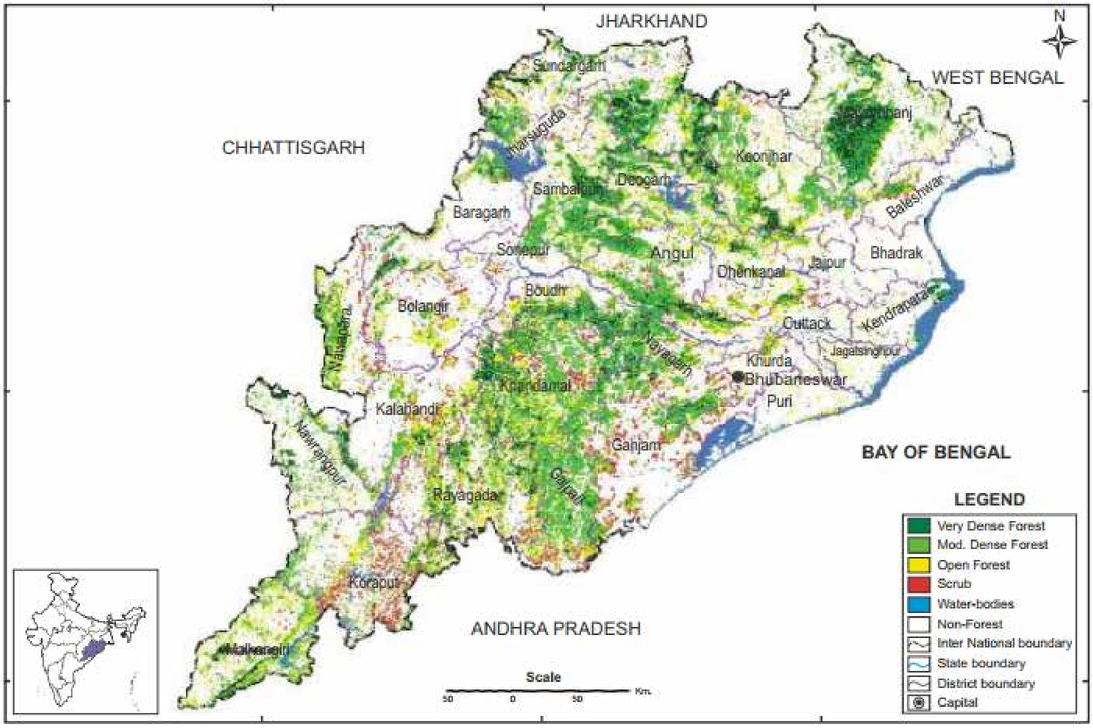

Figure 14 - Forest map of Odisha[15]

Carbon Stock change of Forest Biomass

The equation used to quantify carbon (C) emission and removal is:

C stock = Growing stock * Specific gravity * Dry weight of the wood * Carbon fraction

Where;

Specific gravity = Oven dry weight/Green Volume

In order to estimate the carbon sequestered in biomass during 2011-12, a comparison study was carried out between the growing stocks of forest in 2009 and 2011 (FSI report, 2011 and 2013). (See Table 19 for changes in growing stock between 2009 and 2011).

13 State of Forest Report (Odisha) 2011
14 State of Forest Report (Odisha) 2013
15 State of Forest Report (Odisha) 2013

Table 19 - Growing stock of biomass in 2009 and 2011 in million cubic metres[16]

Categories	2009	2011
Volume of growing stock in forest	285.9	304.57[17]
Volume of growing stock in Trees Outside Forest (TOF)	73.6	74.49

Carbon Stock Change of Afforestation & Reforestation

The methodology used to calculate emissions and sequestration based on change in carbon stock from Afforestation & Reforestation activity, which is in line with IPCC Good Practice Guidance for LULUCF:

Annual increase in carbon stocks due to biomass increment in forest land remaining forest land ($\Delta C_{FF\ G}$)

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

$\Delta C_{FF\ G} = \sum ij\ (Aij \bullet GTOTALij) \bullet CF$

Where:

$\Delta C_{FF}G$ = 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}

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

$G_{TOTAL\ ij}$ = 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 (G_{TOTAL})

G_{TOTAL} is the expansion of annual increment rate of above ground biomass (G_w) 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 G_w data are available as in the case of naturally regenerated forests or broad category of plantation. In case G_w data is not available, the increment in volume (I_v) can be used with biomass expansion factor for conversion of annual net increment to above ground biomass increment.

