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Strategic Rice Cultivation for Sustainable Low Carbon Society Development in Southeast Asia

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ABSTRACT: This research work focused on the assessment and identification of strategic rice cultivation practices, i.e. rotation with energy crops, to enable Southeast Asia (SEA) to develop towards a self-sufficient low carbon society, thereby contributing to global warming mitigation and climate change adaptation. The results indicate that to rotate the cultivation of rice with the cultivation of selected energy crops is a good strategy to reduce greenhouse gas (GHG) emissions and would contribute to increased soil carbon storage in the long term. The expansion of this strategy to all of SEA would not only contribute to enhancing biomass resources utilisation for biofuel and bioenergy, but would also alleviate the competition faced for planting food and fuel crops while minimising land-use change. Moreover, such strategic practices would help increase the carbon sink potential of the agricultural sector and enhance the welfare of rural communities. However, the existence of a market for energy crops is a prerequisite for the successful implementation of such a practice in the region. It is, therefore, imperative to formulate and implement clear policies on renewable energy and biomass utilisation, which should be strongly promoted both at the country and SEA regional levels.

KEYWORDS: *rice, energy crops, climate change, low carbon agriculture, soil carbon stock, GHG emission*

Introduction

Southeast Asia (SEA) covers an area of 410 million hectares and agricultural land represents about 20% of the total area. Over the past decades, agricultural land has been expanding in SEA, some into previously forested areas. Such land-use changes reflect the development of intensive agriculture, which is a major economic activity in SEA. According to the Food and Agriculture Organization (2012), rice plantation covers an area representing about 12.5% of global crop plantation area (see FAOSTAT data available at http://faostat.fao.org/). This translates into rice production amounting to 659 million tonnes in 2012, contributing US$ 164 billion to the world economy.

SEA represents the largest area of rice plantation coverage representing 30% of the world plantation. Maximising rice yield in this region is, therefore, essential to increasing global food stock. Nevertheless, the current climate and energy crisis strongly influence the regional potential of rice production. Temporary or permanent conversion of rice plantation into plantation of oil palm or other energy crops has already taken place in many SEA countries, notably Thailand and Indonesia.

HIGHLIGHTS

- » Cultivation of energy crops in rotation with rice is a good strategy to reduce GHG emissions in rice fields.
- » Strategic rice cultivation practices can enable SEA to move towards development of a sustainable low carbon society.
- » Sustainable low carbon agriculture can help address the competition between food and fuel crop cultivation while enhancing carbon sink potential and increasing welfare of farmers in SEA.

The present study aimed at identifying strategic rice cultivation practices that would help tackle both climate and energy security issues, by rotating rice with energy crops in order to fully utilise the rice plantation fallow period, hence optimising rice and energy feedstock production. The proposed cultivation practices aim at reducing GHG emissions while increasing potential

