

IR-2 Studies on Methodology for Establishing Greenhouse Gas Inventory System

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1. Introduction

Global warming is the most serious global environmental issue from the following three points; (i) Global warming is based on the model prediction and it is difficult to recognize as a serious problem, however, (ii) the damage to the earth climate system is fatal, and (iii) it is caused by GHG accumulation in the atmosphere coming from the fossil fuel consumption and the decrease of forest which are accompanied by the development of human society. The GHG monitoring and the research activities on the carbon cycle, climate model predictions, assessment of the climate change risks are important. One of the bases of these researches is the inventory of greenhouse gases, and the full coverage and the accuracy of it are required. In addition to it, it was simply a national inventory before, but the greenhouse gases inventory has come to be the base of implementation of the Kyoto Protocol of UNFCCC.

On the other hand, the scientific researches are not enough to support the establishment of the inventory data system especially in developing countries of Asia-Pacific area, and the establishment of the information network and system is an urgent request.

2. Research Objectives

The objectives of this project are to identify data gaps and problems in greenhouse gas inventories, to prioritize these issues for future research activities and to establish the national greenhouse gas inventory systems especially for the Asia-Pacific countries. The individual research objectives are as follows:

- (1) Development of methodology to improve national greenhouse gas inventory systems.
- (2) Improving the accuracy of greenhouse gas emissions from Industry and agriculture sectors.
- (3) Improving the accuracy of greenhouse gas emissions from land use, land use change and forestry sector.
- (4) Evaluation of methodology of emission inventory of CH₄ and N₂O in terrestrial ecosystems.

3. Results

3-1. Development of Methodology to Improve National Greenhouse Gas Inventory Systems

Establishment of national greenhouse gas (GHG) inventory systems by Parties is essential to sound implementation of the UNFCCC and the Kyoto Protocol. With this background, the main objectives of this study are to identify data gaps and problems in GHG inventories especially for the Asia-Pacific region, to prioritize these issues for future research activities, and to improve the national inventory systems in Japan and the Asia-Pacific region.

To this end, efforts were made to collect existing data on GHG emission factors in the region from various reports and literatures, and to compile those data into a table. The table clearly showed the lack of country- or region-specific data available, and thus it proved the necessity of research activities to develop such data that reflect national circumstances appropriately.

Then, an international workshop was convened to discuss and prioritize research areas to cope with in particular in Agriculture Sector, Land-Use Change and Forestry Sector, and Waste Sector. The workshop also produced a roster of the GHG inventory experts in the region, and the network of those experts were established. (NAPIID: Network for Asia Pacific to Improve (GHG) Inventories Database.)

Subsequently, intensive discussions and research efforts were made through the NAPIID to address the issues of high priority that were identified at the workshop. For example, a collaborative research project for the LUCF Sector was conducted jointly with research institutes in South East Asia (the Philippines, Thailand and Indonesia), with aims to:

- Collect as much data as possible on forest aboveground biomass, site-specific or species-specific wood density, climate, agroclimatic zone, agroecological zone, soil type, slope, forest area, etc. in the three Southeast Asian countries.
- Further improve allometric regressions for relating standing crop and volume to total biomass.
- Assess the results from application of GIS approach in modelling and predicting estimates of annual biomass increment and aboveground biomass at different locations and environmental conditions.

As regards the Agriculture Sector, an international workshop was convened to comprehensively review recent articles on methodologies for estimation of GHG emissions from rice paddies, which resulted in some recommendations to the IPCC.

All these activities and results of this study have implications for the IPCC National Greenhouse Gas Inventories Programme whose technical support unit is based in Japan (in the Institute for Global Environmental Studies), hence this study can be regarded as one of considerable contributions to the IPCC from Japan.

3-2. Improving the Accuracy of Greenhouse Gas Emissions from Industry and Agriculture Sectors

The main objective of this study is to improve the reliability or accuracy of estimates of GHG emissions from industry and agriculture sectors in the Asia-Pacific region. To meet this objective, the Eco-Frontier Fellow researchers conducted some case studies with GHG inventories of their own countries.

In the fiscal year 1999, methane (CH₄) and nitrous oxide (N₂O) emissions from animal manure management systems (AMMs) in China were estimated using IPCC methodology Tier 2 with modifications, and subject to sensitivity analysis.

