6 Low Carbon Agriculture for Indonesia: Challenges and Opportunities

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- Agriculture plays an important role in the national economy and food security of Indonesia. Increasing food production, while not adversely impacting the climate and local environment, is a challenge to be met.
- Indonesia has set an economy-wide emission reduction target of 20%. This would require rapid and substantial scaling up of mitigation technologies in agriculture sector as well. Prioritization of mitigation technologies is important from the context of policy focus. Such a prioritization is possible through estimation of marginal abatement costs and cost-benefit analysis of mitigation options.
- While some mitigation technologies have already been promoted, it is far from being sufficient in meeting the sectoral mitigation target. The major barriers for expanding these technologies have been lack of proper incentives for technology adoption and capacity building of farmers.
- The best way to enhance the efficiency of a technology is to target it to the specific ecosystem conditions. While focusing on individual technologies, there is a need to consider how these technologies behave in the existing context of knowledge and infrastructure on the ground.

6.1 Introduction

Indonesia is an agrarian economy with agriculture contributing to 13.8% of national GDP in terms of value addition and employs 38% of Indonesian population. The government of Indonesia has made serious efforts to improve the food self sufficiency and nutritional security over the past decade. The national expenditure on agriculture stood at 21.9 trillion IDR in 2007, which is double the expenditure made in 2001 (The World Bank, 2008). Despite the rising investments in agriculture, Indonesia is still a net importer of cereals, pulses and sugar and is facing the challenge of hunger and malnutrition with nearly 38% of its children suffering from under weight and malnutrition. Indonesia is classified as ‘serious’ in global hunger index by International Food Policy Research Institute (IFPRI).

While the above challenges are yet to be fully addressed, the climate change brings another dimension of challenge to the Indonesian agriculture which includes it being vulnerable to the climate change impacts while also contributing to the climate change (Las & Unadi, 2010). Agriculture contributes to climate change in both direct and indirect means. As a direct source,

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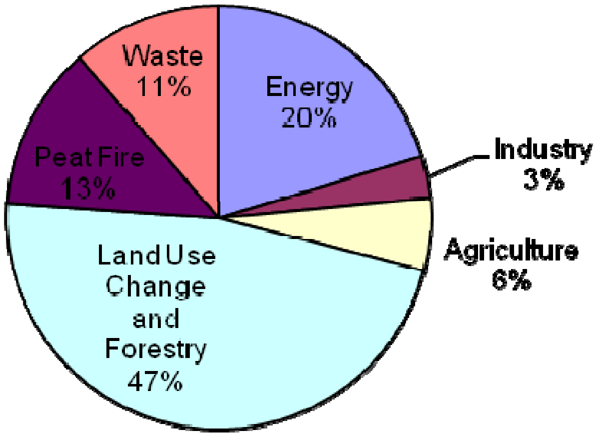
Indonesian agriculture contributes to about 6% of total greenhouse gas (GHG) emissions and the sector stands fourth after land use, land use change and forestry, fuel combustion, and waste sectors. The major contributors of GHG emissions in agriculture sector are rice paddies (Methane emissions to the tune of 34,860 GgCO2e), soil fertilizations (nitrous oxides emissions to the tune of 15,534 GgCO2e), and other minor sources such as emissions from manure piles, biomass burning etc (to the tune of 12,271 GgCO2e) (Suryahadi & Permana, 2010).