Average annual increment in biomass

$G_{TOTAL} = G_W \bullet (1 + R)$ In case aboveground biomass increment (dry matter) data are used directly

$G_W = I_V \bullet D \bullet BEF_1$ In case net volume increment data are used to estimate G_W

16 State of Forest Report (Odisha) 20011 & 2013

17 This includes growing stock in agro forestry & urban area – as per FSI report 2013

Where:

G_{TOTAL} = average annual biomass increment above and below ground, Tons d.m. ha^{-1} yr^{-1}

G_W = average annual aboveground biomass increment, Tons s d.m. ha^{-1} yr^{-1}

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

I_V =average annual net increment in volume suitable for industrial processing, m3 ha^{-1} yr^{-1}

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

BEF_1 = biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless

Change in afforested area over the past few years[18]:

Table 20 - Change in afforestation

Year	Area Afforested (Hectares)
2001-02	29471
2002-03	17467
2003-04	36212
2004-05	29075
2005-06	22924
2006-07	28740
2007-08	62614
2008-09	98738
2009-10	92584
2010-11	233445
2011-12	182187
2012-13	107287
2013-14	117667
Total	**1058411**

The trend shows a continuous rise in afforestation activity over the past few years in the state of Odisha. In the past 10 years there has been over 200% of increase in afforestaton leading to increased sequestration.

Based on the methodology, it was estimated 28.3 million Tons of CO_2 Eq. was sequestered during 2011-12. Sequestration from living biomass in forest land contributed the highest of 21.5 million Tons of CO_2 followed by 5.6 million Tons of CO_2 of sequestration due to afforestation activities[19]. 1.1 million Tons of CO_2 sequestration was due to reforestation/afforestation activity carried out during base year.

18 Principal Chief Conservator of Forests

19 Sequestration due to afforestation carried out only during the base year 2011-12 have been considered

9. 6 FUEL WOOD

The emissions from fuel wood cutting have been estimated based on change in carbon stock (Table 21). Data for fuel wood production has been collected from the Economic Survey of Odisha 2012-13. This data does not include fuel wood cutting in unorganised sector.

Table 21 - Emissions from fuel wood cutting

Fuel Wood	Production (P) MT	Net Change in Carbon Stock in MT P X 0.8 X 0.4	Net CO_2 Emission in Tons of CO_2 (2011-12)
Fuel Wood	24,305	7,777.6	28,518
Timber	22,657.5	7,250.4	26,585
Bamboo	200,000	64,000	234,667
Total	**289,769**		

It was estimated that around 2.89 million Tons of CO_2 was released as a result of fuel wood usage during 2011-12.

9. 7 EMISSIONS AND REMOVAL FROM NON-FOREST CATEGORIES

The three non-forest categories included in this study are cropland, grassland and wetland. The net emissions/ removals from non-forest land categories: grasslands and croplands have 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 as outlined in Table 22.

Table 22 - GHG emission and removals from non-forest land categories: Grassland & Cropland

Land use	Annual Average Sequestration (Tons of CO_2/ha/Year)	Area in 2011-12 (million ha)	Net CO_2 Emissions and removals]
Grassland			
Grazing land	0.198	494,000	97,812
Scrubland	0.198	461,957	91,467
Land put to Non-agricultural uses	0.198	1,298,000	257,004
Culturable waste	0.198	375,000	74,250
Total Grassland	**0.198**	**2,628,957**	**520,533**
Cropland			
Net sown area	1.13	5,292,000	-5,974,668
Current fallow	1.13	888,000	-1,002,552
Other fallow	1.13	229,000	-258,541
Other Miscellaneous	1.13	342,000	-386,118
Total Cropland	**1.13**	**6,751,000**	**-7,621,879**

Table 23 - GHG emission and removals from non-forest land categories: Wetlands

Type of Wetland	Carbon Stock in Tons (2011-12)	Carbon Stock in Tons (2009-10)	Net Change in Carbon Stock in Tons	Net CO_2 Sequestration in Tons of CO_2 (2011-12)
Littrol & Swamp Forest	171,732	166,807	4,925	-9,030
Mangroves[20]	-	-	506,929	-1,858,741
Total				**-1867771**

