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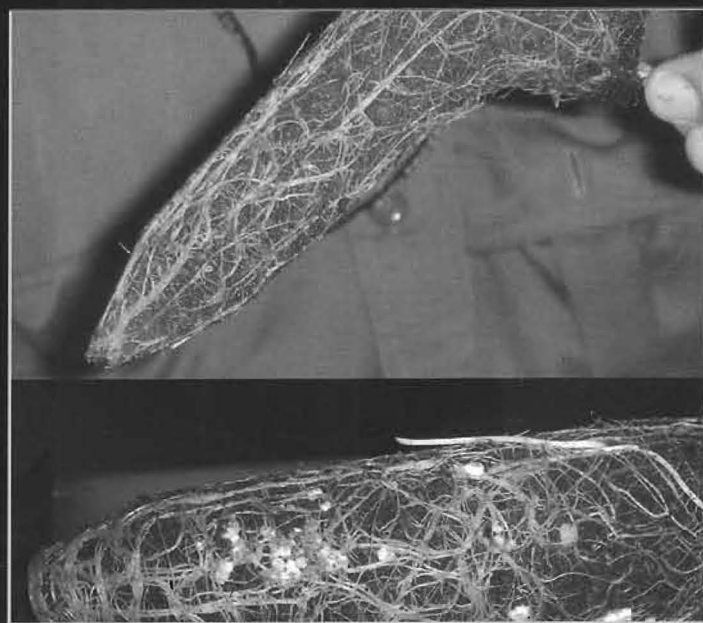
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## INDONESIAN FARMERS CAN CONTRIBUTE IN REDUCING GREENHOUSE GASES EMISSION FROM WETLAND RICE FIELD

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### ABSTRACT

*Agricultural sector contribute significantly to the total GHG emission. There are some GHG mitigation options available but so far non of these mitigation options is being implemented by farmers. There is no real action have been taken by government to encourage farmers to implement the available mitigation option to reduce GHG emission from wetland rice field. We discuss some mitigation options and we suggest two additional GHG mitigation options namely crops rotation and System of Rice Intensification (SRI) that probably more attractive to farmer to implement them. However the impacts of these two proposed options as GHG mitigation options should be studied further.*

*Key words: Greenhouse gases (GHG), mitigation option, farmer contribution, SRI, crop rotation*

### INTRODUCTION

According to the UN Secretary General, Ban Ki-moon, world leaders have demonstrated their political will to make a breakthrough on climate change. He addressed his speech recently on the wrapping up the UNFCCC Meeting held in Bali Indonesia in last September 2007, attended by over 150 nations including 80 heads of State or Government. He added, technological solution for pushing forward the goal of adaptation and mitigation to global climate change already exist and global collaboration must be urgently needed to help the developing countries to reduce their GHG emission. This means every country should take a serious and real action(s) to implement the available GHG mitigation options to reduce their GHG emission.

Based on UNFCCC (2006) in some Asian countries, the highest GHG emission come from energy sector, followed by agriculture or industrial sectors and waste. However, looking at GHG emission from agricultural sector only, in Asian developed countries such as in Japan and Korea, GHG emission from agricultural sector is very low while in the developing countries, the percentage of GHG emission from agricultural sector is much higher. GHG emission from agricultural sector in China, India, Indonesia and Thailand have a significant contribution to the total GHG emission of each corresponding country. This also means that mitigation technology applied in the agricultural sector in these later mentioned countries might have a significant effect in the reduction of their total GHG emission.

Until now, in the agricultural sector in Indonesia, although there are some GHG mitigation options available but none of these mitigation options are being applied by

farmer to reduce GHG emission from agricultural land. In relation to this, it is interesting to discuss the possible contribution of Indonesian farmers in reducing GHG emission when these mitigation options are adopted. Some possible obstacles and encouraging factors that might be faced in implementation of mitigation options are also interesting subjects to discuss. As we all know that GHG gases mainly consist of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O and NO but due to the lack of data available particularly in the developing countries, only one or two of these gases, mainly CH<sub>4</sub> and N<sub>2</sub>O are discussed.

