Reduction and Quantification of the Impact of Greenhouse Gas Emission from Irrigated Rice into the Climate Change

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Mémoire

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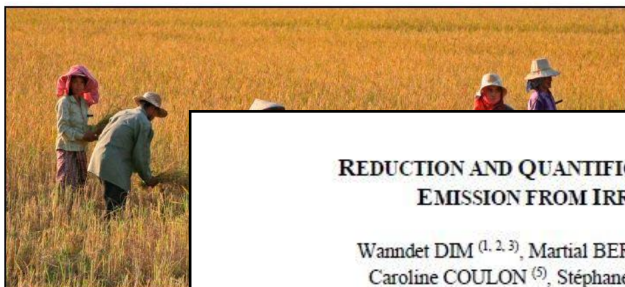
Impacts de la riziculture d'Asie du Sud-Est sur le changement climatique: comparaison des méthodes d'évaluation



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NOTES DE SYNTHÈSE | RIZICULTURE ET CHANGEMENT CLIMATIQUE

COMMENT QUANTIFIER ET RÉDUIRE LES IMPACTS DE LA RIZICULTURE IRRIGUÉE SUR LE CHANGEMENT CLIMATIQUE ?

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COSTEA
Pour une irrigation durable

Reduction and Quantification of the Impact of Greenhouse Gas Emission from Irrigated Rice into Climate Change

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Abstract

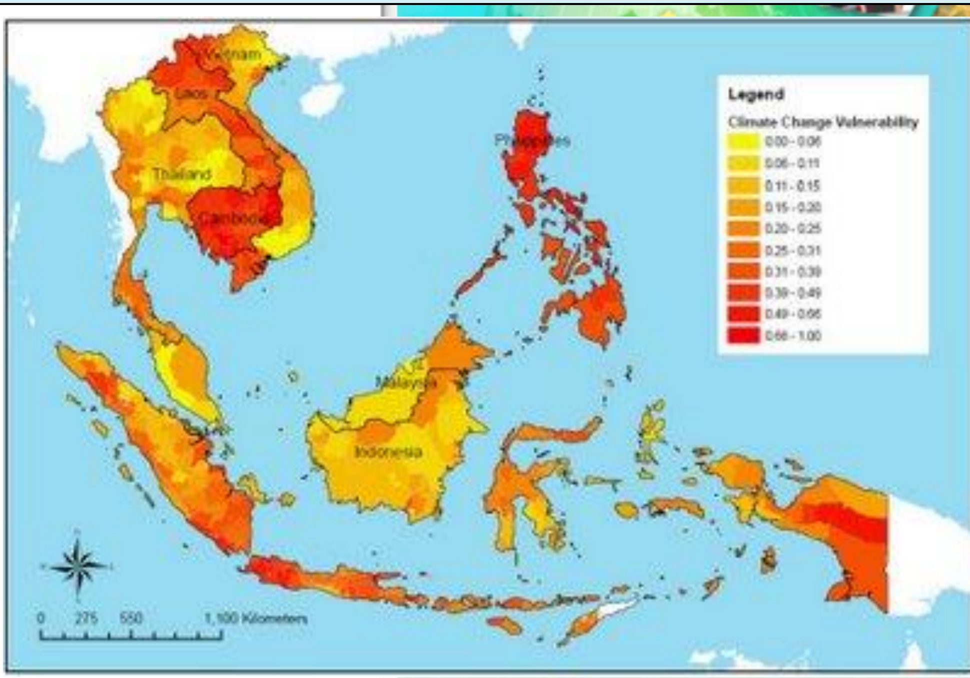
Globally rice is a crucial crop for the most ingredients provides food consumption with substantial environmental impacts. Based on the International Rice Research Institute (IRRI), rice typology has been divided into 4 systems: upland, rainfed lowland, deep-water, and irrigated rice. The result shows the significance of greenhouse gas (GHG) emission on environmental impacts with EX-Ante Carbon-balance Tool (EX-ACT) apply in Southeast Asia countries. In the irrigated rice systems, water management such as irrigation and drainage is a key issue in controlling the amount GHG emitted in both of Tier1 and Tier2. Depending of the level of drainage, the emissions of methane (CH_4) can be reduced by a factor up to 4 or 5. The irrigated rice (IR2) in wet season was flooded precision greater than 30 days and continuously flooded in water regime of cultivation has the most emit to the atmosphere. Its system is without drainage presents the highest emissions (7.78 tCO_2-eq/ha/cycle), while the drainage at least once during the season reduced the emissions (2.29 tCO_2-eq/ha/cycle). For IR2 with the straw incorporated shortly greater than 30-days before cultivation, it contributes large amount emission (23.47 tCO_2-eq/ha/cycle); by comparing to straw incorporated long greater than 30-days, compost, farmyard manure and green manure before cultivation are different 42, 62, 54, and 67 percentages, respectively.