Swine was the largest contributor to CH₄ emissions and slurry manure management system had the largest share for CH₄ emissions from AMMs. N₂O emission from AMMs was mainly attributable to non-dairy cattle, poultry and swine. Pasture and drylot manure

management systems were the biggest contributors to N₂O emissions from AMMs. The distributions of CH₄ and N₂O emissions were also analyzed. Shandong, Sichuan, Henan and Hunan provinces were the most important contributors to GHG emissions from 1990 to 1996.

The priority of the activities to improve GHG emission inventories was as follows:

- (1) Investigate animal management system usage data.
- (2) Investigate nitrogen excretion data.
- (3) Investigate feed intakes

The data collection and experiments should focus on the major animals (non-dairy cattle, swine and poultry), major manure management systems (solid, pasture and slurry) and in the provinces with higher GHG emissions.

In the fiscal year 2000, CH₄ emissions from enteric fermentation in China from 1990 to 1998 were estimated in accordance with 4 different IPCC methods (i.e., Tier1 and Tier2 methods suggested by the Revised 1996 IPCC Guidelines as well as methods with and without assessment of treated straw as suggested by the IPCC Good Practice Guidance). The study proved that the extension of project to enhance the use of treated straw as feed resulted in reduction of CH₄ emissions from yellow cattle. In order to properly evaluate the merit of treated straw, it is recommended to use the method suggested by the IPCC Good Practice Guidance. To improve the quality of the emission inventory of CH₄ from enteric fermentation, a series of measures are recommended: modification of emission factors to reflect the change of livestock production systems over time in each region; field measurement of methane emission factors; lab experiments on CH₄ conversion rate of different roughage; survey of animal production data including feed intake, livestock weight, feed digestibility, population in different regions and different management; calculation of CH₄ emissions from non-ruminant animals.

In the fiscal year 2001, attempts were made to apply the IPCC Good Practice Guidance to Cambodian GHG inventories. CH₄ emission from enteric fermentation and manure management were identified as the key source categories in Cambodia, which means improvement of estimates for these source categories are of high priority. With this in mind, the emission factors for non-dairy cattle, buffalo and swine were developed in order to enable Tier 2 estimates for these key source categories. The study showed that the total CH₄ emission from livestock management in Cambodia were estimated to be 191.54 and 191.85 Gg in 1994 and 1999 respectively. There are small differences in methane emission estimate between applying the Tier 1 method of the Revised 1996 IPCC Guidelines, and the Tier 2 method of IPCC Good Practice Guidance. However, based on reliable data, Tier 2 method is recommended to apply for more accurate estimates. For these two key source categories, IPCC-GPG was successfully applied for improving the GHG inventory in Cambodia this study.

3.3 Improving the Accuracy of Greenhouse Gas Emissions from Land Use, Land Use Change and Forestry Sector

The main objective of this study is to improve the reliability or accuracy of estimates of GHG emissions by sources and removals by sinks in the Land Use, Land-Use Change and Forestry (LULUCF) Sector in the Asia-Pacific region. To meet this objective, the Eco-Frontier Fellow researchers conducted some case studies with GHG inventories in the region.

In the fiscal year 1999, national GHG inventories of the Philippines, Indonesia and Thailand and related literature were reviewed. The major outcomes of these reviews were the following findings and strategies for improvement of the estimates in this sector in the region.

- (1) The major problems for the LULUCF sector in these countries are the lack of activity data and the limited access to sparsely available data.
- (2) There is a strong need to develop a database to improve the quality of activity data and emission factors.
- (3) Formation of network of scientists and institutions involved in GHG inventories in SEA can facilitate sharing, updating and validating of data or other information in GHG inventory for LULUCF sector. It is also necessary to conduct field measurements to examine the relevant parameters.

In the fiscal year 2000, the study was focused on "fallow" which is broadly viewed in the tropic region, including secondary forest; abandoned cropland; pasture or degraded wasteland; and the intervening time between crops during a single year. A review of literature of fallow systems in the Philippines resulted to a long list of fallow species including trees, shrubs, herbs and grasses, and the identification of different fallow systems. Fallow-related anthropogenic activities include shifting cultivation, secondary forests, agroforestry, rehabilitation of degraded lands and tree plantations. A number of literatures on these fallow-related activities were reviewed. According to the reviews, these fallow-related activities have great potential in mitigating climate change through the sequestration of carbon in the growing vegetation and soils.