### GHG EMISSION FROM AGRICULTURAL SECTOR

According to UNFCCC Report (2006), GHG emission from agricultural sector in developing Asian countries is higher than GHG emission from agricultural sector in the developed Asian countries such as Japan and Korea (Figure 1). In Japan, the GHG emission from agricultural sector was only 2% of the total GHG emission while in Korea, it was only 4% of the total GHG emission. The percentage of GHG emission from agricultural sector in developing countries was 15% in China, 26% in Indonesia, 28% in India and 35% in Thailand. The total amount of GHG emission from each country was China (4.058 Mt CO<sub>2</sub>), Japan (1.355 Mt CO<sub>2</sub>), India (1.214 Mt CO<sub>2</sub>), Indonesia (323 Mt CO<sub>2</sub>), Korea (299 Mt CO<sub>2</sub>) and Thailand (224 Mt CO<sub>2</sub>). GHG emission from agricultural sector in China, India, Indonesia and Thailand occupied a high portion of the total GHG emission. This means that mitigation options applied in the agricultural sector might have a significant effect in reduction of the total GHG emission from these countries.

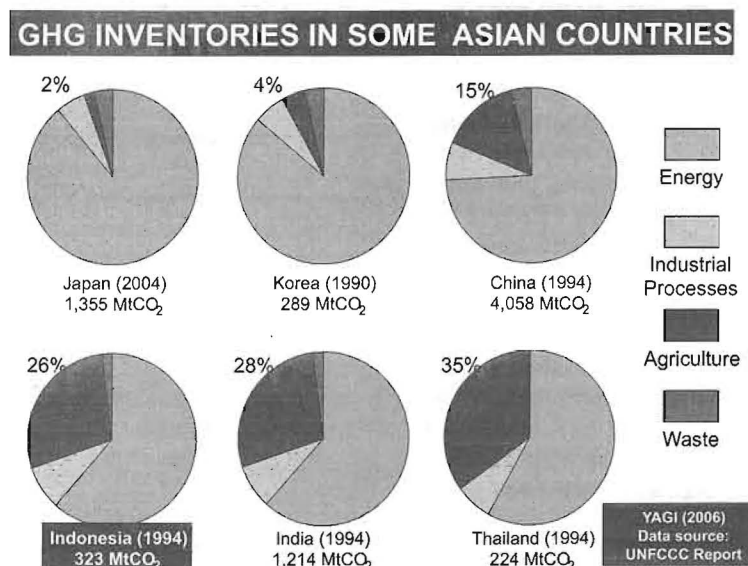


Figure 1. GHG Inventories in some Asian Countries (UNFCCC Report 2006, modified by Yagi, 2006)

The distribution of GHG emission from agricultural sector in Japan and Korea is presented in Table 1. Rice field is one of the most important source of GHG emission from agricultural sector. In Japan, as high as 30.0% of GHG emission from the agricultural sector come from rice cultivation while in Korea, GHG emission from rice cultivation even higher, as high as 44.9% of the GHG emission from agricultural sector. However, as it has been stated earlier, the GHG emission from agricultural sector in both countries was only 2% (Japan) and 4% (Korea) of the total GHG emission in each country. There is no data available about the contribution of the rice field on GHG emission from agricultural sector in other Asian countries such as Indonesia, China, Thailand and India. However, it is more likely that the percentage of GHG emission from rice field is also high in these countries.

Table 1. Greenhouse Gas (GHG) Emission from Agricultural Sector in Japan and Korea

Country	Source of GHG from agricultural sector (%)			
	Rice cultivation	Other Agricultural soils	Manure management	Enteric fermentation/ Other
Japan <sup>1</sup>	30.0	-	38.0	-
Korea <sup>2</sup>	44.9	21.1	17.7	16.3

<sup>1</sup>Inubushi and Yagi (2006) only for methane; <sup>2</sup>Shin and Lee (2006).