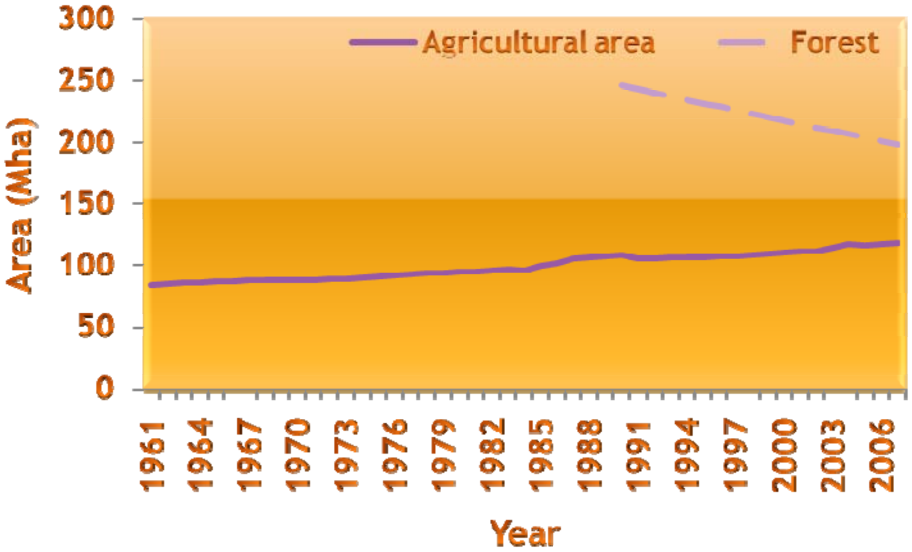
Figure 6.1. GHG emissions from various sectors in Indonesia



Source: Las and Unadi 2010

The indirect contribution of agriculture to GHG emissions is through demand for land. The growing population exerts pressure on food that in turn exerts pressure on land and other sources forcing intensive cultivation practices such as fertilizer applications and irrigation water pumping. In a scenario of increasing population, the agriculture is expected to produce more food either through vertical expansion (increase in productivity) or through the horizontal expansion (land use changes from forests to agricultural purposes). In Indonesia, both these phenomenon can be seen in the recent past. The productivity levels of Indonesian agriculture have increased over the years and more specifically in food crops such as rice. The rice productivity has more than doubled over a period of 40 years (FAO, 2010), mostly due to employment of high yielding varieties, irrigation, fertilizers, and pesticides. At the same time, the cereal demand during the past four decades has also increased from 10 million tons in 1961 to 39 million tons in 2005 (FAO, 2010). In order to meet this demand, over the same period, the area under primary crops has increased by 113% and the area under agriculture has increased by 25.6% while the area under forests has reduced by 38% in the last two decades alone (FAO, 2010). This partially indicates that agriculture has played a role in converting the land under forests to agriculture in Indonesia. This is in conformity with the trend observed in the Southeast Asia (Figure 6.22.).

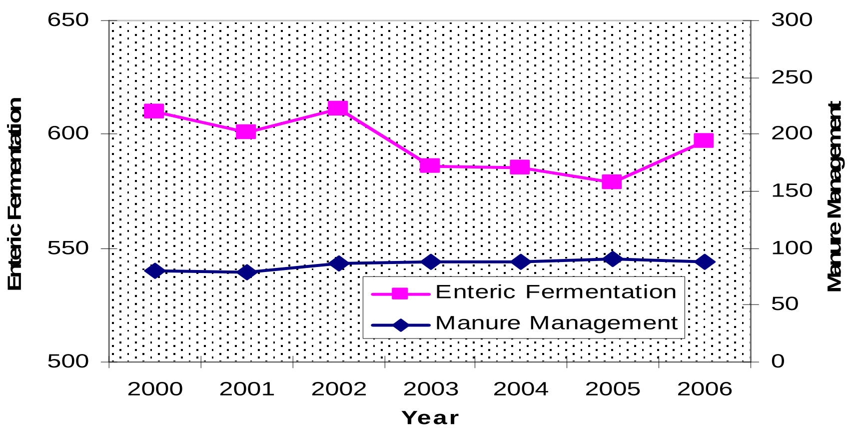
Figure 6.2. Expansion of area under agriculture with concomitant decline in area under forests in Southeast Asia



Source: Prabhakar 2010

Indonesia is a major non-vegetarian population. With growing income levels, the per capita consumption of animal products is also increasing over the years. As result, the emissions from animal husbandry are significant in Indonesia. The enteric fermentation contributes to the tune of 12,755 GgCO2e of methane annually. As shown in Figure 6.3, the animal husbandry related emissions have shown an increasing trend since 2003 owing to relative increase in animal population (Suryahadi & Permana, 2010).