3.4 Evaluation of greenhouse gas emission inventory from terrestrial ecosystems

- (1) The major factors controlling N_2O and NO emissions from agro-ecosystems in Japan were soil type, forms and amount of fertilisers applied to agricultural fields, application method of fertilisers, soil moisture contents, in addition to soil temperature and soil pH.
- (2) A new methodology for NO emission inventory has been developed, using three parameters, i.e., cultivated area, application amount of nitrogen fertilisers, and the emission factors for 13 types of major crops in Japan. Using this method, the total emission of NO from upland crop and rice paddy fields in Japan was calculated to be 7.83 GgN y^{-1} in 1998. The uncertainty of this estimate, however, is large because many emission factors have not been measured in the fields yet. The field study should be conducted to evaluate these emission factors in future.
- (3) Soil types, a cultivation method of non tillage and direct seeding, and crop cultivation and soil moisture conditions in non ricegrowing period have been newly identified to be major factors controlling CH_4 emission from rice paddy fields, in addition to organic matter application, water management regimes and cultivars.
- (4) Rice paddy fields emit not only CH_4 but also N_2O , because nitrogen fertilizers, mineral nitrogen in irrigated water, and green manure or upland crops in non ricegrowing period are the sources of N_2O -N. CH_4 and N_2O emissions should be totally reduced because they are in a tradeoff relationship (Fig. 1).
- (5) In forest soils in Japan, the absolute value of CH_4 uptake rate was estimated to be as much as 85% of the total CH_4 emission rate in rice paddy fields, by using the flux values of CH_4 uptake measured in some forest areas. The emission of N_2O from some forest soils has been found to be almost equal to that from upland fields in Japan. These new findings strongly suggest the importance of field study on CH_4 and N_2O emissions from forest soils, as well as carbon budget in forest ecosystems.
- (6) CH_4 emissions from peatlands in Indonesia were much lower than those measured in the other tropical region. It indicates that the CH_4 emission factor in tropical Asia is different from the one in the other tropical region.
- (7) According to the biomass burning experiment in Japan, the emission factor of CH_4 and N_2O from the burning of rice straws and wheat straws was estimated to be different from that used in good practice guideline by IPCC.
- (8) A study on indirect N_2O emissions from nitrogen used in agriculture in Japan suggests that the value of emission factor by IPCC would be overestimated, and more field research is needed to clarify the controlling factors in Japan.

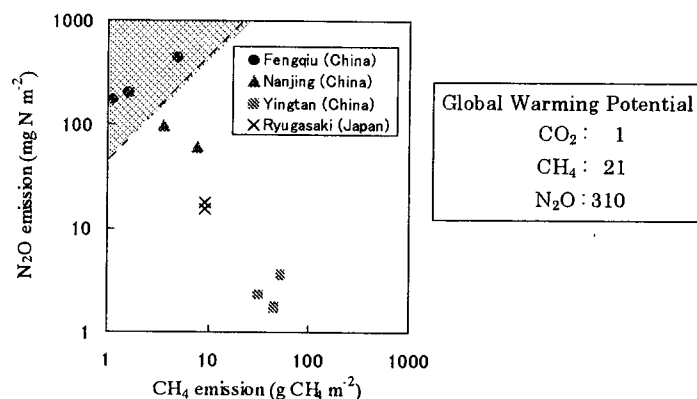


Fig. 1 The emission rate of CH₄ and N₂O from rice paddy fields in rice growing season in China and Japan. N₂O emission is higher than CH₄ emission in pink-colored area, in comparison with the equivalent CO₂ emission converted, by using global warming potential.

4. Discussion

The greenhouse gas inventory has two functions; one is as the base of scientific analysis of increase of atmospheric greenhouse gases and its effect on climate, and the base of sounding of implementation of the Kyoto Protocol of UNFCCC. In both cases, the accuracy and full coverage are important. The problems to be solved common among different sectors of emission and countries are summarized as follows:

- (i) The variability of activities in the sectors of agriculture, livestock-farming, forestry, and waste management are so large, and the emission factors should be improved fitting to the practice of each countries.
- (ii) The lack of data and the limited accessibility make the inventory difficult to be reliable. The additional observation and sampling analysis are required beside the analysis of data from literatures.
- (iii) There is a potential to be improved as the researchers and the governmental officers in charge are so aggressive, and the cooperation of Japanese scientists and the supports are desired.