The reason is majority of rice field ecosystem in these countries is flooded rice ecosystem while in Japan and Korea, the majority of rice ecosystem is irrigated rice ecosystem (Wassmann, 2006). China, India and Indonesia are claimed as the main methane emitting countries in the world (Shearer and Khalil, 2000). China was reported to produce as much as 20 Tg of methane per year from rice cultivation. This was rather overestimated since in the last report, China emitted only 8 Tg methane per year. In Indonesia, flooded or wetland rice ecosystem is also considered to be the main source of methane in agricultural sector. In 2005, with the harvested area of wet

land rice field in Indonesia 11.8 millions hectares (Table 2), methane emission was reported to reach 6.2 Tg per year (Husin *et al.*, 1994).

Table 2. Rice Harvested Area and Rice Production in Indonesia (BPS, 2007)

Year	Rice harvested area (ha)	Yield Rate (ton/ha)	Total rice production (ton)	Production growth (%)
2002	11,521,166	4.469	51,489,694	2.04
2003	11,488,034	4.538	52,137,604	1.26
2004	11,922,974	4.536	54,088,468	3.74
2005	11,839,060	4.574	54,15,097	0.12
2006	11,786,430	4.620	54,454,937	0.56
2007*	11,757,845	4.689	55,127,430	1.23

\*=Second forecast

However, other scientists reported that the methane emission from rice cultivation in Indonesia was only 3.7 Tg per year (Matthew *et al.*, 1991) and more lower figure was reported by Bachelet and Neue (1993), i.e. 3.5 Tg methane per year. It was calculated that the methane emission from rice field in Indonesia was about 5.2 Tg. As additional information, according to Duxbury and Mosier (1997) global methane emission from agriculture sector was about 205 – 245 Tg methane per year. However, it is important to note that rice field ecosystem may act as source as well as sink of methane as reported by many authors (Rath *et al.*, 1999; Wang and Adachi, 1999; Wang *et al.*, 1999; Kumaraswamy *et al.*, 2000; Wassmann and Aulakh, 2000; Inubushi *et al.*, 2002). The magnitude of methane as well as N<sub>2</sub>O emitted from rice field ecosystem depend on the agricultural practices applied on a particular soil.

**GHG EMITTED FROM WETLAND RICE FIELD CULTIVATED WITH OTHER CROPS**

In some parts of Indonesia, in good irrigation water management or in the area where irrigation water insufficient, wetland rice field (sawah) is cultivated with upland crops such as maize, soybean, peanut and other tuberous crops such taro or vegetable crops. Cultivating wetland rice field with other crops, reduce GHG emission from this soil or this soil might become a sink of GHG instead of source. To study this, we set up a series of experiments in 2005 – 2006 in Bogor, West Java, Indonesia. The farmers' wetland rice field cultivated with different crops according to the farmer' cultivation practices obtained in very small area (1-2 ha) were used to take GHG samples. This very limited sampling area was meant to keep the soil characteristics and the microclimate of the area of study were similar. In this study we limited GHG emission only to methane emission. The results of methane emission from three wetland rice field location were presented in the Table 3. These data showed that wetland rice field cultivated with rice in three location constantly emitted methane gas much higher than wetland rice field cultivated with upland crops. Moreover, it was also observed in these three experimental locations that when wetland rice field cultivated with a certain upland crop, the land became a sink of methane gas instead of source. This is really interesting phenomenon.

To ensure the results of the first experiment, the methane gas emission from the same site in Cihideung Ilir and Marga Jaya was monitored in the second cropping season. Data in Table 4 showed that when wetland rice field in the first growing season planted with upland crops taro or mixed vegetable crops (Marga Jaya location), methane emission was only  $-0.92 \pm 0.02 \text{ g CH}_4 \text{ m}^{-2}$  and  $-0.03 \pm 0.11 \text{ g CH}_4 \text{ m}^{-2}$ , respectively. However, when in the second growing season, these crops were replaced by wetland rice, methane emission jumped out very significantly to  $75.47 \pm 100.02 \text{ g CH}_4 \text{ m}^{-2}$  and  $38.60 \pm 10.39 \text{ g CH}_4 \text{ m}^{-2}$  respectively.