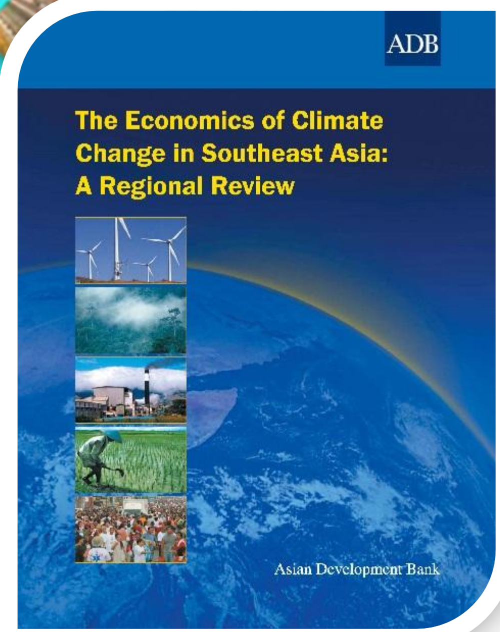
Keywords: *EX-ACT, greenhouse gas, methane (CH_4), and irrigated rice*

Impacts of Climate Change in Southeast Asia

The Intergovernmental Panel for Climate Change 4th Assessment Report (*IPCC, 2007*) states the Southeast Asia was expected to be seriously affected by the adverse impacts of climate change.

Since the economy of those countries relies on agriculture and natural resources as primary income (*Westphal et al., 2013*). Climate change ***has been and will continue*** to be a critical factor affecting productivity in the whole regions.





- IPCC, 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change…
- Westphal, M.I., Hughes, G., Brömmelhörster, J., Asian Development Bank (Eds.), 2013. Economics of climate change in East Asia…

INTRODUCTION

Phenomena events in Southeast Asia

Floods in Cambodia, 2011
Photo credit: Evangelos Petratos EU/ECHO

Tacloban in the Philippines, 2013
Photo credit: Trocaire via Wikimedia Commons

Udon Thani province, 2014
Photo credit: EPA/Barbara Walton

- In the last five years, there has been an increase in the number of floods and periods of drought, and some of the most devastating cyclones.
- In Indonesia, the Philippines, Thailand and Vietnam, the annual mean temperatures are projected to rise by 4.8 degree census by 2100, and the global mean sea level will increase by 70 cm during the same period (ADB, 2009).

- ADB, 2009. The Economics of Climate Change in Southeast Asia: A Regional Review

INTRODUCTION

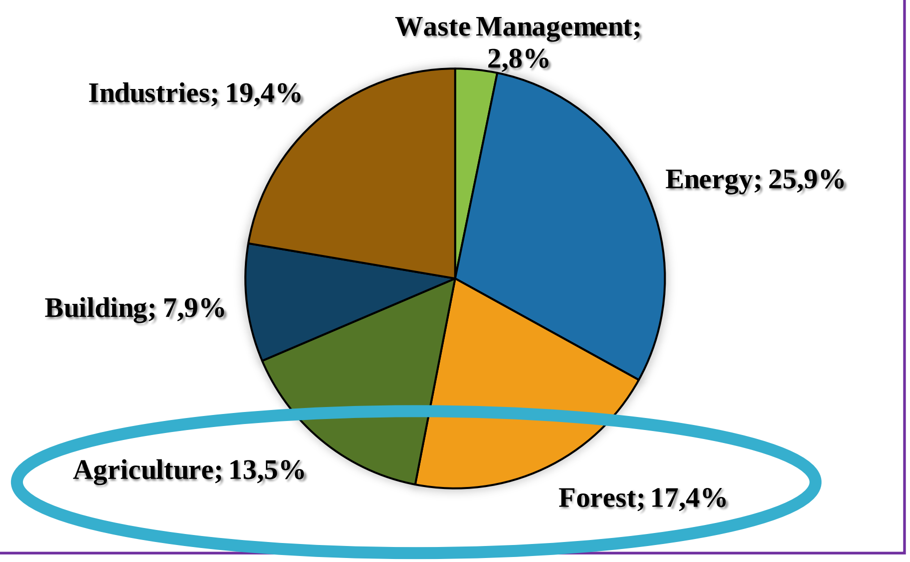
Agriculture, Forestry, and Other Land Use (AFOLU) sector

- Agriculture, Forestry, and Other Land Use (AFOLU) sector plays a central role for food security and it is a critical resource for a sustainable development.
- Agriculture's domain stays at the top of globalization in which for providing food for 7 billion habitants (IPCC, 2014).