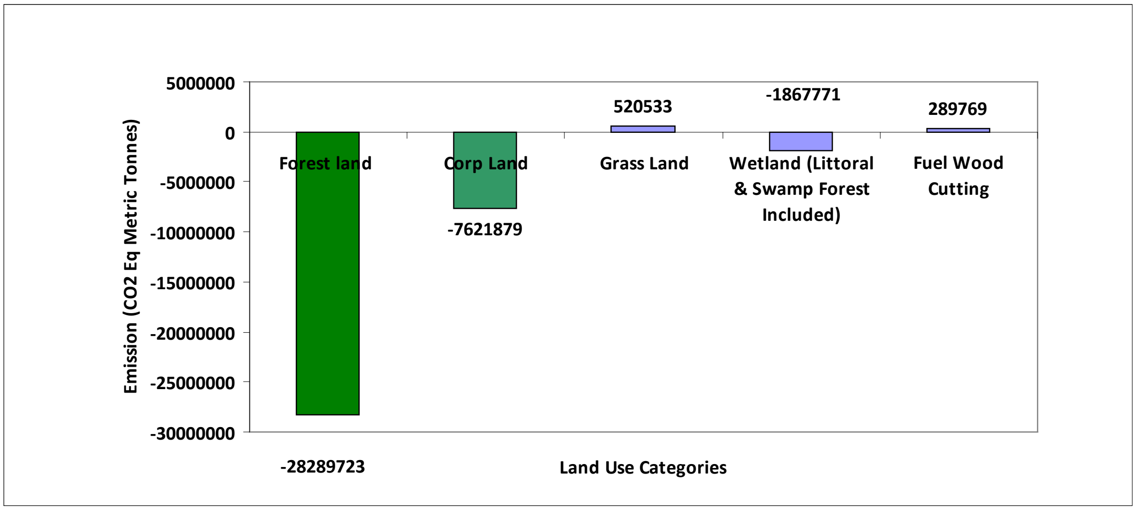

Figure 15 – Emissions & Removal from LULUCF

Net GHG emissions and removals are shown in the table 24. Removal from forest land during base year was about 28.3 million Tons of CO_2, while emissions from non-forest land emits around 0.52 million Tons of CO_2 specifically from removal of grasslands and 0.29 million Tons of CO_2 from fuel wood cutting. From cropland, 7.6 million Tons of CO_2 and wetlands 1.87 million Tons of CO_2 was sequestered during 2011-12.

The net sink constituted 37.7 million Tons of CO_2 Eq. while net emissions were 0.8 million Tons of CO2 Eq. On the whole around 36.9 million Tons of CO_2 Eq. emissions were sequestered during 2011-12 from land use, land use change & forestry.

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

Table 24 - GHG Emissions Summary – Land Use, Land Use Change & Forestry

Emission Source	CO_2 emissions/removals (MT) [-removals and + sequestration]
Forest land	-28,289,723
Corp Land	-7,621,879
Grass Land	520,533
Wetland	-1,867,771
Fuel Wood Cutting	289,769
Total	**-36,969,070**

20 FSI report 2013

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

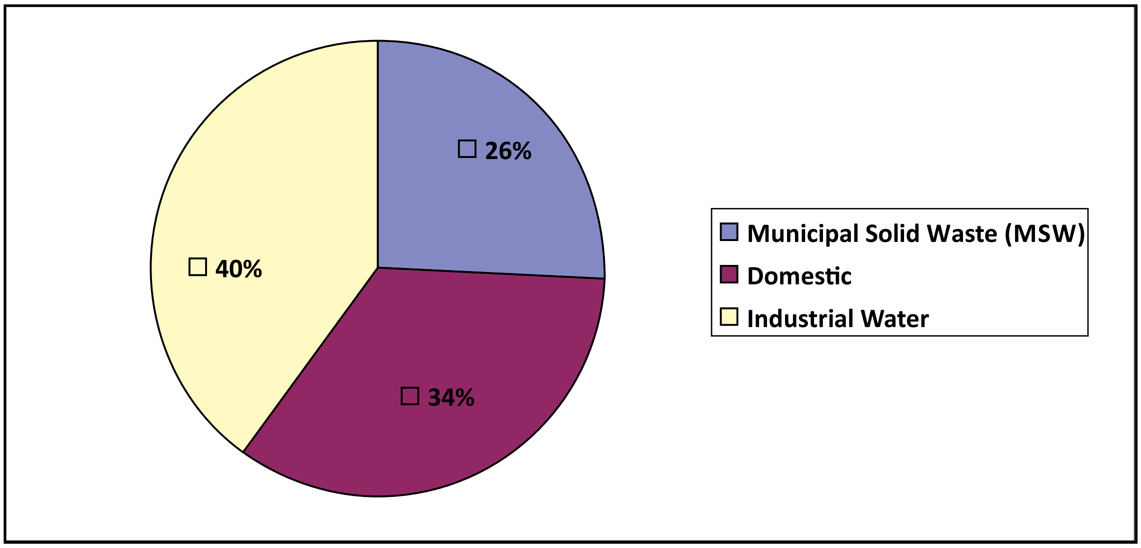

Figure 16 - GHG Emission distribution by waste sector (% CO_2 Eq.)

10.1 MUNICIPAL SOLID WASTE

In Odisha, 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 = $(\sum CH_4 \text{ generated} - RT) * (1 - OXT)$

R_T = Methane recovered in year T, Tons

OX_T = Oxidation factor in year T (fraction)

CH_4 generated from the landfill depends on the amount and composition of waste and waste management practices as well.

CH_4 generated in year T is represented as

$CH_4 = DDOC_m \text{ decompo}_T * F * 16/12$

Where,

F = Fraction of CH_4 by volume

16/2 = Molecular weight ration, CH_4/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

$DDOC_m = W*DOC*DOC_f* MCF$

W = Mass of waste deposited, tones

DOC = Degradable organic carbon in he deposition year

DOC_f = 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[21]. According to discussions with the CPCB almost 100% of the MSW collected is discarded in landfills by means of open dumping and only a fraction of the waste goes for treatment. The value for degradable organic carbon fraction used was 0.11 (NEERI, 2005). Values used for methane correction factor was 0.4, fraction of degradable organic carbon that decomposes (DOC_f) was 0.5, fraction of methane in the landfill was 0.5 and rate constant was 0.17/year as specified in the IPCC guidelines (IPCC, 2002). Treated waste accounts for only 33 TPD (composting, vermicomposting, biogas plant, RDF etc), which is assumed to have insignificant or nil emissions.