Table 3. Methane Emission from Wetland Rice Field Cultivated with Other Upland Crops (Suprihati, 2007; Iswandi *et al.*, 2007)

Location	Crop	Total methane emission (g CH <sub>4</sub> m <sup>-2</sup> )
1. Cihideung Ilir*	Wetland rice	15.93 ± 1.81
	Maize	0.21 ± 0.09
	Vegetable	0.06 ± 0.06
	Sweet potato	2.00 ± 1.63
	Yam bean	-1.19 ± 1.47
2. Marga Jaya*	Wetland rice	4.94 ± 3.15
	Taro	-0.92 ± 0.02
	Long bean	0.16 ± 0.10
	Sweet potato	0.21 ± 0.01
	Mixed crops	-0.03 ± 0.11
3. Pasar Rebo**	Wetland rice	7.50 ± 0.53
	Vegetable	0.46 ± 0.53
	Sweet potato	-0.77 ± 0.64
	Yam bean	-0.39 ± 0.51
	Maize	0.16 ± 0.18

\*= Iswandi *et al.* (2007); \*\* Suprihati (2006)

Table 4. Methane Emission from Wetland Rice Field Cultivated with Other Upland Crops for Two Consecutive Growing Seasons (Iswandi *et al.*, 2007)

Location	First growing season	Methane emission (g CH <sub>4</sub> m <sup>-2</sup> )	Second growing season	Methane emission (g CH <sub>4</sub> m <sup>-2</sup> )
Cihideung Ilir	Wetland rice	15.93 ± 1.81	No crop	±
	Maize	0.21 ± 0.09	Peanut	0.29 ± 0.15
	Vegetable	0.06 ± 0.06	Sweet potato	-1.6 ± 1.48
	Sweet potato	2.00 ± 1.63	No crop	±
	Yam bean	-1.19 ± 1.47	Sweet potato	0.33 ± 0.53
Marga Jaya	Wetland rice	4.94 ± 3.15	No crop	±
	Taro	-0.92 ± 0.02	Wetland rice	75.47 ± 100.02
	Long bean	0.16 ± 0.10	Vegetable	0.55 ± 0.34
	Sweet potato	0.21 ± 0.01	Sweet potato	-0.02 ± 0.14
	Mixed crops	-0.03 ± 0.11	Wetland rice	38.60 ± 10.39

It is important to note that in the second growing season where wetland rice field at Cihideung Ilir location was planted with sweet potato, as high as  $-1.67 \text{ g CH}_4 \text{ m}^{-2}$  was absorb in this site. This means that as high as  $16.7 \text{ kg CH}_4$  was absorbed per hectare of wetland rice field. This was really interesting result obtained in this study.

**SOME OPTIONS OF GHG MITIGATION**

Some options of GHG mitigation from wetland rice field which have been investigated in some countries are presented in the Table 5. Irrigation water management, selection of rice cultivar, type, dosage and timing of fertilizer application, cultivation method, and organic matter application are among the mitigation options proposed by scientist to reduce GHG emission from wetland rice field.

These mitigation options were reported to be effective methods to reduce GHG emission from wetland rice field. However, the effectiveness of the GHG mitigation options varied considerably. Up to now, none of these option is being practiced by farmers widely. Adoption of the GHG mitigation options by farmer depend on many factors such as easiness of the option to be implemented, no additional cost or an extra work have to be done by farmer and no reduction in rice yield. Therefore we propose additional options of GHG mitigation, i.e. crop rotation in wetland rice field and System of Rice Intensification (SRI), a new introduced rice cultivation system which could be more attracted to farmer to implement these options. In the next sub-topic we elaborate these to additional GHG mitigation options.