AFOLU is responsible for ***a quarter*** of global greenhouse gases (GHG) emission.
The agriculture sector has consider as a mitigation potential source and as a major source of GHG and directly contributing to *14%* of total global emissions (Smith et al., 2008).

About 15 $GtCO_2$-eq/year
(Thornton, 2012; Vermeulen et al., 2012)

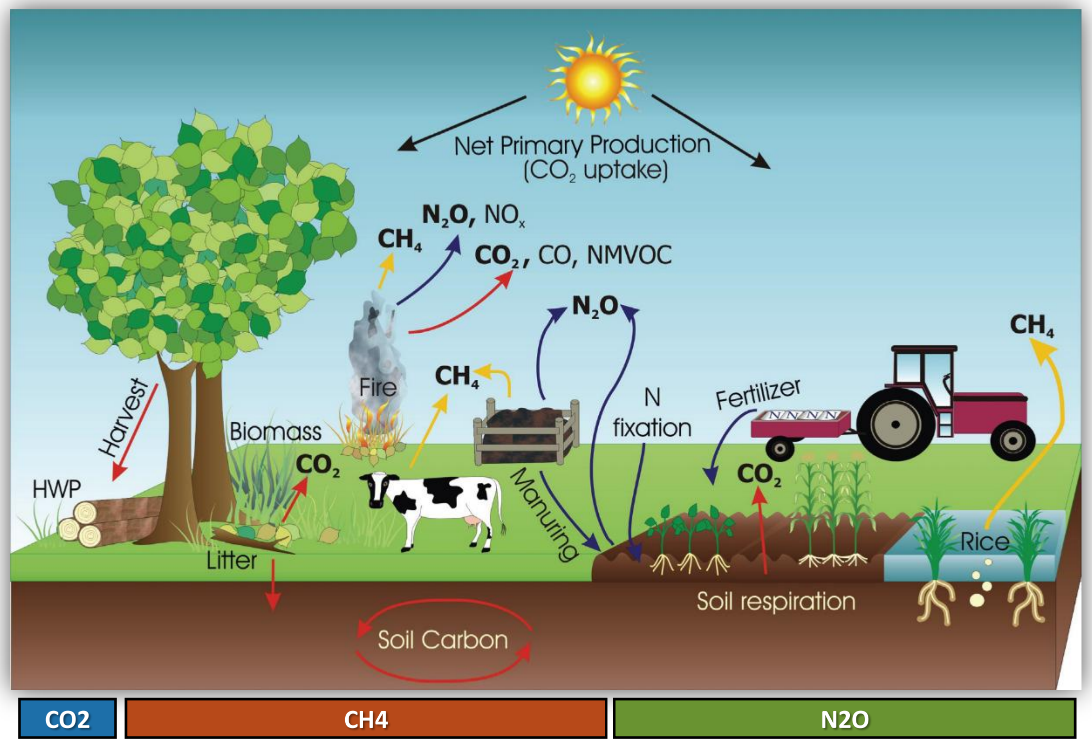
Annual greenhouse gas emission by sector



- IPCC, 2014. Climate change 2014: mitigation of climate change: Working Group III contribution to the Fifth Assessment Report of the Intergovernmental …
- Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., … , 2008. Greenhouse gas mitigation in agriculture
- Thornton, P.K., 2012. Recalibrating food production in the developing world: Global warming will change more than just the climate
- Vermeulen, S.J., Campbell, B.M., Ingram, J.S.I., 2012. Climate Change and Food Systems. Annu. Rev. Environ. Resour.

Major sources of emission from agriculture

Carbon dioxide CO_2, methane CH_4 and nitrous oxide N_2O are the atmosphere significant emissions from agriculture where together account for approximately one-fifth of the annual increase in radioactive forcing of climate change (Cole et al., 1997).