Figure 6.3. Indonesian Methane Emission from Livestock in 2000-2006



Source: Suryahadi & Permana, 2010

If no corrective measures are taken, the above trends may continue in the future as well. Most available future projections indicate that the non-CO_2 emissions will continue to increase in agriculture sector at global and regional levels (Christensen, et al., 2007; Stern, 2007; United

States Environmental Protection Agency, 2006). Similar projections available for Indonesia also indicate an increase in agricultural emissions from 0.17 GtCO2e in 2005 to 0.25 GtCO2e by 2020. Similar projections were also made for methane emissions from the animal husbandry sector in a BAU scenario (Suryahadi & Permana, 2010).

There are several other trends that would enhance emissions from agriculture sector in the future, if unhindered. These trends include change in the source and amount of on-farm energy consumption, reducing organic matter application, and burning of paddy straw. Though the energy related emissions are, including farming, are accounted in the energy sector, the policies and interventions for reducing on-farm energy should have to come from the agriculture sector and hence it deserves particular attention in the discourse on GHG mitigation in agriculture. Trends such as increasing farm mechanization associated with rural to urban migration of population and increased groundwater pumping for irrigation can have significant impact in terms of on-farm direct energy consumption. In terms of indirect energy consumption, the declining organic matter inputs in soils necessitate increasing inorganic fertilizer use resulting in demand for crude oil. In addition, expansion of cash crops such as oil palm is projected to increase demand for fertilizers in Indonesia (Heffer & Prud'homme, 2008).

6.2 What low carbon society means for Indonesian agriculture?

From the foregone discussion, it is clear that the historical and current agro-economic situation and the current and future projected emissions from agriculture indicate a challenging puzzle i.e. GHG mitigation while meeting the food security needs of the growing population of Indonesia. From this context, the low carbon society for Indonesian agriculture means producing sufficient food for the country to meet the food and nutritional security while not degrading the environment and contributing to the climate change. As simple as it may look, the task could be difficult looking at the growing food and nutritional insecurity of the country. This requires identifying agro-technologies those will satisfy the following conditions: 1. mitigate GHG emission, 2. provide yield and income advantages, 3. lower abatement costs, and 4. provide developmental co-benefits. The following are necessary for achieving the task of GHG mitigation in Indonesia: a sound approach that identifies GHG mitigation technologies that do not impact the food production in agriculture and allied sectors, and sufficient policy environment that helps in scaling up of these GHG mitigation technologies.

6.3 Current state of low carbon agriculture in Indonesia

Low carbon agriculture is not a new concept for Indonesia since it has been implementing various policies to promote low input and organic agriculture over the past decade. Much of these policies were driven primarily not because of climate change but due to environmental degradation and food safety issues. To site an example, the subsidies that have been in existence for the long time have been known leading to the fertilizer imbalance, pesticide overconsumption and decline in factor productivity (Lesmana & Hidayat, 2008; Sano & Prabhakar, 2010). As a result, Indonesian government has been actively promoting organic agriculture as a low-input and eco-friendly agriculture. One of the significant programs to mention is the 'Go Organic 2010' program by the Government of Indonesia that aims at developing Indonesian organic agriculture as significant organic food exporter in the world. A roadmap has been developed to achieve the set goals. Though the area under low-input and organic agriculture has been growing at a steady rate, with an estimated area of 17783ha in 2005 (Willer, Yussefi-Menzler, & Soren, 2008), several limitations including poor availability of organic fertilizers, poor access to agro-technology, and high cost of organic certification are hampering the rapid expansion.

As a part of its initiative to promote environmentally friendly agriculture, the government of Indonesia has made significant investments in promoting the system of rice intensification (SRI), the technology that is known to save irrigation water, reduced seed rates, bring early crop maturity, and significantly increase the rice yields (Uphoff, 2006). Various other technologies are also being promoted which include Implementation of no-burning practices for land clearing in particular in horticulture and agriculture plantation sub-sectors, introduction of low methane emitting rice varieties (Ciherang, Cisantana, Tukad Belian and Way Apo Buru), use of agriculture waste for bio-energy and composting, biogas technology for reducing methane emission from livestock sector, and formation of R & D Consortium on Climate Change in Agricultural Sector. Several of these programs have been implemented through the '*Bantamas'* program (Las & Unadi, 2010). Though there are no statistical figures available on the extent of adoption of these technologies, the ongoing engagement with various stakeholders indicate significant efforts being invested by both the government and the non-governmental organizations in the spread of these technology using various media such as farmer field schools and climate field schools.