Table 5. Some Mitigation Options of GHG Emitted from Wetland Rice Field

Option	Detail and GHG emission	Literature
Water management	Saturated irrigation water 24.17% less CH <sub>4</sub> emission than flooding but increase N <sub>2</sub> O by 98.7%, increased rice yield 12% Mid season drainage reduce GHG emission Intermittence irrigation water 30% less than flooding GHG emission with mid season drainage 25.86% < farmer practiced ; Multiple drainage 33.53% < farmer practiced	Suprihati (2007) Wassmann, <i>et al.</i> (2000) Shin and Lee (2006) Chidthaisong (2006)
Selection of rice cultivar	High-yielding cultivar with low MTC such as IR65598 and IR65600, economically feasible, environmentally sound promising approach for methane mitigation Rice with a few unproductive tiller, small root system, high root oxidative activity, high harvest index ideal for mitigation GHG CH <sub>4</sub> emission varied according to soil and rice variety Selected cultivar emitted less CH <sub>4</sub> without reducing rice yield; IR64 better than Membaramo, Way Oporuru and Cisadane	Aulakh <i>et al.</i> (2000) Wang and Adachi (2000) Singh <i>et al.</i> (1997) Setyanto <i>et al.</i> (2004)
Fertilizer application		Wassmann (2006)
Cultivation method	direct seeding 55% less CH <sub>4</sub> than transplanting	Shin and Lee (2006)
Organic matter	Not composted rice straw ( 6 ton): increase 11.3% CH <sub>4</sub> ; 51.2% N <sub>2</sub> O, 8% rice yield increase Composted rice straw 45% less CH <sub>4</sub> emission	Suprihati (2006); Iswandi <i>et al.</i> (2007) Shin and Lee (2006); Yagi (2006)
Combination	Saturated water treatment, rice straw application and urea application: increase rice yield 115%, reduce CH <sub>4</sub> by 50%, N <sub>2</sub> O by 77% and GWP by 50%.	Suprihati, 2007
Crop rotation	Wet land rice to upland crops reduce CH <sub>4</sub> emission very significantly (Proposed mitigation option)	Iswandi <i>et al.</i> (2007) (this publication)
System of Rice Intensification (SRI)	Intermittence irrigation, less in organic fertilizer, young seedling, single seed, wider space with and without organic matter amendment: 78 rice yield increase; 20% less input; 40% less water; 50% less inorganic fertilizers (Proposed mitigation option)	Iswandi <i>et al.</i> (2007) (this publication)

## ADDITIONAL OPTIONS OF GHG MITIGATION

### Crop rotation in wetland rice field

As we aware, in Indonesia wetland rice field is the major source of GHG emission from agricultural sector. The GHG emitted from wetland rice field actually is not only methane gas but also other important GHG, i.e. CO<sub>2</sub> and N<sub>2</sub>O. So far, the study on CO<sub>2</sub> emission from wetland rice field in Indonesia is very scare, this is also the same to some degree for N<sub>2</sub>O. It is also well known that in a good irrigation management area, crop rotation between wetland rice with other upland crops is frequently done by farmers. This is not only for the economic reason to get more benefit but also to control pest and deceases. Other reason is because irrigation water for the second consecutive wetland rice is not sufficient. So, this situation could be more encouraged by government by preparing better accessibility for farmers to agricultural inputs such as seed of upland crops, fertilizers, pesticides as well as with guaranty for a better price for their agricultural yield. In the Table 4, it had been shown clearly, a tremendous amount of methane emission was reduced when the wetland rice field is cultivated with upland crops. Many cases, the source of methane emission site was converted to a sink of methane gas site. It is important also to note that the amount of methane was sink in this agricultural system was high. However, this proposed option of GHG mitigation should be evaluated intensively in the future.