Applying this methodology the methane emissions from municipal solid waste were estimated to be 8113 Tons (i.e. 170,375.3 Tons of CO_2 Eq.)

10.2 WASTE WATER TREATMENT AND DISPOSAL

Wastewater arises from a number of domestic, commercial and industrial sources. The generated effluent may be treated on site or directed in sewers to a centralized treatment plant or discharged into a water body without any treatment. Hence, the method of wastewater handling has a crucial role to play in emission quantification. Generally, CH_4 is emitted when water is treated or disposed anaerobically.

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 CH_4 emissions estimate have 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)[22].

The INCCA report estimated CH_4 emissions of India using Tier II approach, which uses country specific emission factors and country specific data. Emission estimates have 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.

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21 INCCA report 2007

22 Emission factor used = Total CH4 emissions/total urban population

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

Td = {Σ (Ui x Tij x 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 CH_4 / 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 CH_4 recovered in inventory year, kg CH_4/yr

Using this methodology for urban population, the methane emissions were estimated to be around 8395.3 Tons.

N_2O emissions:

N_2O emissions occur irrespective of the handling method due to the presence of protein in wastewater. The simplified equation to determine N_2O from wastewater is:

$N_2O_{Emissions} = N_{Effluents} * EF_{Effluents} *44/28$

Where,

$N_2O_{Emissions}$ – $N_2O_{Emissions}$ in inventory year, Tons N_2O/year

$N_{Effluent}$ – Nitrogen in the effluent, Tons N/year

$EF_{Effluent}$ – Emission factor for N_2O emissions from wastewater, Tons N_2O-N/Tons N

44/28 - Conversion factor for Tons N_2O-N into Tons N_2O

$N_{Effluent}$ is calculated using the following formula:

$N_{Effluent} = P * Pr * F_{NPR} * F_{NON\text{-}CON} * F_{IND\text{-}COM} * N_{Sludge}$

Where,

P – Human population

Pr – Annual per capita protein consumption, ton/per/yr

F_{NPR} - Fraction of nitrogen in the protein (Default = 0.00016 ton N/ ton of protein)

$F_{NON\text{-}CON}$ - Factor denoting non-consumed protein addition to the wastewater (Default – 1.4[23])

$F_{IND\text{-}COM}$ - Factor representing the addition of industrial and commercial discharged protein into the sewer system (Default – 1.25[24])

N_{Sludge} – Nitrogen detached along with the sludge (Default = 0), Tons N/yr

23 IPCC

24 IPCC

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 N_2O emissions were estimated to amount to 155.3 Tons and that of methane to be 8395 Tons.

The overall emissions from domestic waste water were estimated to be 0.2 million Tons of CO_2 Eq.

10.2.2 INDUSTRIAL WASTE WATER

Odisha has a substantial share of India's industrial production and the high concentration of industries generate considerable amount of wastewater leading to very high emission levels. To quantify the emissions from industrial wastewater sources, major industries viz., sugar, paper and pulp, distilleries, fish processing, beverages and dairy were taken into consideration.

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

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

Where,

Ti - CH_4 emission during the quantification year, Tons CH_4/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[25])

EFi – Emission factor for industry i, Tons CH_4/COD for treatment/discharge pathway

Ri – Methane recovered in the inventory year, Tons CH_4/yr

In order to estimate emissions from industrial waste water, Tier I approach was used. The emission factors for each of industries have been taken from INCCA and IPCC reports.

Few industries which recover and reuse their waste water have also been taken into consideration during estimations. The sectors for which reuse percentage is considered are as follows :

Distillery – 75%

Dairy – 75

Sugar – 70%

In 2011-12 emission due to industrial waste water was estimated to amount to 0.26 million Tons of CO_2 Eq.

10.3 GHG EMISSION SUMMARY - WASTE SECTOR

The total GHG emitted from waste sector in 2011-12 in Odisha was 0.7 million Tons of CO_2 Eq. Industrial waste water has been the dominant source of CH_4 emission in Odisha and amounts to 40% of the total CO_2 Eq. from waste. Domestic wastewater and municipal solid waste constituted 34% & 26% of the emissions respectively.

Table 25 - GHG Emission Summary - Waste Sector

Emission Source	CO_2 Eq. (MT)
Municipal Solid Waste	170,375
Domestic Waste Water	224,450
Industrial Waste Water	264,191
Total	**659,016**

25 IPCC

11. INDUSTRIES

Odisha's industrial sector contributes about 26 percent share to its GSDP. It has a number of energy intensive industries, almost all of which are designated consumers. Industrial sectors included in this study are aluminum, cement, chlor alkali, fertilizer, iron and steel, pulp & paper, railways, textile and thermal power stations.