A speech delivered by the Indonesian President at the Conference of Parties 13 at Bali, Indonesia, outlined a three-pronged strategy to rejuvenate Indonesian agriculture sector (Las & Unadi, 2010). This include harmonization of economic development and environment conservation, to boost the capability to absorb carbon in forest, agricultural land, and ocean, and a commitment to reduce green house gas emissions in various policy initiatives. The development of agriculture sector was identified as a general strategy with both adaptation and mitigation built into it. Indonesia is the only developing country in East Asia that has announced an ambitious economy-wide mitigation target of 20% at Copenhagen. This includes a reduction of 8 MtCO2e through the support of the national budget and an additional reduction of 11 MtCO2e through the support of developed counties. The focus for agriculture sector includes food crops, estate crops, livestock, land and water management, and R&D. The plan proposes to undertake 5 main activities and 1 supporting activity for mineral soils and 2 main activities and 1 supporting activity for peat lands. The plan proposes to spend an estimated 0.7739 trillion USD for GHG mitigation from mineral and peat lands (Las & Unadi, 2010).

6.4 Low-carbon technologies for Indonesian agriculture

The research in Indonesia and elsewhere has already identified several technologies with the potential to mitigation GHG emissions (Table 6.1.) and animal husbandry sectors (Table 6.2). These technologies have already been either developed or are being adopted by farmers. This indicates that there is no dearth of mitigation technologies in agriculture and animal husbandry.

Table 6.1. List of agro-technologies that have mitigation benefits

Technology	Major Benefits
1. Zero-tillage	1. Zero-Tillage saves 70-90 L of diesel/ha 2. Saves water (to the tune of ~1.0x106 L water) 3. Farmers save USD 40-55/ha 4. Reduced/ eliminate burning of crop residues
2. Leaf color charts	1. Reduced N applications and hence reduced demand for fertilizers 2. Reduced pest incidence 3. Yield advantages
3. System of rice intensification with mid-season drainage	1. Saving in irrigation water 2. Higher yields 3. Reduced pests and diseases 4. Reduced labor costs 5. Higher income
4. Aerobic composting	1. Doest contribute to CO_2 emissions 2. Eliminates CH_4 and N_2O emissions 3. Considered as a natural cycle
5. Alternative nutrient management strategies through altering sources	1. Slow releasing fertilizers such as coated urea granules and super granules has the potential of reducing leaching losses and increased N use efficiency and reduced N usage 2. Neem coated urea/sulfur coated urea/tar coated urea formulations that inhibit nitrification leading to less N_20 emissions

Source: Prabhakar, 2010

Table 6.2. List of mitigation technologies that are either currently at adoption or development stage in Indonesia

Techniques	Methane Reduction (%)	Feed Efficiency	Animal Production	Strengths	Weaknesses
Dietary Supplementation					
1. Unsaturated fatty acid	10	Increase	+15%	Local product Simple application	Needs scaling up and in limited supply
2. Probiotic (Yeast)	8	Increase	+9	Local product Easily adoption	Needs scaling up and in inconsistent results
3. Concentrate	8	Increase	126	Easily adoption Simple application	Limited supply
4. Fish oil + Zn	54	Increase	+61.2	Local product	Needs scaling up and in limited supply
5. Ionophore Salinomycin	Decrease	Increase	+26.6%	Advanced Technology Effective	Limited supply, imported product, and poisonous
6. Mineral bypass nutrients	Decrease	Increase	22%	Local product	Need diffusion action
7. Defaunating agents	Decrease	Increase	+20%	Local product Abundant Simple application	Inconsistent result and needs maintenance
8. Urea molasses block	Decrease	Increase	+6%	Simple application Advanced technology	Need extension program
9. Leguminous	Decrease	Increase	Increase	Local resources Simple application	Limited plantation, limited use, and poisonous
Mechanical and chemical techniques					
1. Chopping and Pelleting	Increase	Increase	Expensive	-	Cumbersome
2. Sodium hydroxide	Increase 10-20	Increase	Expensive	Simple	Poison
3. Ammonia	increase	Increase	Expensive	Simple	Poison

