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Sector-wise GHG Inventorization for Union Territory of Puducherry with Special Reference to Agriculture – Phase I

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Abstract: *The anthropogenic emission of greenhouse gases (GHGs), that is, carbon dioxide (CO_2), methane (CH_4),* and *nitrous oxide (N_2O), is bringing about major changes to the global environment. Whereas most of the emissions come from combustion of fossil fuels* and *industrial processes, agriculture accounts for 10%–12% of the total anthropogenic emission of GHGs. The emissions under Puducherry region mainly from enteric fermentation, manure management* and *agricultural soils in agriculture sector. Total emission (tCH_4/year) through enteric fermentation, manure management* and *rice cultivation are 4,036.00; 354.00* and *1,900.00 respectively. Whereas carbon dioxide equivalent (CO_2e) emission (Million Tonnes of CO_2e/year) computed through enteric fermentation, manure management* and *rice cultivation are 0.0848; 0.0075* and *0.0399 respectively. The adoption of improved management practices* and *mitigation technologies could help in reducing emissions. The study concludes that the GHG emissions in the agriculture sector remain significant* and *their proper assessment is required for climate change adaptation* and *mitigation policies.*

Keywords: *GHG Inventorization, Agriculture, Live stock, Union Territory of Puducherry, Manure Management.*

1. INTRODUCTION

In the recent period, the anthropogenic increase in atmospheric GHGs has become a cause of serious concern due to their impact on the earth' s radiation budget and related global environmental change issues [1, 2, 3]. Human influence on the climatic system is currently very clear, and the recent anthropogenic emissions of green house gases (GHG's) are highest in history [4]. Anthropogenic emission of green house gases is identified as the major sources of GHGs accumulating in the atmosphere and resulting in global warming [5, 6]. Hence, the understanding and the quantification of the non-CO_2 GHGs emissions is also important because of the fact that, the abatement strategy is less expensive and more effective in mitigating climate change [7, 8].

Climate variability manifested through alteration in frequency, intensity, spatial extent, duration of weather and climate extremes, including climate and hydro-meteorological events such as heat waves, heavy precipitation events, drought and tropical cyclones (*eg.* Thane, 2011) followed by natural disasters like Tsunami (2004) is posing greater risks to human life by endangering the sustainability of the natural systems and the economy in the Union Territory of Puducherry (UTP).

Hence, sector wise, phased out GHG inventory is necessitated to quantify the CO_2 equivalent emissions. For this purpose, the methodology is developed for Phase I, focusing on the emission calculation and mitigation plan for agricultural sector of the UTP.

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Globally, the decade of 1990's which saw the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) and the publication of the update on Climate Change 1992 by the Inter Governmental Panel on Climate Change (IPCC) are taken as the beginning for the preparation of the dedicated assessments on climate change. More over, India's environment policy is anchored in the Constitution of India, Article 48-A of the Constitution which states that, "the State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country". India's first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate related mitigation and adaptation measures along with identification of eight core missions—running through 2017 (NAPCC, 2008) provides, a sharper focus with multiple strategies, implemented through eight National Missions, outlining priorities for mitigation and adaptation to combat climate change, supplemented by actions of the State Governments, Non-governmental Organizations (NGOs), initiatives of the private sector and other stakeholders. Most of the States and Union Territories have put in place, the State Action Plan on Climate Change (SAPCC) attempting to mainstream climate change concerns in their planning process.

2. CLIMATE CHANGE ACTION PLAN FOR THE UNION TERRITORY OF PUDUCHERRY

The National Action Plan on Climate Change (NAPCC, 2008) calls for the launch of missions on Agriculture, Water, Solar, Energy, Forestry, Sustainable Habitat, Himalayan Ecosystems and Strategic Knowledge on Climate Change[9]. In line with the Govt. of India decision, the Union Territory of Puducherry has formulated the state level action plan on climate change. The Climate Change Action Plan 2009 [10] was developed in line with the '*National Action Plan on Climate Change (2008)*' with six fold missions and disaster management (Figure 1). The mission on agriculture, and Green India mission has been combined into a single one. The CCAP aims to develop climate resilient policies, knowledge management mechanisms for informed decision making and to undertake effective monitoring and evaluation for identifying entry points for climate proof actions and also for identifying the existing lacunae.