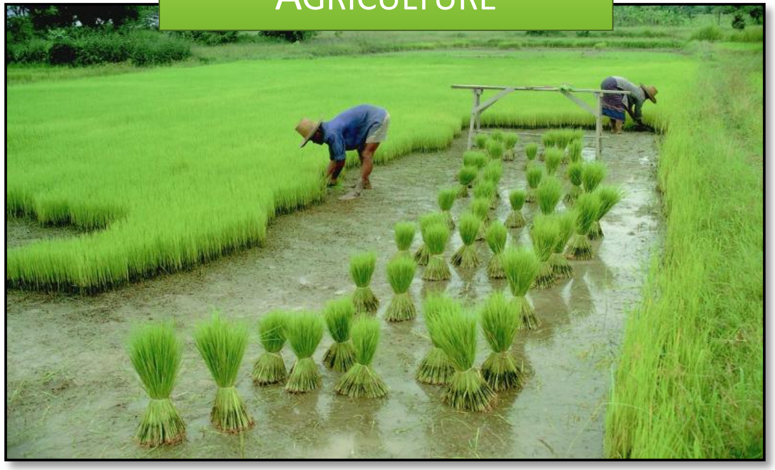


- Cole, C.V., Duxbury, J., Freney, J., Heinemeyer, O., Minami, K., Mosier, A., Paustian, K., Rosenberg, N., Sampson, N., Sauerbeck, D., others, 1997. Global estimates of potential mitigation of greenhouse gas emissions by agriculture. Nutr. Cycl. Agroecosystems 49, 221–228

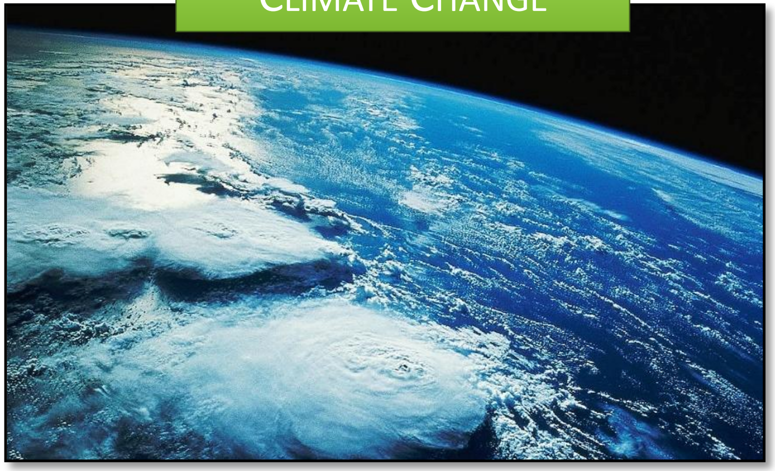
Global mitigation potential on agriculture

Many rural development projects promoting the adoption of sustainable agriculture and land management practices could play an important role in mitigation, either by reducing emissions or by sequestering carbon (Palmer and Silber, 2012).

AGRICULTURE



CLIMATE CHANGE



- cropland management, (Bernoux et al., 2003)
- improve animal production,
- management of livestock waste,
- management of irrigation water,
- nutrient management and etc... (Cerri et al., 2010).

- Palmer, C., Silber, T., 2012. Trade-offs between carbon sequestration and rural incomes in the N'hambita Community Carbon Project, Mozambique
- Bernoux, M., Volkoff, B., Carvalho, M. da C.S., Cerri, C.C., 2003. CO_2 emissions from liming of agricultural soils in Brazil. Glob. Biogeochem
- Cerri, C.C., Bernoux, M., Maia, S.M.F., others, 2010. Greenhouse gas mitigation options in Brazil for land-use change, livestock and agriculture

