Greenhouse Gas Emissions from Rice Fields of Bengaluru Urban District, India

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Abstract— *Anaerobic decomposition of organic material in flooded rice paddy fields produces methane and is considered one of the most prevalent sources for atmospheric methane. Methane from the rice paddy fields escapes to the atmosphere primarily by diffusive transport through the rice plants during the growing season. This paper aimed at the inventarisation of greenhouse gas emissions from the flooded rice paddy fields using Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines - Tier 1 approach for Agriculture, Forestry and Other Land-use sector. The methane emission from rice paddy fields for the year 1990-1991 was 1.255 Gg or 31.364GgCO$_2$e, while 2012-2013 accounts for 0.269Gg or 6.725GgCO$_2$e. The overall decrease of 21.44% of methane emissions from rice paddy fields was observed during the last two and half decade. The rice paddy fields are decreased over the years due to rapid expansion of the built-up environment in the outskirts of the urban area.*

Key words: Agriculture, greenhouse gas, methane, flooded paddy fields.

I. INTRODUCTION

Globally rice provides the staple food for over 60% of the world's population. It has a central role in providing food with substantial environmental impacts. India is the second largest producer and consumer of rice in the world next to China and accounts for 21% of the world's total rice production. Paddy cultivation is an important source of methane emissions (a potent greenhouse gas), emitted from flooded paddy fields, and the energy needed for pumping water. Methane is the primary greenhouse gas from flooded paddy fields, so understanding methane production is important for understanding the overall greenhouse gas burden of rice production. The total methane emissions from a paddy field are determined by methane production, oxidation and transport (Frenzel *et al.,* 1999). Methanogenesis, methane production, is a microbial process strictly limited to anaerobicconditions (Ma *et al.*, 2010) and flooding is the key driver of soil anaerobic conditions, so the flooding regime is critical to methanogenesis (Yan *et al.,* 2005). Although not all rice is grown in flooded conditions, globally 90% of rice land is at least temporarily flooded (Wassmann *et al.*, 2009).Understanding how these emissions arise, and potential mitigating steps, this paper is aimed at the science associated with greenhouse gas emissions from the flooded paddy fields.

II. STUDY AREA AND METHODOLOGY

2.1 Study Area

The present study was carried out in Bengaluru urban district; one of the fastest growing cites in India, with a population of 8.4 million (Census of India, 2011) indicating a development of 2196 sq.km geographical area (DES, 2013); located 920m above mean sea level, and experiencing a salubrious climate throughout the year with an annual rainfall of about 850-950mm. Bengaluru is branded as 'Silicon Valley of India' for heralding and spearheading the growth of Information Technology (IT) based industries in the country. Bengaluru has become a cosmopolitan city attracting people and business alike, within and across nations (Sudhira *et al.,*2007). Agricultural lands, open lands and barren lands are converted into urban settlements. From the past two and half decade, rapid urbanization, land utilization and variability in annual rainfall leads to conversion of agriculture land into urban settlements which resulted in the decrease of paddy cultivation over the years.

2.2 Methodology

Greenhouse gas emissions from paddy cultivation and urea fertilization are typically small, often negligible for most urban regions, so this category needs to be carefully considered. The key greenhouse gases of concern in paddy cultivation and urea fertilization are methane and carbon dioxide respectively. The greenhouse gas emission inventory was associated with paddy cultivation and urea fertilization using Intergovernmental Panel on Climate Change (IPCC) guidelines - Tier 1 approach for Agriculture, Forestry and Other Land-use sector (IPCC, 2006).The annual paddy cultivated area and total quantity of urea fertilisation data's were collected from Directorate of Economics and Statistics, Government of Karnataka for greenhouse gas emission (methane and carbon dioxide) inventory. The inventory is based on national emission factors and are carried out for the financial year (i.e., April - March) 1990-1991, 2000-2001, 2010-2011, 2011-2012 and 2012-2013.

Equation 1: Methane emission from rice cultivation

$$CH_{4Rice} = A \times t \times EF_i \times 10^{-6}$$

Where:

CH_{4Rice} = Amount CH_4 emission from rice cultivation (Gg CH_4 yr-^{1})

A = Annual harvested area (ha yr^{-1})

t = Cultivation period of rice (day)

EF_i = Emission factor for harvested area (kg CH_4 ha^{-1} day)

Equation 2: CO_2 emissions from Urea fertilization

$$CO_2\text{-C Emission} = M \times EF \times 10^{-6}$$

Where:

CO_2-C Emission = CO_2-C emission from Urea fertilization (Gg Cyr^{-1})

M = Annual amount of Urea fertilization (tonnes urea yr^{-1})

EF = Emission factor [tonnes of C (tonne of urea)$^{-1}$]

Equation 3: Greenhouse gas emission to Equivalent Carbon dixode

$$CO_2e = GHG \times GWP$$

Where:

CO_2e = Equivalent Carbon dioxide

GHG = Greenhouse gas

GWP = Global warming potential

III. RESULTS AND DISCUSSION

The process of urbanization can involve direct change in land use, as formerly agricultural land becomes incorporated within built-up areas. Urban areas can shape emissions from agriculture and other land-use change. The urban trends towards suburbanization that is cities are sprawling and encroaching on land that may previously have been covered with agriculture field – thereby reducing the cultivation of crops especially paddy. The consumption patterns of increasingly wealthy urban residents can shape the type of agricultural activities that is taking place. For example, the growing paddy is associated with emissions of methane which is a potent greenhouse gas.