Source: adopted from Suryahadi and Permana 2010

The next step is prioritizing these technologies for wider dissemination and adoption, both through the government driven policy initiatives and by the individual players. Such a prioritization should not only consider GHG mitigation potential but also consider yield and income advantage to the farmers. Prioritizing low carbon technologies is possible through marginal abatement cost curves, Benefit-cost analysis, and abatement cost per unit production.
Marginal abatement costs refer to the cost incurred in mitigating a unit of carbon (equivalent) emissions when compared to the business as usual scenario (Equation 2) (Prabhakar, 2010).

$$MAC = \frac{Mc}{M_{GHG}};\ Mc = C_a - C_b;\ M_{GHG} = GHG_a - GHG_b;\ GHG_a = Activity \times Ef \times Sf$$ **…Equation 1**

Where, MAC is marginal abatement cost ($\$t^{-1}$); Mc is the marginal cost of the new technology when compared to the baseline technology; M_{GHG} is marginal reductions in GHG emissions; C_a is cost of technology a; C_b is cost of technology b; GHGa is GHG emissions from technology a; and GHGb is GHG emission from technology b. Activity refers to activity data (e.g. area under particular technology or amount of biomass burnt or amount of particular fertilizer type used); Ef refers to emission factor, factor that provides GHG quantity by multiplication with the activity data; Sf refers to scaling factor, factor that modifies a sub-practice from the base line practice (e.g. intermittent irrigation as against continuous flooding).

The preliminary analysis carried out indicated that the SRI has higher potential for abatement (2016 kg CO2e per hectare per season followed by the zero-tillage systems (450 kg CO2e per hectare per season). Zero tillage has negative costs since adoption of technology saves on tillage and fuel costs while SRI could prove costly due to labor intensiveness of operations.

Figure 6.4. Marginal abatement costs of various technologies for Indonesia

Source: Prabhakar, 2010

The benefit-cost ratio (BCR) refers to the ratio of total benefits obtained per unit of cost incurred in mitigating GHG emissions (Equation 2). Various costs considered for the BCR analysis are listed in Table 6.3. The data on actual benefits and costs were obtained by interviewing farmers.

$$BCR = \frac{TotalBenefits}{TotalCosts}$$ **……………………………………………………………………Equation 2**

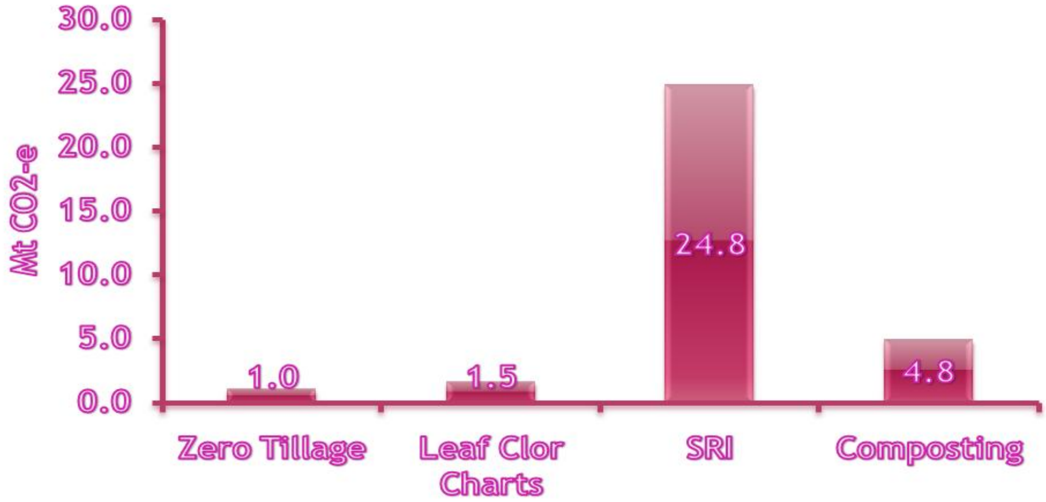
Table 6.3. List of costs and benefits considered for cost benefit analysis of various agro-technologies