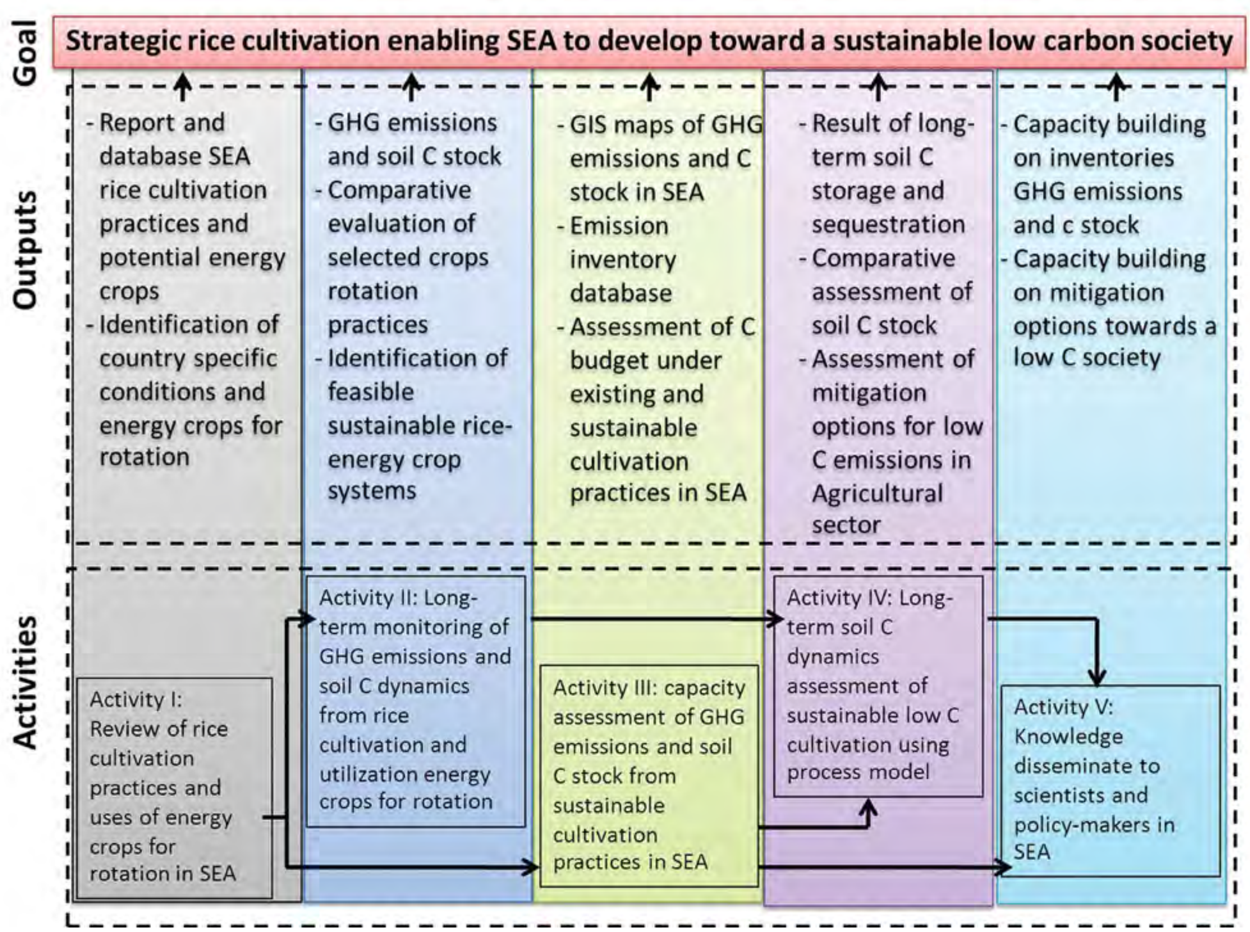

Figure 1. Research framework.

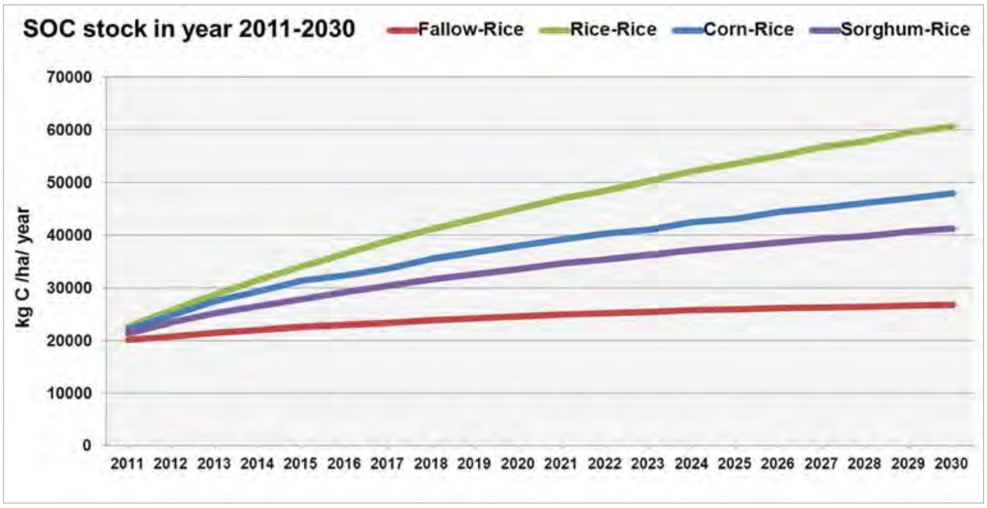

Figure 2. Simulation of annual SOC dynamics over 20 years.

long-term soil carbon stock by optimising land-use change and cultivation practices. Sustainable development is considered in terms of enhancing economic and social benefits while developing a low carbon society to bring down net GHG emissions and increase soil carbon stock.

Methodology

Several activities were undertaken in order to evaluate strategic rice cultivation practices, starting with an assessment of the current status of rice cultivation practices in SEA and of potential crops that can be used in rotation with rice. Such information was collected via a literature survey, a meeting of experts, and a questionnaire survey that was conducted in Thailand and Indonesia. Following this initial assessment, we evaluated the long-term GHG emissions and soil carbon dynamics of various rice cultivation systems, including rotation with selected energy crops (corn and sorghum), at an experimental site in Thailand.

Socio-economic considerations associated with such practices were then taken into account to come up with possible options for strategic rice cultivation in rotation with energy crops. The data generated from this assessment served as input to the Agriculture and Land Use (ALU) software[1] and the DeNitrification-DeComposition simulations (DNDC) model[2] to investigate GHG emissions, carbon stock and soil carbon dynamics for various scenarios of rice cultivation systems.

While the simulations were performed first only for the case of Thailand, where experimental data on GHG emissions had been generated and soil carbon measurements had been performed — it is possible to expand the simulations to other SEA countries, including Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, and Viet Nam. The overall research framework of this study is illustrated in Figure 1.