3.1 Paddy cultivation

Anaerobic decomposition of organic material in the flooded rice fields produce methane, which escapes to the atmosphere primarily by transport through the rice plants. The annual amount of methane emitted from a given area of rice is a fraction of the number and duration of crop grown, water regimes before and during cultivation period, and organic and inorganic soil amendments. Soil type, temperature and rice cultivar also affect methane emission. Table 1 presents the annual paddy cultivated area in Bengaluru urban district from the year 1990 to 2013.

TABLE 1
ANNUAL PADDY CULTIVATED AREA

Year	Paddy harvested area (ha yr^{-1})
1990-1991	7317
2000-2001	6974
2010-2011	1895
2011-2012	1688
2012-2013	1569

Source: Directorate of Economics and Statistics, Bengaluru

The methane emission from paddy cultivation for the year 1990-1991 was 1.255 Gg or 31.364Gg CO_2e, while 2012-2013 accounts for 0.269Gg or 6.725Gg CO_2e (Figure 1&2). The overall decrease of 21.44% of methane emissions was observed during the last two and half decade. The paddy cultivation area is decreased over the years due to rapid expansion of the built-up environment in the outskirts of the urban area. The maximum paddy cultivation was observed in the northern and southern part the Bengaluru urban district; now in these parts the agriculture lands are converted into residential sectors, commercial sectors and industrial estates. Similarly, Indian Greenhouse Gas Emissions report 2007 revealed that paddy cultivation emitted 69.87 million tons of CO_2eq or 3.27 million tons of methane. The emissions cover all forms of water management practiced for rice cultivation, namely, irrigated, rainfed, deep water and upland rice.