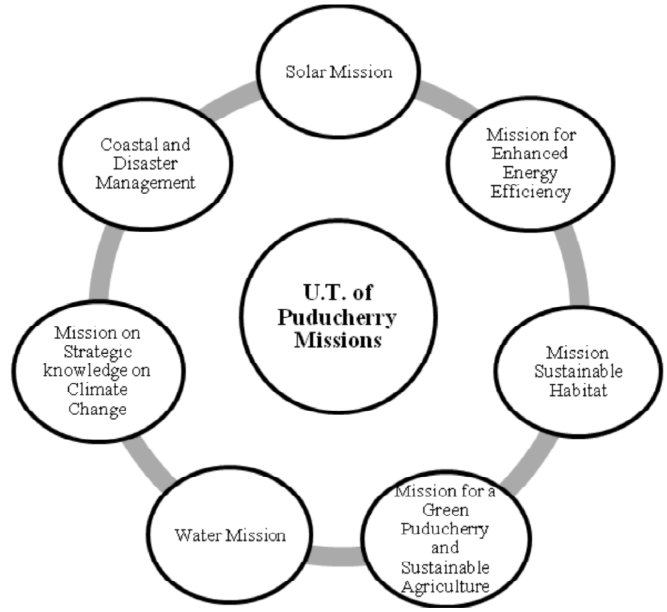

Figure 1: Missions conceived under CCAP for Union Territory of Puducherry

The present paper has made an attempt to examine GHG inventorization for agricultural sector covering enteric fermentation, manure management and rice cultivation.

3. METHODOLOGY

The Adaptation Policy Frameworks for Climate Change [11] and the National Programs of Action Plan, provide a guideline for developing country like India to identify priority activities that respond to their urgent and immediate needs with regard to adaptation to climate change [12, 13]. One such activity which is being adopted widely is the sector-wise GHG emission [14, 15]. For the purpose of computing GHG emission for the agriculture sector, the approach outlined in IPCC Guidelines 2006 [16] and India's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) published in 2012 by Ministry of Environment and Forests (MoEF), Govt. of India (GoI) was adopted.

Most developing countries have reports no more than two annual emission inventories over the past two decades[17]. This inventory is used as a starting point to phase out agriculture sector and to

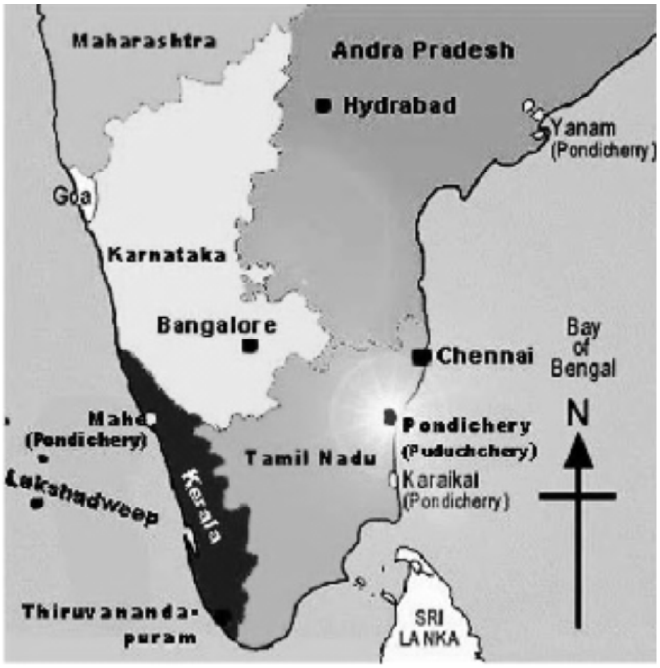

Figure 2: The four geographically disconnected regions of the Union Territory of Puducherry

evolve mitigation strategies at UTP. This strategy enabled to provide more accurate and comparable quantification of GHG sources [18, 19] in the region of Puducherry.