Of these aluminum contributes 27% of Odisha's total emissions (61.4% of emission from industrial sector) followed by iron & steel and cement with 24.3% and 5.5% of total CO_2 Eq. emissions from the industrial sector. The remaining CO_2 Eq. emissions are from the ferro alloy industry with 3.7%, pulp & paper industry with 2%, chemical industry & ceramic with 0.2% each and others (pet coke & bitumen) contributing to about 2.7% of the emissions(Figure 17).

Most 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 I has been used only in the case of ferro chrome, where emission factor from IPCC has been used for estimation.

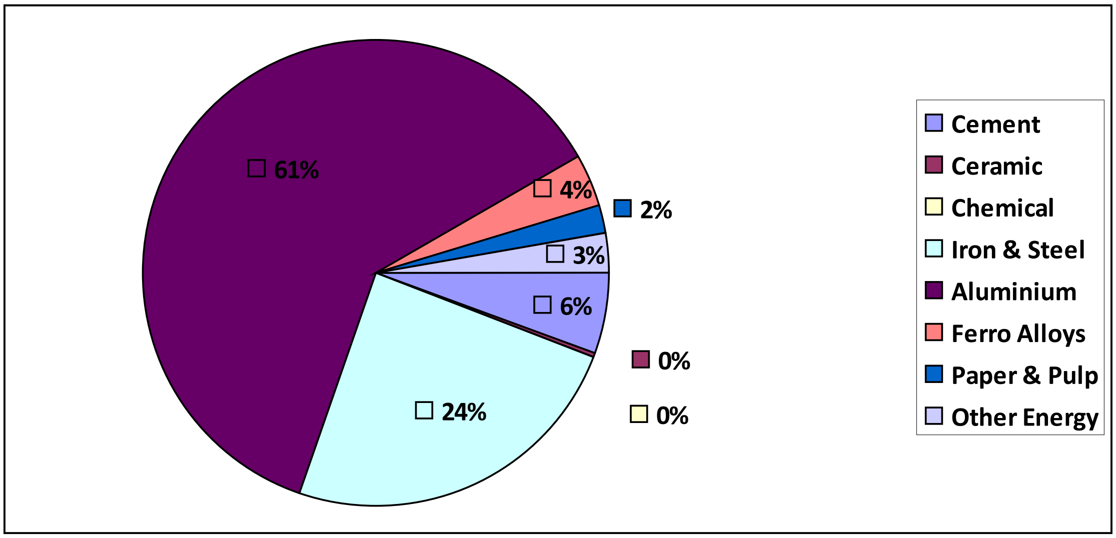

Figure 17 - GHG emission distribution by industrial sector (% CO_2 Eq.)

Aluminium and Iron & Steel industry together contribute to 85% of Odisha's total CO_2 Eq. emissions.

Aluminum production in India is concentrated in four large plants, three of which are in Odisha (NALCO, Vedanta and Hindalco). With a contribution of 48% to nation's total production, Odisha is the premier state in the country for aluminum, both in terms of production capacity and actual output. The total emissions estimated from the aluminium industry (including refinery and smelter) are 29.7 million Tons of CO_2 Eq. emissions during the year 2011-12 which forms 30% of Odisha's overall GHG emissions. This includes both process & fuel emissions directly sourced from sustainability reports of the three producers.

Greenhouse gas emissions in the production of primary aluminum comes from processes such as coke calcination, anode production and consumption, lime production, and electrical generation. Process carbon dioxide emissions make up about half of total direct carbon dioxide equivalent emissions from aluminum production with the remaining greenhouse gases (GHG) emitted being per fluorinated carbon (PFC) gases namely CF_4 and C_2F_6. Commercial aluminum production has been identified as the largest emitter of these two compounds. Although the amount of PFC emissions is not great, the impact is magnified because of the high global warming potentials (GWPs)[26] of these two gases over their lifetime.

26 GWP of CF46500 & GWP of C2F6 9200

Steel is the core industry in the state. Odisha has about 10% of steel production capacity in the country, with 25% of total iron ore reserves and a production capacity of 7.79 MTPA of steel and 6.24 MTPA of sponge iron. The total emissions estimated from the iron & steel industry is 11.7 million Tons of CO_2 Eq. emissions during the year 2011-12. The process emissions of iron & steel have been sourced from the Low Carbon Strategy Road Map (Planning Commission).

Exports are likely to trickle to negligible level as exporters have been hit hard by steep export duty of 30 per cent and also high transport cost. Besides, exports of the ore are no longer remunerative owing to price correction in the global market. Judging by this the resulting emissions from processing of iron ore in the state is poised to increase over the coming years.