Total Costs	Total Benefits[26]
Operational costs	Yield per ha (t/ha)
Human labor	Value of main product per ha
Bullock labor	Value of by product per ha
Machine labor	
Seed	
Fertilizers and manures	
Fertilizers	
Manure	
Insecticide	
Irrigation	
Interest on working capital	
Fixed cost	
Rental value of owned land	
Land tax	
Depreciation on implements and farm buildings	
Interest on fixed capital	

Source: Prabhakar, 2010

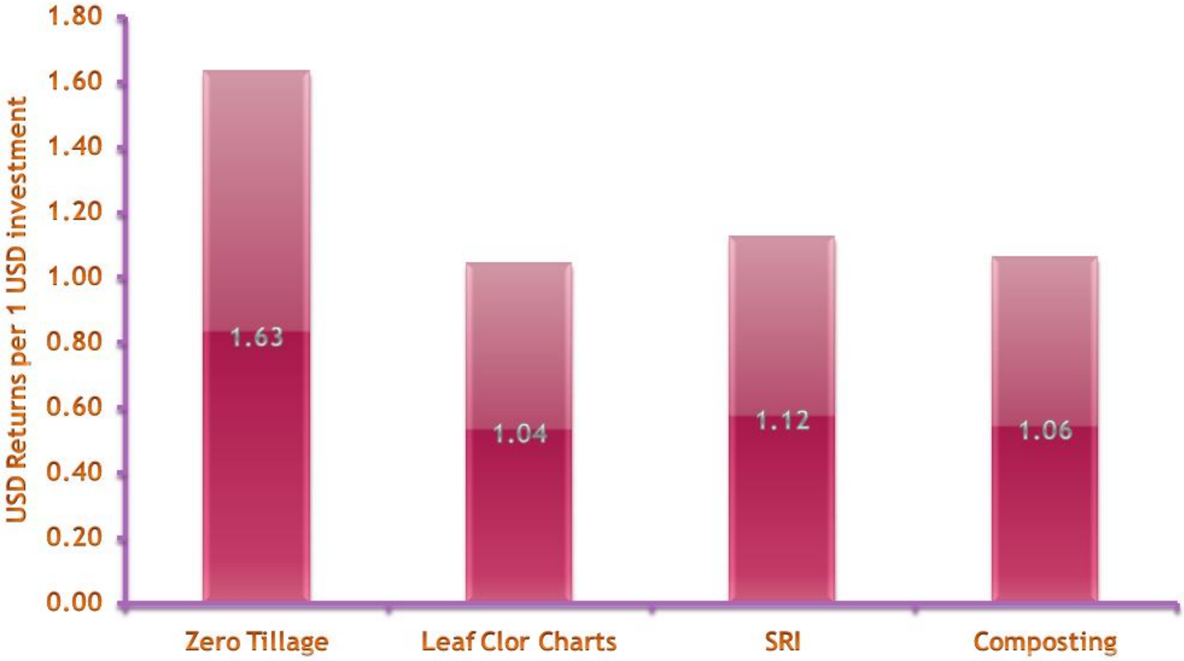
These technologies would be able to provide substantial mitigation benefit at the national level. The cumulative mitigation potential of the four technologies depicted in Figure 6.5 could be as much as 32.1 Mt CO2e per annum which is 43% of the GHG emissions in 2000 (75.42 MtCO2e).

Figure 6.5. Cumulative mitigation potential of agriculture technologies in Indonesia



[26] For assessing the benefits presented in Figure 5.6. Please note that the non-monitory and indirect benefits mentioned in Table 6.1 are not quantified for this analysis.