3.1 Study Area

The boundary selected for this study is Puducherry, which is one of the Union Territories of India, situated on the Coromandal coast, 160 kms. South of Chennai, (11° 56′ N; 79° 53′E) comprising of four geographically disconnected regions (Figure 2) (Nandhivarman *et. al.*, 2012) Puducherry, Karaikal, Yanam, Mahe. The Union Territory of Puducherry (UTP) known for its rich ecosystem and French heritage comprising of four geographically isolated regions viz. Puducherry, Karaikal, Mahe and Yanam extending over an area of 479 sq. km. Puducherry (294 sq. km.), lying on the east coast of Tamil Nadu is the capital of the Union Territory; Karaikal (157 sq. km.), part of the fertile Cauvery delta is situated on the East Coasts of Tamil Nadu, Yanam (30 sq. km.), skirted on the east and south by the Godavari River lies near the state boundary of Andhra Pradesh, Mahe (9 sq. km.), bounded in the south west by the Arabian Sea and in the north by the Ponniyam River lies on the West Coast of the country near the state boundary of Kerala [20]. Puducherry has witnessed development in most of the sectors with education and health sector demonstrating remarkable stride, since the merger of the four distinct regions with Indian Union in 1962. Education, both schooling and higher education followed by health and social security aspects have been making noticeable progress due to the measures undertaken by the proactive government machinery.

3.2 The Three Tire Approach

Although greenhouse gas inventory is prepared at the national level no initiatives has been undertaken to down scale it at the regional level. Hence in this study 'GHG Inventorisation', the standard provided by Intergovernmental Panel on Climate Change by 2006 was adopted. The IPCC 2006 guideline suggests "a three tier approach for estimation of GHG emission [21, 22]:

- ***Tier I:*** In this approach, the activity data are relatively coarse, for example, nationally or globally available estimates of deforestation rates; agriculture production statistics and global land cover maps, etc are used.
- ***Tier II:*** This approach uses the same methodological approach like that of Tier 1, but along with it, the emission factors and activity data which are defined by the country are applied.
- ***Tier III:*** This approach applies higher order methods, including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by disaggregated levels.

The uncertainties in estimation however, are reduced when it moves up the tier ladder.

3.3 Emission of carbon dioxide (CO_2) from Agricultural Sector

Agriculture sector in the UTP is the mainstay of rural livelihood by providing direct and indirect employment to about 50% and 20% respectively for the rural population (Puducherry Development Report, year 2011-2012. The proportion of net area irrigated to the net area sown is around 79.6% indicating that the irrigation facility in the Union

Territory is highly developed by fully depending on ground water resource. According to the study done by Indian Agricultural Research Institute, the direct and indirect emission of greenhouse gas for the UT of Puducherry for the year 2000 cumulates to 0.1 Tera Gram [23]. In this study, the method of emission due to enteric fermentation, manure management and rice cultivation is detailed below:

3.3.1 Enteric fermentation

Apart from the fact that, the livestock accounts for about 18% of the global GHGs emissions including the emissions such as CH_4 from enteric fermentation, N_2O from manure and fertilizer, and CO_2 from land-use, agriculture also plays substantially in the climate change through energy use [24] directly and indirectly. Livestock sources contribute as a major anthropogenic source of methane emission from agriculture sector. The methane emissions from livestock have principally two components, *i.e.* emissions from 'enteric fermentation' and 'manure management'. About 37% of anthropogenic methane is attributed to enteric fermentation by ruminants as part of their normal digestive processes. Livestock manure management is also a significant source of methane with global emissions accounting to 9.3 Tg/ year [25]. Whereas livestock also contributes a small but significant emission of nitrous oxide (N_2O) from animal waste management systems.

The second potent GHG 'methane' is produced in herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for easy absorption and assimilation through the bloodstream. The amount of methane that is released depends on the type of livestock, digestive tract, age, weight of the animal, followed by quality and quantity of the feed consumed. Ruminant livestock (*e.g.*, cattle, sheep) are major sources of methane with moderate amounts produced from non-ruminant livestock (*e.g.*, pigs, horses). The ruminant gut structure fosters extensive enteric fermentation of their diet. The specific emission factor was calculated by NATCOM as a part of preparing the GHG inventory towards national submission is used for calculation of UT specific sectoral emission (Table 1):

Table 1
Specific emission factors for different livestock (enteric fermentation and manure management)

Category of livestock	*Number of livestock*	*Emission Factor (kg CH_4/head /year) – Enteric Fermentation*	*Emission Factor (kg CH_4/head/ year) – Manure Management*
Dairy cattle (Indigenous)	6,134	28 ± 5	3.50 ± 0.20
Dairy cattle (Cross-bred)	79,062	43 ± 5	3.80 ± 0.80
Dairy buffalo	3,325	50 ± 17	4.40 ± 0.60
Sheep	4,694	4 ± 1	0.30
Goat	69,567	4 ± 1	0.20
Horses and ponies	32	18	1.60
Donkeys	60	10	0.90
Pigs	728	1	4.00

Source: CTRAN

Since, the latest available statistics present for the livestock population was based on 2007 census in UT; the same is used for calculation. Based on the total population of livestock in each category and the specific emission factor pertaining to enteric fermentation, the total methane emission was calculated as 4,036 tCH_4/year (84,768 tCO_2e/year).