11.1 GHG EMISSIONS SUMMARY - INDUSTRIAL SECTOR

Table 26 - GHG Emissions Summary - Industrial Sector

Emission Source	CO_2 Eq. (MT)
Cement Industry	2,683,800
Ceramic Industry	83,839
Chemical Industry	93,954
Iron & Steel Industry	11,759,561
Aluminium Industry (Smelter & Refinery)	29,751,739
Ferro Alloys Industry	1,792,365
Pulp & Paper	989,232
Other	1,306,967
Total	**98,525,876**

12. LOW CARBON GROWTH IN ODISHA STATE

The overall approach for emission reduction strategy of Odisha should be to pursue an aggressive emissions reduction target. In line with the national commitment of reducing emissions intensity by 20-25% of 2005 levels by 2020, this study explored all possible options to help the state of Odisha achieve similar emissions intensity reduction. Based on the mitigation options identified, an **emissions intensity reduction of 20-25% by 2020 for the Odisha state looks feasible.**

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 uncomplicated.

With over 75% of emissions in Odisha arising out of energy and power related sources, it is imperative for the state to adopt an overall renewable energy strategy to reduce carbon intensity of power generation and lower its overall emission footprint. With per capita energy consumption in the state bound to rise with increasing urbanization and better standards of life and industrial growth; it is essential for the state to embark on a low carbon power supply to achieve its overall reduction targets. Odisha's commitment in this direction can be explicit if the state can adopt an implementation plan for the voluntary **Renewable Power Obligation (RPO)** significantly exceeding any mandatory values that the central government may impose. Implementing such a voluntary ambitious yet achievable RPO will project the state's commitment 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 contribution is one of the key criteria for effective implementation of the state's low carbon strategies. For a transition economy like India, and a progressive yet attractive investment destination such as the state of Odisha, 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 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. Increasing urbanization, greater demand of land for industrial, agricultural and residential purposes is resulting in rapid deforestation land use change issues. Carbon sinks in various states are gradually depleting and increasing the overall environmental concerns – water, soil and climate. States pursuing low carbon growth should lay due focus on LULUCF not only from the standpoint of carbon mitigation, but also to address other serious 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 assumes paramount importance.

In the baseline year of this study, 2011-12, energy related emissions were estimated to be approximately 78 million Tons of CO2 equivalents, over 55% of overall Odisha's emissions. To address such a large share of the emissions profile, 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 2020.

Renewable energy (RE), internationally and in India as well, promises to be an excellent alternative to address the serious issue of meeting increased energy demand, yet lowering the emission intensity. Odisha has been a pioneer in promoting renewable energy utilization in the country over the last couple of decades. The current installed capacity in RE amounts to 90MW and an additional 2330 MW in hydro power. This accounts for almost 45% of Odisha's power mix. While several forms of RE such as hydro, bio mass, solar forms have been adopted in the state, wind power stands out as the single largest potential RE source. Odisha, being a coastal state, has strategic wind flow patterns, making the state a preferred wind power installation site, not only for developers in Odisha, but across the country as well. The state offers further potential for renewable energy supply.

India, as committed in NAPCC, aims to derive 15% of its energy requirements from renewable energy sources by the year 2020. **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 buy a certain percentage of their power from renewable sources of energy. To achieve its overall low carbon growth and emission intensity reduction targets, it is imperative for distribution companies, open access consumers and captive power consumers also to play their role in meeting renewable energy targets. 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 Odisha Electricity Regulatory Commission has implemented Renewable Purchase Obligations in the state to promote the generation and use of renewable energy. Odisha has also released a notification indicating the %RPO for the obligated entities as seen in Table 27

Table 27 - %RPO for the obligated entities

RPO	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Solar	-	-	0.1	0.15	0.2	0.25	0.3
Non Solar	0.8	1	1.2	1.4	1.6	1.8	2
Co Generation	3.45	3.5	3.7	3.95	4.2	4.45	4.7
Total	**4.25**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**

Based on the above table, the RPO obligation is expected to increase to 7% by the year 2015-16. One of the obligated entities under RPO are captive power generators. The current capacity of captive power plant in the state is 5320 MW and estimated power generation for these units in the year 2011-12 was 33964 million kWh. Thus, the number of RECs to be traded/purchased in the market should be 1.69 million RECs (at 5% RPO in year 2011-12). The estimation of REC to be purchased by captive power plant is indicated in Table 28. For each year it is assumed that the power generation will increase by 5%. The RPO/REC implementation will result in avoided emissions, as power plant generation from coal (carbon intensive) will be substituted by purchase of instruments in form RECs.

Table 28 - REC to be purchased by captive power plant

	Captive Power Plant (Generation MWh)	RPO (MWh)	RECs (Million)	Avoided Emission Million Tones)
2011-12	33964706.934	1698235.347	1.698	1.393
2012-13	35662942.281	1961461.825	1.961	1.608
2013-14	37446089.395	2246765.364	2.247	1.842
2014-15	39318393.864	2555695.601	2.556	2.096
2015-16	41284313.558	2889901.949	2.890	2.370
Total			**11.352**	**9.309**

The REC implementation by OERC indicates an yearly increase of 0.5% of total RPO. However, it is recommended that the increase in RPO % for the year 2014-15 should be 10% and 12 % in 2015-16. The RPO increase is supported by the fact that the cost and technical of cleaner technologies such as wind, solar, bio gas and cogeneration has improved and will continue to improve over time. The increase in the RPO will result in avoidance of 8.30 million tons of CO_2 for the year 2014-15 and 2015-16 as seen in Table 29.