Global mitigation potential on irrigated rice system

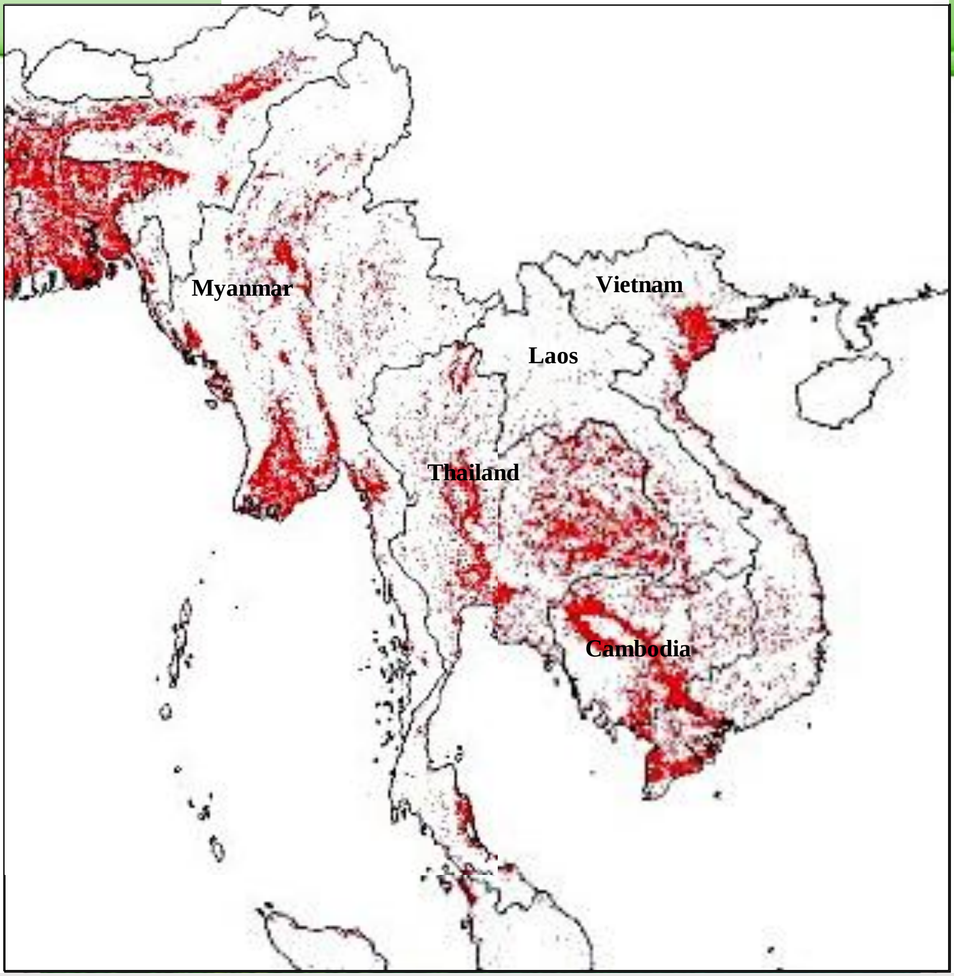
- A global potential estimates mitigation of 770 $MtCO_2$-eq/yr by 2030 from improved energy efficiency in agriculture e.g., through reduced fossil fuel use (R. Lal, 2004; Smith and Conen, 2004).
- The mechanisms of rice for methane emissions specifically related to rice under submergence, leaving aside voluntarily emissions of other gases, inherent in any farming activity.
    - Irrigated rice is not only the largest source of CH_4 but also the most promising target for mitigating CH_4 emissions from rice as state in Southeast Asia (Wassmann et al., 2000).
    - Then, the EX-ACT tool designed to assess rural development projects in terms of their carbon footprint for this rice system. It presents a series of simulation results of methane emissions for different rice typologies. In different driving scenarios are including rice systems with introduce different practical changes in the management of water or overlooked at the contributions of organic amendment matter that influence methanogenic process.

- R. Lal, 2004. Soil carbon sequestration to mitigate climate change. Geoderma 123, 1–22. doi:10.1016/j.geoderma.2004.01.032
- Smith, K.A., Conen, F., 2004. Impacts of land management on fluxes of trace greenhouse gases. Soil Use Manag. 20, 255–263. doi:10.1079/SUM2004238
- Wassmann, R., Neue, H.U., Lantin, R.S., Makarim, K., Chareonsilp, N., Buendia, L.V., Rennenberg, H., 2000. Characterization of methane emissions …

Objective

A discussion on the margins of reducing methane emissions from irrigated-rice cultivation and on the assessment of impacts of organic amendment technique in a wider view incorporating other externalities of that production.