3.3.2 Manure management

Methane is emitted from anaerobic decomposition of animal waste in the backyard of the farm. However, the emission of methane depends on the number of animals farmed, the rate of waste produced per animal, and 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 producing significant amount of methane. The temperature, climatic conditions and the retention time of the storage unit greatly 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, hence less methane is produced.

The specific emission factor was calculated by NATCOM as a part of preparing the GHG inventory towards national submission is used for calculation of UTP specific sectoral emission (Table 1). Based on the total population of livestock in each category and the specific emission factor pertaining to manure management the total methane emission is calculated as 354 tCH_4/year (or 7,452 tCO_2e/year).

3.3.3 Rice Cultivation

Since, rice cultivation in India is done through water logging, methane is emitted during the rice cultivation process, mainly due to anaerobic decomposition of the organic matter. The emission of methane pertaining to rice cultivation however depends upon the type of irrigation, soil, temperature, climatic conditions and also the type of water application. The specific emission factor was calculated by NATCOM as a part of preparing the GHG inventory towards national submission is used for calculation of UT specific sectoral emission (Table 2)

Table 2
Specific methane emission through different water application

Type of irrigation	*Type of water application*	*Specific Methane emission (kg CH_4/ha)*
Irrigated	Continuously flooded	162.00
	Single aeration	66.00
	Multiple aeration	18.00
Rain-fed	Drought prone	66.00
	Flood prone	190.00
Deep water	Deep water	190.00

Source: CTRAN

Based on the total 20,926 ha (2009-10) of land area under paddy cultivation with 80% of land under irrigation (considering single aeration) and 20% of the area under non irrigated flood prone area the total methane emission is calculated as 1,900 tCH_4/year (39,901tCO_2e/year).

3.4 **Result** and **Discussion**

Since, the credible data on plant availability, plant utilisation, and production efficiency were not available, the estimation of agriculture sector (enteric fermentation, manure management and rice cultivation) were computed using the Tier 1 methodology as suggested by IPCC 2006 guidelines. The inventory of GHG emission from agriculture sector based on the available data is presented as follows (Table 3):

The total emission (tCH_4 /year) through enteric fermentation, manure management and rice cultivation are 4,036.00; 354.00 and 1,900.00 respectively. Whereas carbon dioxide equivalent (CO_2e) emission (Million Tonnes of CO_2e/year) computed through enteric fermentation, manure management and rice cultivation are 0.0848; 0.0075 and 0.0399 respectively. Even though these assumptions might have resulted in slight over-estimation than the actual, it is thus necessary that this estimation process may be carried forward along the IPCC tier ladder for a more accurate GHG estimation in the near future or phase II.

4. CONCLUSION

Initially the inventory of GHG emission from agricultural sector (enteric fermentation, manure management and rice cultivation) was carried out. Even though the field burning of agricultural residues and soil carbon are sources of agricultural emission, they are however eliminated from calculations, in this Phase I. Specific emission factor used for national GHG inventory is considered for the estimation of inventory for the agriculture sector.

Table 3
GHG emission from agriculture sector (enteric fermentation, manure management and rice cultivation)

Category	*Total Emission (tCH_4/year)*	*Total Emission (tCO_2e/year)*	*CO_2e emission (Million Tonnes of CO_2e/year)*
Enteric Fermentation	4,036.00	84,768.00	0.0848
Manure Management	354.00	7,452.00	0.0075
Rice Cultivation	1,900.00	39,901.00	0.0399
Total	6,290.00	1,32,121.00	0.1321

The sector –wise GHG inventory from agriculture at the UTP was the first step to streamline the climate change mitigating strategies. Even though the inventory is based on the calculation of the emissions from the ongoing process related with agriculture, yet more research is needed for in this sector for accurate emission calculation.

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