Table 29 – Emissions avoided due to increased RPO

	Captive Power Plant (Generation MWh)	RPO (MWh)	RECs (Million)	Avoided Emission (Million Tones)
2014-15	39318393.86	3931839.386	3.931	3.22
2015-16	41284313.56	4954117.627	4.954	4.06

While the state's overall target is to increase RE based power sources, fossil fuel based power would still continue to be a major source of power supply. While the newer power plants will adopt the latest technology and achieve good energy efficiency levels by design, it is essential to continuously improve existing power stations and thereby, reduce their emission intensity. Power, being a highly sensitive state supply commodity, and with subsidies & cross-subsidies offered for various strategic reasons, pricing remains a major area of concern.

Power Plant Efficiency assessments provide an opportunity to evaluate the efficiency of existing power plants. Odisha, being a power surplus state, also emits about 85% of its emissions in the energy sector from power generation. Typical average efficiency of power plants is 31.5% while the national average stands at 41%. This provides huge scope for assessment and evaluation of the improvement of efficiency of existing power plants within the state. There is a critical need to continuously improve energy efficiency and conservation activities within power plants. This would also provide an opportunity to address the relatively high losses associated with transmission and distribution (approx. 38%).

The state's Electricity Board receives a substantial share of funds from the state fiscal budget to sustain its operations and hence, would not be in a position to explore significant improvement opportunities in existing power stations. It is therefore proposed to create a **'Power Plant Refurbishment Fund'** to create a fund source for the electricity board to gradually refurbish & modernize its power stations. The power plant refurbishment fund can be formed from the revenue generated from sale of electricity. This fund can be utilized to improve the performance of its least efficient plants annually. Over the next 6 years (until 2020), this fund would help improve most of its older power stations and significantly reduce the overall emission intensity from them.

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)[27]. Motor vehicle penetration in the country is still one among the least in the world.

Odisha has a large and extensive road and rail network. Its transport related emissions in the base year 2011-12 was estimated to be 6 million Tones of CO_2 equivalent. With a fast growing automobile market and growing disposable incomes and increased need for transportation, India is bound to witness significant increase in transportation related activities in the years ahead. To attenuate the increasing emission levels, key strategies are required 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[28], 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 Odisha as well. It is proposed to charge a fuel cess

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

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

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.

To give public transportation systems a major thrust, a **green tax** is proposed on the purchase of new private vehicles. This would create a sense of awareness and responsibility amongst individual vehicle owners to utilize mass transportation as well as provide financial support for state governments to establish good public transportation systems for its citizens to utilize. It is proposed to charge green tax on new vehicles at the rate of 1% of the vehicle cost. This green tax can be channeled to develop public transportation system and inter-city transportation across the state.

12.3 INDUSTRY

Odisha has been in the vanguard of industrialization and a preferred investment destination. One of the major contributors to the industrial growth has been the state's enabling industrial policy. 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 year is estimated to be about 48 million Tons of CO_2 equivalents during 2011-12.

Steel is the core industry in the state, contributing to about 25% of total emissions from the iron & steel industry during the year 2011-12. With the state introducing export duty of 30 per cent and discouraging export of unprocessed iron ore; exports are likely to trickle to negligible level. Besides, exports of the ore are no longer remunerative owing to price correction in the global market. Judging by this the resulting emissions from processing of iron ore in the state is poised to increase over the coming years.

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[29]. Several mandatory energy efficiency improvement measures have also resulted in significant capacity building and awareness among the industry fraternity. Under the NAPCC, National Mission on Enhanced Energy Efficiency (NMEEE) has embarked on a new initiative, first of its kind in the world, 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 that could be traded. More than 25 of the designated energy consumers are based out of Odisha. 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 are to meet their PAT targets, anticipated energy reduction is 300 million kWh in a two year period.

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 Odisha could consider to promote non fossil fuel based energy such as 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 partially the energy requirements of cement industries and addressing the waste management issues of the state.

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 (technology, finance, skills and supporting management resources) and access to markets.

29 Energy costs in India being among the highest in the world.

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: a) reduced pollution intensity and increased resource efficiency of target SME industry clusters; b) reduced exposure of employees and communities to risks from industrial clusters and improved employee and community well-being; and c) enhanced public-private partnering 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.

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 as 70% of the floor space in India in 2030 is yet to be built. Building sector has 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 Odisha 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 government such as West Bengal (Kolkata) are providing incentive for promotion of Green Buildings.