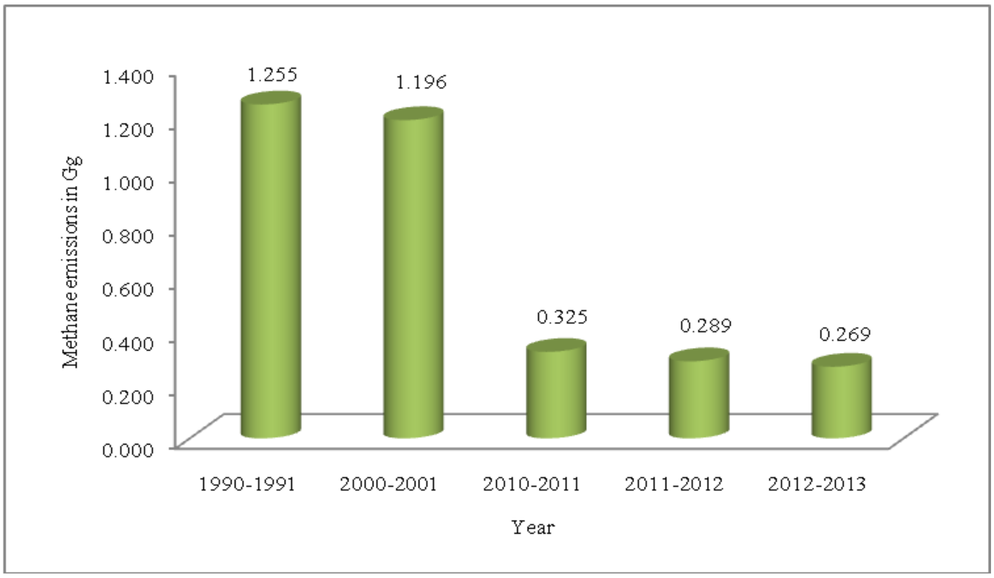

FIGURE 1: METHANE EMISSION (Gg) FROM PADDY CULTIVATION

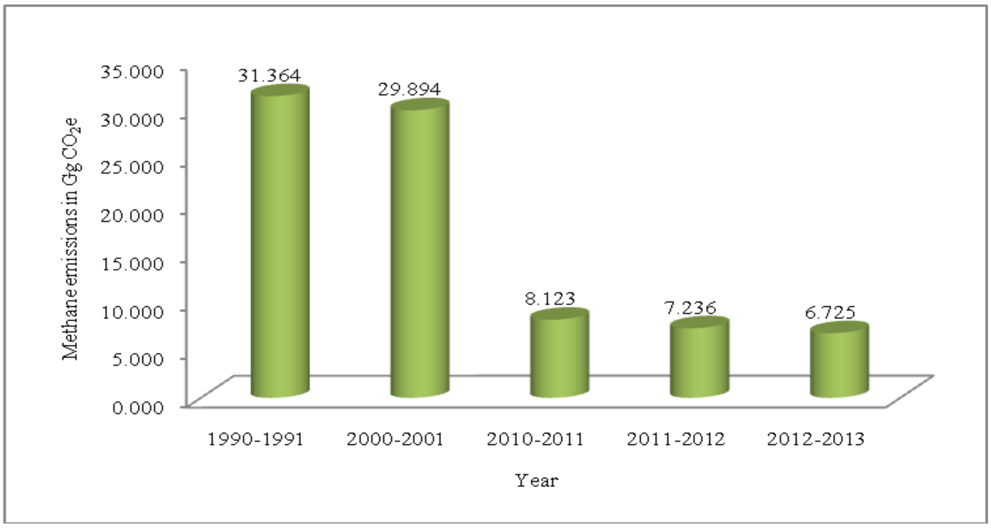

FIGURE 2: METHANE EMISSION (Gg CO_2e) FROM PADDY CULTIVATION

3.2 Urea as a fertilizer

Addition of urea to soils during fertilization leads to a loss of carbon dioxide that was fixed in the industrial production process. Urea is converted into ammonia, hydroxyl ion and bicarbonates in the presence of water and urease enzymes. Similar to the soil reaction following addition of lime, bicarbonates that is formed evolves into carbon dioxide and water. Table 2 explains about the utilization urea applied in the agriculture fields.

TABLE 2
ANNUAL AMOUNT OF UREA FERTILIZATION

Year	Annual amount of Urea Fertilization (tonnes urea yr^{-1})
1990-1991	19992.28
2000-2001	16602.73
2010-2011	25823.41
2011-2012	42405.20
2012-2013	32428.35

Source: Directorate of Economics and Statistics, Bengaluru

The carbon dioxide emission from urea fertilization for the year 1990-1991 was 3.998Gg, 2011-2012 was 8.482Gg, while 2012-2013 accounts for 6.486Gg (Figure 3) in Bengaluru urban district. There was increase in the utilization of urea in the year 2011-2012 because of increased rainfall in that particular year and Government of Karnataka has given subsidy to the farmers to buy the fertilizers. This in turn increased the yield and production of crops.

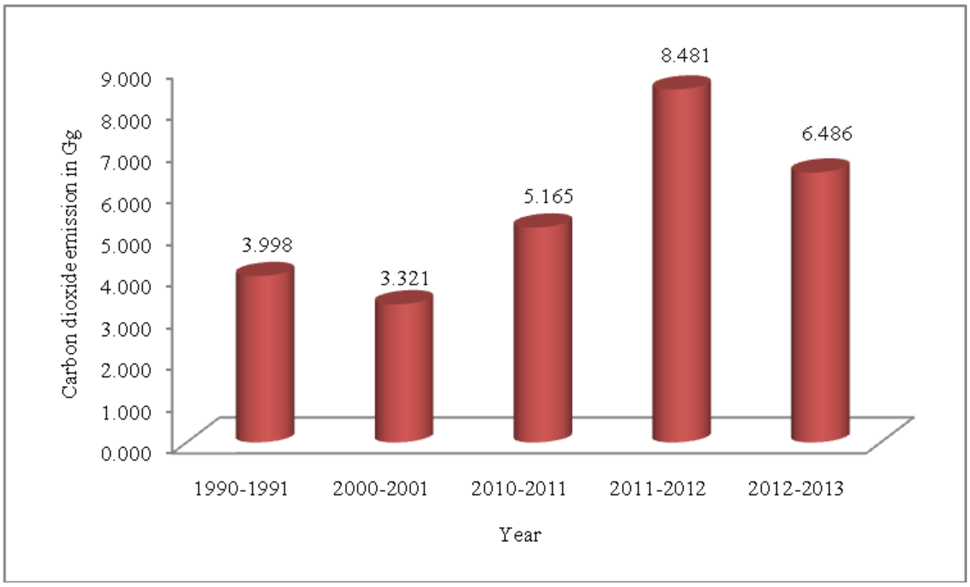

FIGURE 3: CARBON DIOXIDE EMISSIONS FROM UREA FERTILIZATION

IV. CONCLUSION

Overall, agriculture sector need to be improved by adopting new technologies based on the availability of water resources. Methane emissions from the paddy fields can be minimize by changing the water management, but at the expense of converting flooded paddy field to dry paddy filed. And also, understanding the trade-offs between greenhouse emissions is important before different methods of rice production are advocated on grounds of climate mitigation. Finally, it is important to note that greenhouse gas emissions are of great importance they must be put within the wider picture of sustainable development.

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