Study area

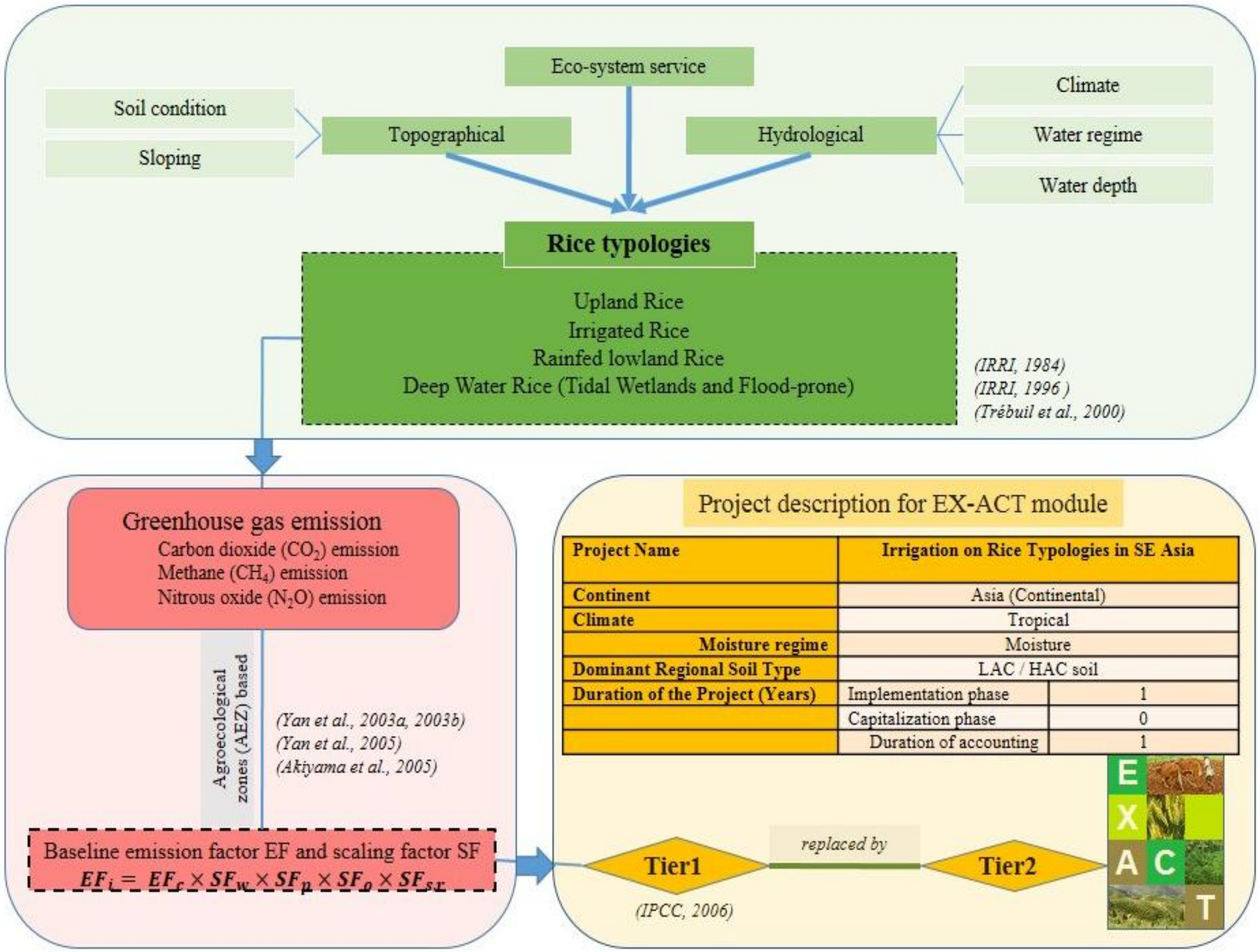


Spatial distribution of paddy rice derived from analysis of Moderate Resolution Imaging Spectroradiometer (MODIS) 8-day surface reflectance data in 2002 for South-East Asia, the resultant paddy rice map has a spatial resolution of 500 m, *(Xiao et al., 2006)*

- Xiao, X. et al., 2006. Mapping paddy rice agriculture in South and Southeast Asia using multi-temporal MODIS images. *Remote Sensing of Environment*, 100(1), pp.95–113

MATERIALS AND METHODS

Calculation procedure



Project Name	Irrigation on Rice Typologies in SE Asia	
Continent	Asia (Continental)	
Climate	Tropical	
Moisture regime	Moisture	
Dominant Regional Soil Type	LAC / HAC soil	
Duration of the Project (Years)	Implementation phase	1
	Capitalization phase	0
	Duration of accounting	1

- Trébuil, G., Hossain, M.A., 2004. Le riz: enjeux écologiques et économiques, Mappemonde (France). 1275-2975, (no. 2004). Belin, Paris
- Yan, X., Yagi, K., Akiyama, H., Akimoto, H., 2005. Statistical analysis of the major variables controlling methane emission from rice fields. Glob. Change …
- Akiyama, H., Yagi, K. & Yan, X., 2005. Direct N $_2$ O emissions from rice paddy fields: Summary of available data: N $_2$ O EMISSIONS FROM RICE FIELDS …

MATERIALS AND METHODS

Baseline emission factor

Tier1

The IPCC default for EF_C is 1.30 $kgCH_4$/ha/day (with an error range of 0.80 - 2.20), estimated by a statistical analysis of available field measurement data (Yan et al., 2005).