Commercial Buildings	Residential buildings	Government buildings
Regulatory Measures > Compulsory Green buildings for spaces greater than 20,000 square feet > 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 feet > 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 photovoltiacs 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 to green specifications

12.5 AGRICULTURE

Agriculture is one of the predominant sectors for the economy of Odisha. Agriculture is, a sector of enormous value, but it emits mammoth quantities of GHG into the atmosphere. 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 Odisha 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.** 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. This can result in emissions reductions of 67.9 million Tons CO_2 eq. Financial savings from the projects can be funneled into research project 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. On the crop management front, polices focusing on crop insurance can be provided to farmers who cultivate crops in 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. Government can provide financial incentives and crop insurance to encourage farmers to adopt this cultivation practice.

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. Odisha however, has seen a continuous rise in afforestation activity over the past 10 years. With a 200% increase in afforestated land since 2003-04; afforestation activity in the base year alone accounted to 1.1 million Tons of CO2 of sequestration. Thus, 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. Indeed, this community involvement will improve not only the economics status of people involved but also provide ecosystem services and environmental benefits for generations to come. Here, the Odisha 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: This 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

CO_2 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 factors 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: Emissions 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 CO_2 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 10^6 Tons

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

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

Sequestration: The process of storing carbon in a carbon pool

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

Source: Any process or activity which releases a greenhouse gas

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

AGB – Above Ground Biomass

AFLOU – Agriculture Forest and Other Land Use Category

BGB – Below Ground Biomass

BGJY - Biju Gram Jyoti Yojana

BSVY - Biju Saharanchala Vidyutikiran Yojana

C - Carbon

CAGR – Compound Annual Growth Rate

CDM – Clean Development Mechanism

CFL - Compact Fluorescent Lamp

CH_4 - Methane

CO_2 – Carbon dioxide Equivalent

CO_2 Eq. – Carbon dioxide Equivalent

DOM – Dead Organic Matter

ECBC – Energy Conservation Building Codes

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

IPCC – Intergovernmental Panel on Climate Change

INCCA - Indian Network for Climate Change Assessment

Km – Kilometer

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

N_20 – Nitrous Oxide

NAPCC – National Action Plan on Climate Change

NH_3 – Ammonia

OHPC - Odisha Hydro Power Company

PAT – Perform, Achieve and Trade

PCRA - Petroleum Conservation Research Association

PFC – Per Fluro Carbon

PLCC – Power Line Carrier Communication

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

USD – Unites States Dollar

VCs – Verified Carbon Standard

VHF – Very High Frequency

Annexure 1

Coal Based Thermal Power Plants	Installed Capacity (MW)
IB Thermal Power Station	420
Talcher Thermal Power Plant (TTPS)	460
Talcher Super Thermal Power Plants (STPS-I)	1000
Talcher Super Thermal Power Plants (STPS-II)	2000
Independent Power Producers	**Installed Capacity (MW)**
Arati Steels Ltd.	50
Sterlite Energy Ltd.	1800
Captive Power Generation	**Installed Capacity (MW)**
Arati Steels, Ltd. Cuttack	40
Action ISPAT & Power, Jharsuguda	37
Aryam ISPAT & Power, Sambalpur	18
Bhushan Power & Steel, Jharsuguda	376
Bhushan Steel. Dhenkanal	410
Dinabandhu (Yadani), Duburi	10
FACOR Power Ltd, Bhadrak	45
Hindalco Industries Ltd, Hirakud	367
ICCL, Chooudwar	138
IFFCO Ltd, Paradeep	110
Jain Steels & Power, Jharsuguda	8
Jindal Stainless Ltd, Duburi	250
JSPL, Meramunduli, Dhenkanal	270
Maheshwari ISPAT, Khuntuni, Cuttack	24
Maithan Ispar, Duburi	30
MSP Metallic Ltd, Jharsiguda	24
NALCO, Angul	1200
Narbheram Power & Steel, Dhenkanal	8
NBVL, Duburi	95
NVNL, Duburi	62.5
OSISL, Polashponga	36
Patnaik Steel & Alloys, Polashponga	15

Captive Power Generation	Installed Capacity (MW)
Rathi Steek & Power, Sambalpur	2
RSP, Rourkella	220
SMC, Power Generation	33
Shree Ganesh Metallic Ltd, Jharsuguda	32
Shree Mahavir Ferro Alloys Pvt. Ltd.Sundargarh	12
Shyam Metallic, Rengali, Sambalpur	30
Tata Sponge Iron, Ltd. Joda	26
Vedanta Aluminium, Jharsuguda	1215
Vedanta Aluminium, Langigarh	90
VISA Steel, Ltd, Jhakapur, Jajpur	75
Paradeep Phosphate	32
ACC Bargarh	20
Hydro Power Generation	**Installed Capacity (MW)**
Burla Hydro Power Plant	275.5
Chipilima Hydro Power Plant	72
Balimela Hydro Power Plant	51
Rengali Hydro Power Plant	25
Upper Kolab Hydro Power Plant	32
Upperindrbati Hydro Power Plant	600
Machakund	114.75
Chukha HEP	270
Tala HEP	1020
Teesta- V HEP	510
New & Renewable Energy Sources	**Installed Capacity (MW)**
SHEP, Bio Mass & Solar	90