Results and Discussion

Project investigations found that in ASEAN countries, rain-fed rice fields occupy an area of 19.8 million hectares. Such coverage represents almost half of the total area of rice cultivated in the region. These fields are used for only 4 to 5 months per year with single cultivation, while for the rest of the year the land is

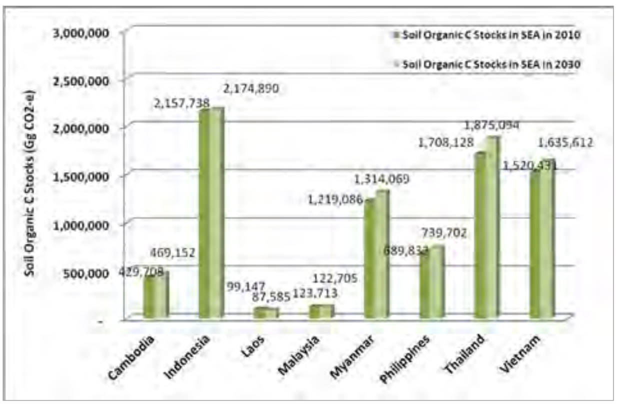

Figure 3. SOC stocks in SEA in 2010 and 2030 with implementation of rotating cultivation of energy crop and rice.

1 The ALU software is publicly available at http://www.nrel.colostate.edu/projects/ALUsoftware/

2 The DNDC biogeochemistry model is available online at http://www.dndc.sr.unh.edu/

left to lie as fallow.

The project investigations revealed that sustainable low carbon agriculture through improved practices of rice cultivation, particularly, through rotation with energy crops during fallow period, is a sustainable and strategic rice cultivation option to follow. There are three main reasons supporting this finding as detailed below.

In terms of environmental performance, rotation with energy crops in rain-fed areas can reduce annual GHG emissions and increase soil organic carbon (SOC) storage over the long term. As seen in Figure 2, DNDC simulations indicate that significant changes in SOC could be achieved over 20 years.

Similar trends were observed across various crop rotation systems that were investigated. SOC contents for the crop rotations rice-rice, corn-rice and sorghum-rice were observed to increase over the simulated period 2010–2030. The highest rate of increase in SOC was observed for double cropping of rice, which is due to, as demonstrated in our experiment, the incorporation of crop residue into the soil. The results show that SOC storage for rice-rice, corn-rice and sorghum-rice systems are 42%, 33% and 25% higher, respectively, than the baseline (fallow-rice crop system).

For the eight SEA countries investigated in the present project, the SOC stock change of rice cultivation was also estimated using ALU for the period 2010–2030 based on rotated cultivation of rice and energy crops. The results are reported in Figure 3. They indicate that Thailand is the country with the highest gain, followed by Viet Nam and Myanmar.

The results obtained from both the DNDC model and ALU software showed that long-term implementation of energy crop rotation using corn and sorghum can contribute to enhancing SOC as compared to having either rain-fed rice cultivation with fallow land instead in that period. Results from ALU also show that, for most countries in SEA (except Lao PDR and Malaysia), rice fields can act as a carbon sink.

It was also found that farmers would benefit from gaining additional income as a result of producing several crops, instead of just rice as in the monoculture system. Thus, for instance, rice rotation with either corn or sorghum brings 1.5 and 1.7-fold increases in income, respectively, over a single rice rain-fed cultivation with fallow land instead in that period. to farmers than opting for only rice rain-fed cultivation. In terms of land-use change and competition with food crops, introducing a crop rotation system can help avoid this as the same area of land is used to cultivate two kinds of crops.

Conclusions

The results of this study are in line with reports from IPCC which indicate that the agricultural sector offers a promising carbon sink potential, particularly in Asia. Indeed, the results of this research work indicate that rice fields could provide an interesting carbon sink potential if appropriate cultivation practices were to be implemented, i.e. rotation with energy crops.

In SEA, the types of energy crops that can be cultivated in rotation with rice in rain-fed ecosystems can differ between countries depending on physical and ecological characteristics. Corn and sorghum were selected as suitable rotation crops because of

Figure 4. Photos of energy crop and rain-fed rice.

their short life, low water requirement and their potential for conversion to bioenergy, including biofuel.

However, to successfully implement such rotation systems depends on the existence of a market for energy crops. The formulation and implementation of clear policies on renewable energy and biomass utilisation are therefore necessary and should be promoted.

The knowledge generated from this project was disseminated to ASEAN countries through expert meetings of experts and training events. Country reports on rice cultivation including potential of energy crops for rotation during fallow period were exchanged and discussed. This project also built the capacity building of scientists and policy makers in the region in assessing the influence of alternative cultivation practices on soil carbon stock and GHG emissions were performed. The events organised over the course of this research work aimed at providing an opportunity for multilateral communications and exchange of experiences and knowledge among ASEAN participants and experts on rice cultivation practices. Through these activities, a network of ASEAN countries was established, involving particularly, Cambodia, Myanmar, Indonesia, Japan, Viet Nam and Thailand, enabling potential further collaboration in the future on strategic rice cultivation in the region.

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PROJECT TITLE

Strategic Rice Cultivation for Sustainable Low Carbon Society Development in Southeast Asia

COUNTRIES INVOLVED

Indonesia, Japan, Thailand

PROJECT DURATION

Two-year project

APN FUNDING

US$ 80,000

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