According to the development of region-specific emission factors and estimation of CH_4 emission from rice fields in the South-East Asia countries or based on the FAO-AEZ, (Yan et al., 2003).

Tier2

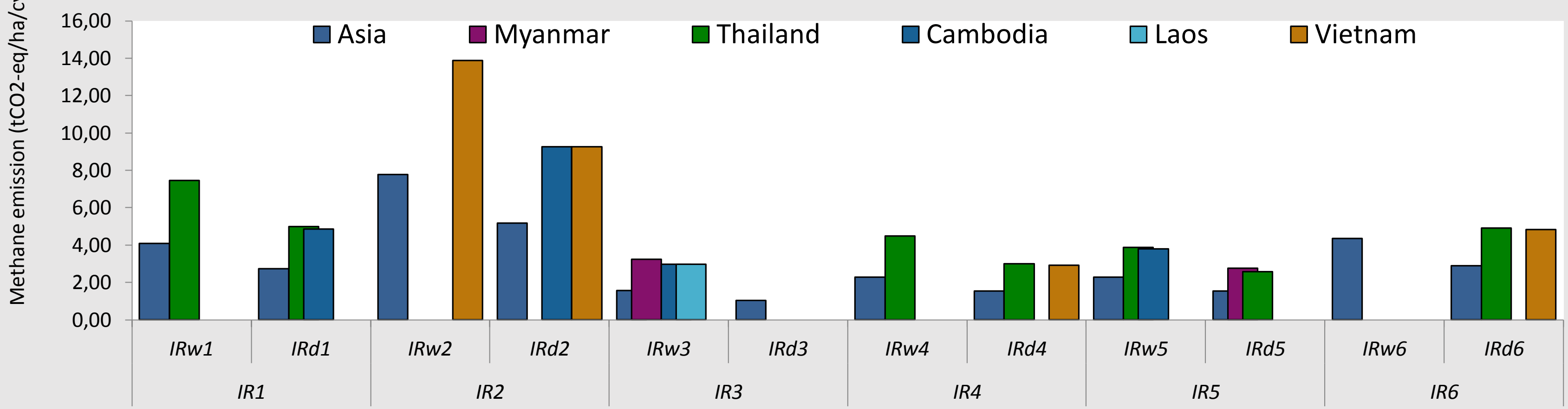
Table 1: CH_4 emission factors ($kgCH_4$/ha/day) for various countries in Southeast Asia

Agro Ecological Zones	Country and region		Irrigated	Rainfed	Deep-water
FAO-AEZ 2	Myanmar		2.5176	1.7058	2.880
	Thailand	Northern	2.0400	1.4400	0.7440
		Northeastern	3.1200	2.2008	
		Central	1.9584	1.3824	
		Eastern			
		Southern			
FAO-AEZ 3	Cambodia		2.3208	1.4544	1.4616
	Laos				
	Vietnam				

- Yan, X., Ohara, T., Akimoto, H., 2003. Development of region-specific emission factors and estimation of methane emission from rice fields in the East, Southeast and South Asian countries. Glob. Change Biol. 9, 237–254. doi:10.1046/j.1365-2486.2003.00564.x
- Yan, X., Yagi, K., Akiyama, H., Akimoto, H., 2005. Statistical analysis of the major variables controlling methane emission from rice fields. Glob. Change Biol. 11, 1131–1141. doi:10.1111/j.1365-2486.2005.00976.x

Methane emission estimation from irrigated-rice system

Methane emission (tCO2-eq/ha/cycle) for different types of irrigated rice systems with different countries in wet and dry seasons



IR1: non flooded preseason least than 180 days, continuously flooded and without aeration

IR2: flooded preseason greater than 30 days, continuously flooded and without aeration

IR3: non flooded preseason greater than 180 days, intermittently flooded and with single aeration

IR4: non flooded preseason least than 180 days, intermittently flooded and with single aeration

IR5: non flooded preseason least than 180 days, intermittently flooded and with multiple aeration

IR6: flooded preseason greater than 30 days, intermittently flooded and with multiple aeration

- The value of tier1 (Asia) comparing to others has a half different based on to their emission factor baseline in tier2 (Myanmar, Thailand, Cambodia, Laos and Vietnam).
- IR2: continue flood preseason greater than 30 days is the most significant emission factor in the atmosphere while it is suggested to the country where have *twice or triple* of rice cultivation per cycle.