### Application of System of Rice Intensification (SRI)

This system of rice cultivation developed 25 year ago in Madagascar by France pries Laulanie. The basic concept of SRI characterized by using young rice seedling (8-12 days old), a single seedling per hill, wider planting distance (30 cm x 30 cm) and intermittent irrigation water. In addition to the above characteristics of SRI, provision of

organic matter to the soil in form of compost has been recommended (Sato, 2005). This system of rice cultivation have been tested very intensively since 2002 till 2005 in 8 provinces in Eastern part of Indonesia. As much as 12.133 field trials and area of 9.429 ha had been used in this intensive on farm trials. The remarkable results were obtained i.e. an average 78% rice yield increase, 50% less inorganic fertilizers used, 40% less water consumed and 20% less input required (Sato and Uphoff, 2007). This is in line with the results of experiment done in 8 countries carried out by a variety of institutions encompassing almost 6.000 trials. The results showed that; yield increased (t/ha) 52% (range 21-105%); reduction in water use 44% (24-60%); reduction of cost of production 25% (2.2-56%); increase of the net income per ha 128% (59 -412%) (Uphoff, 2007). Currently, this system of rice cultivation are being in 30 rice producing countries. In Indonesia, this rice cultivation has just got political support from the government. President of Republic of Indonesia has given his strong support to implement this System of Rice Intensification (SRI) through Indonesia.

In relation to GHG emission to SRI, it is very obvious that SRI system more likely to emit less GHG since this system use intermittent irrigation water, less inorganic fertilizers, two of the basic options of GHG mitigation studied. In addition to these, SRI increased rice yield in average of 78%. This is the most encouraging factor for farmer to implement this option. Mostly farmers are attracted to use new option when the really got a real benefit such as increase of rice yield. Other encouraging factors are less water requirements (40%), less input (20%) and less seed needed. These all are the most important factors for farmer to adopt this option. Moreover, as national politics, the Government of Indonesia has strongly support this alternative of rice cultivation. However, none or at the very early stage of the study of GHG emission are

being done in SRI system. Therefore, an intensive study of GHG emission as well as in the other microbiological aspects of SRI are urgently needed in the near future.

In relation to this, ICAS Ibaraki University lead by Prof. Dr H. Ohta, has prepared a three-year collaborative study proposal, not only for the field experiments but also for laboratory and greenhouse experiments. The experiments will be done in Japan as well as in Indonesia.

#### POSSIBLE CONTRIBUTION OF (INDONESIAN) FARMER IN REDUCTION OF GHG EMISSION FROM WETLAND RICE FIELD

As it has been discussed in the introduction, every country in the world have to participate by any way to implement any effort to reduce GHG emission of every sector. Actually, as it has stated by leaders of states they would like to take any action to reduce GHG emission as they can. For Indonesian situation, the same as in other countries, in agricultural sector no any single mitigation is being implemented so far. This is also the case in China, India, Thailand, Philippine, Vietnam and in other countries. The contribution of agricultural sector in GHG emission in Indonesia is very big, it reach as much as 26% of the Total GHG emission in the country. Taking into account that the available mitigation option can reduce GHG emission by 50%, this means that as much as 13% of the Total GHG emission in Indonesia can be reduced. If the country like China, India and Thailand take the same action, the considerable high percentage of Total World GHG emission can be reduced. However, the main problem is how to encourage the participation of the farmer to implement the mitigation option.

We here again would like to stress that the farmers will participate in implementing the options of GHG mitigation when the farmers get a real benefit from the options such as increase of rice yield, reduce fertilizer consumption, consume less irrigation water and need less input. These benefits benefit are only provided by SRI system of rice cultivation. However, this suggested option should be intensively evaluated.

In Indonesia situation, there is a strong power to implement GHG mitigation option through SRI, since SRI has got political will of the Indonesia Government. However, the implementation of SRI as an alternative option of GHG mitigation should be back-up by intensive scientific study.

#### CONCLUSIONS

In rice producing countries such as Indonesia, farmers can contribute significantly in reducing GHG emission. Some of the GHG mitigation options are available but none of these option is being implemented by farmer. Crop rotation in wetland rice field between wetland rice cultivation with upland crops is one of additional option proposed. The other GHG mitigation option that probably more attractive to farmer to implement is SRI. Through Sri implementation, the farmers get many direct benefit. Moreover, in Indonesia, SRI has got a strong

support from government. However, the study of the usefulness of SRI as option on GHG mitigation should be studied intensively.

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