Figure 6.6. Benefit-cost analysis of various GHG mitigation technologies for agriculture in Indonesia



Source: Prabhakar, 2010

In terms of CBR, zero-tillage provides higher benefits and lower costs followed by SRI, windrow composting and leaf color charts. It should be noted that there is a mismatch between marginal abatement cost analysis and cost-benefit analysis. Zero tillage proved to be a lucrative technology for farmers while SRI provides maximum mitigation potential. These calculations may vary once the non-monitory and indirect benefits and costs (negative and positive externalities) are included in the equation.

6.5 Technology adoption and need for support policies

From the above preliminary analysis, it is clear that the assessed technologies provided higher benefit-cost ratio (of more than 1) with significant mitigation potential. Despite these advantages, the current rate of adoption of these technologies is still at nascent stages. To date, the area under zero-tillage is negligible in Indonesia. The area under SRI could be roughly estimated from various sources to be <15,000 ha, and substantial amount of paddy straw is still being burnt every year (based on interviews). This signifies that there is a huge gap between the technologies that are available off the shelf and their adoption rate. This gap could be attributed to several deficiencies at the policy level which are listed below.

- No financial incentives for adopting GHG mitigation technologies (farmers adopt technologies that are profitable).

- The technologies with high abatement potential don’t have high benefits per unit investment which farmers consider more (e.g. SRI).

For enhanced technology adoption, there is a need to introduce carbon credits for agriculture sector (soil carbon sequestration) which could provide additional income to farmers. Currently, the carbon price in the EU carbon exchange (ECX) stand at 13 Euros per ton. At this rate, zero-tillage could provide an additional income of 6 Euros per hectare per season (26 Euros for SRI, 26 Euros for aerobic composting, and 1.7 Euros for leaf color charts). Additional measures could include education and capacity building of farmers through rapid expansion of climate field schools and farmer field schools, a shift from benefit-cost based decision making to marginal abatement cost based decision making (coupled with additional income from the carbon markets), and phasing out agricultural input distorting farm subsidies. Subsidies could be diverted to more carbon-friendly technologies such as soil ameliorants to be applied on peat lands (Setyanto, 2010). Improvement of agricultural infrastructure is essential for better performance of some technologies such as SRI. This could include precision leveling of the fields, construction of water delivery and control structures at the tertiary and quarterly canal levels, and better lining and management of primary and secondary canals that enhances the water transmission efficiency with greater adaptation and mitigation co-benefits.

Since agro-technologies are highly location specific, technology targeting in terms of ecological conditions, socio-economic condition of farmers, etc. is important in order to achieve maximum mitigation technologies. The technology targeting could be done for e.g. by zoning based on irrigated ecosystems, rain-fed lowland ecosystems, upland ecosystems, swampy and tidal swamp ecosystems, peat ecosystems, and different soil properties.

The most obvious approach for reducing the agriculture pressure on land would be through improving the agriculture productivity. An increase in productivity by 0.5 tons per hectare of rice, wheat, maize, soybeans, sugarcane, cassava, oil palm, and coconut would release an estimated 90 Mha in China, India, Indonesia, Malaysia, Thailand and Vietnam. This would be more than the land that is lost to deforestation in the last 15 years in Asia (Asia lost 2.9 Mha of forests during 1990-2005).

6.6 Conclusion

Indonesia has made tremendous progress in productivity gains in agriculture sector in the past decade. However, this progress needs to be sustained if the country needs to gain food and nutritional security which may undermine the possible climate benefits if no policy interventions are made to mitigate GHG emissions. The country has announced a economy-wide mitigation target of 20%. In order to meet this target, a substantial amount of GHG emission reduction should have to come from agriculture sector as well. In order to achieve this, there is a need to identify win-win agriculture technologies that would provide needed productivity and income gains while mitigating GHG emissions and providing local environmental and developmental benefits. Several technologies are already available either in a ready-to-adopt or at the early stages of adoption. Rapid scaling up of these technologies would have to be achieved through providing sufficient incentives (direct or indirect), capacity building of farmers, enhanced support for infrastructure, and additional investments in the research and development.

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