RESULTS AND DISCUSSION

Share a different vision of irrigated rice system

- Convention on wetlands of international protected by the Ramsar Convention of 1971 under "**their economically valuable resource, cultural, scientific and recreational value, the loss would be irreparable**", also contribute heavily in the balance sheet of methane flux: 174 $MtCH_4$/year by about 5 million km^2 of wetlands, i.e. an average emission of ***283 $kgCH_4$/ha/cycle***. This compares with the estimate by EX-ACT of ***279 $kgCH_4$/ha/cycle*** (or 7.78 tCO_2-eq/ha/cycle) issued by the IRw2.
- These findings view a change of angle to assess the impacts of rice under all its functions performed. Thus, the flooded rice fields is a surface water which have a refreshing effect on the local climate and help to control GHG emission.

RESULTS AND DISCUSSION

Comparative environmental impacts for different organic amendment type on the continuously flooded

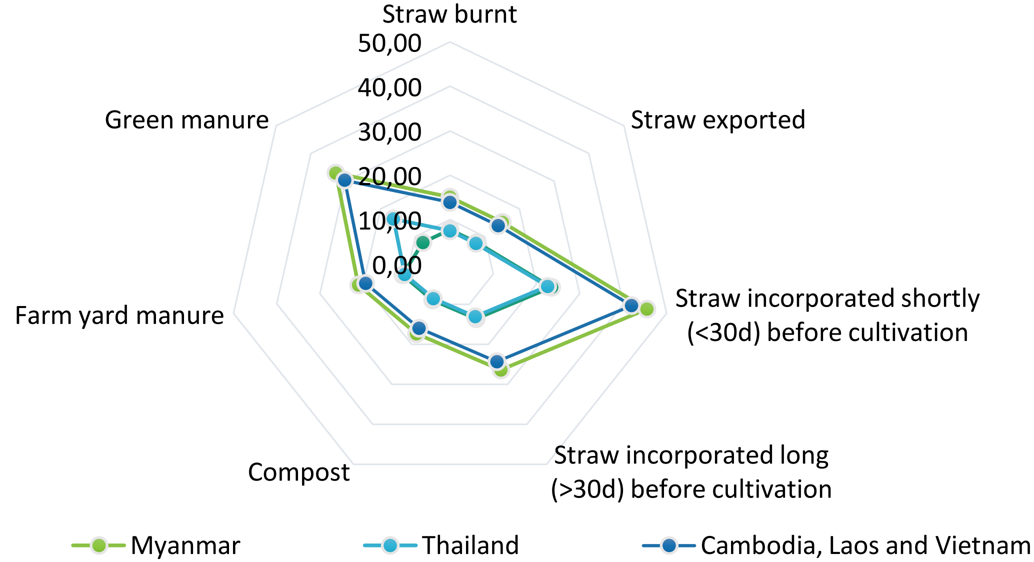
- Based on *Yan et al., (2005)* the straw incorporated shortly greater than 30-days before cultivation has much emission in tier2.

Myanmar: 45.46 tCO_2-eq/ha/cycle,

Cambodia, Laos and Vietnam: 41.91 tCO_2-eq/ha/cycle,

Thailand: 22.55 tCO_2-eq/ha/cycle

Comparative CH4 emission (tCO2-eq/ha/cycle) in different countries in wet seasons



- Margin emission reduction by rice can also be found in the ***straws management*** (except the straw incorporated shorty before cultivation in 30-days), which should be finding new valuation opportunities, and economically attractive for farmers to replace their landfills.
- The feasibility territory-wide in tier2 is should to produce more on straw, compost or farm yard mature rather than deliver green manure.

- The EX-ACT tool show a well result in the first approach with the parameters proposed tier1:
  - ✓ apprehend the different types of rice systems,
  - ✓ different emission of methane on cultivated reference surfaces irrigated rice ***emit more*** than inundated surfaces.

- The irrigated rice (IR2) has a highest emissions (***7.78 tCO_2-eq/ha/cycle***), while the drainage at least once during the season reduced the emissions (***2.29 tCO_2-eq/ha/cycle***).

- Water management such as irrigation and drainage is key issue in controlling the amount GHG emitted. Deeping of the level of drainage, the impact on the GHG emissions can be changed by a factor up to ***4 to 5***.

- The residues burning in irrigated area has ***small amount of emission of CH_4*** as compares to the straw residues.

- For IR2 with the straw incorporated shortly greater than 30-days before cultivation, it contributes large amount emission (***23.47 tCO_2-eq/ha/cycle***); by comparing to straw incorporated long greater than 30-days, compost, farmyard manure and green manure before cultivation are different 42, 62, 54, and 67 percentages, respectively.

Thank you for your kind attention!!!