



MITIGATION CO-BENEFITS OF ADAPTATION ACTIONS IN AGRICULTURE: AN OPPORTUNITY FOR PROMOTING CLIMATE SMART AGRICULTURE IN INDONESIA

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The government of Indonesia has been promoting the system of rice intensification with emphasis on resource use efficiency and climate change adaptation benefits. One question remained to be seen is how the system of rice intensification compares with other technologies such as zero tillage, composting, and leaf color charts which have also been advocated for resource conservation, climate change adaptation and mitigation benefits. In this paper, we made an attempt to quantify the mitigation co-benefits of various agriculture technologies and compared them with the system of rice intensification through marginal abatement costs and cost benefit analysis. The analysis has indicated higher mitigation potential for the system of rice intensification compared to other technologies in question. However, zero tillage provides least marginal abatement cost and higher returns per dollar invested and hence could be a better choice. When assessed for the nationwide mitigation potential, system of rice intensification provides greater mitigation potential compared to other technologies.

Key Words: co-benefits, adaptation, mitigation, Indonesia, synergistic agriculture

1. Introduction

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. However, being a developing nation and vulnerable to a range of climate change impacts, the country also need to focus on adaptation aspects in its response to climate change. Meeting both adaptation and mitigation goals could pose challenge to the country with limited resources necessitating a synergistic approach to the problem. Such a synergistic approach is possible by considering both mitigation and adaptation goals while prioritizing mitigation and adaptation technologies from the context of policy focus. Estimation of marginal abatement costs and cost-benefit analysis of various agro-

technologies could provide a means of meeting the both ends. The paper has identified that there is a considerable potential for the country to promote those adaptation technologies that have significant mitigation potential (and vice versa). 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. This paper was drafted based on the outcome of the consultation meeting on low carbon development organized in Bogor, Indonesia,¹ literature review and assessments made by the authors which were discussed in the consultation meeting.

2. Need for Synergistic Approach to Climate Change in Indonesia

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.² The government of Indonesia has made serious efforts to improve the food self-sufficiency and nutritional security over the past decade. As a result, the national expenditure on agriculture rose by 11% per year from 2001 to 2008.³ 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 (GHI) by IFPRI.⁴ Indonesia has a GHI of 12 in 2012. In comparison, Thailand has a GHI of 8.1, Malaysia has 5.2, and India has 22.9. Hunger index, whose values range between 0 to 40, combines three equally weighted indicators of hunger namely undernourishment, child under weight and child mortality. For more details on Global Hunger Index, please refer to the IFPRI report on Global Hunger Index, 2012.

2.1 As a vulnerable state to climate change impacts

The climate change brings another dimension of challenges to the Indonesian agriculture both due to its vulnerability to climate change impacts and as a contributor to the greenhouse gas emissions.⁵ Past climate observations and available climate change projections indicate that Indonesia is highly vulnerable to climate change impacts.^{6,7} The historical analysis of climatic data has indicated a significant increase in maximum and minimum temperatures across most of the stations in Indonesia along with associated sea level rise.⁷ Past trends also indicated the presence of changes in precipitation, incidence of extreme temperatures and dry spells associated with a clear influence of decadal cycles of El Niño and La Niña. However, the trends were not uniform across the Island nation. For example, significant reduction in December-January rainfall was observed in parts of Sumatra, Java and Papua while an increase in precipitation was observed in eastern Indonesia including parts of Bali and Nusa Tenggara Barat. Despite the limitations in the availability of good quality projections for Indonesia region, the available projections indicated a similar trend as that of the historical trends (e.g. increased wet days in Bali and Nusa Tenggara). Though conclusive evidence is not

yet available on projected negative impacts of climate change on crop production, analysis presented in Indonesian National Communications indicate change in wet and dry spells and seasonal precipitation patterns along with the influence of El Niño could largely pose serious threat to the Indonesian agriculture.

2.2 As a contributor of GHG emissions

In addition being vulnerable to climate change impacts, Indonesia also contributes to climate change in both direct and indirect means. As a direct source, Indonesian agriculture contributes to about 6% of total greenhouse gas (GHG) emissions and the sector stands fifth after land use, land use change and forestry, fuel combustion, and waste sectors (Las and Unadi, 2010; see Figure 1). 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).⁸

Land use changes: 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,⁹ 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 2005.¹⁰ 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.¹¹ 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 (Fig. 2; Prabhakar, 2010; and FAO, 2010) and corroborates to that of the land use change trends presented in the Second National Communication submitted by the Government of Indonesia.⁷

Changing food preferences: 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 a 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 Fig. 3, the animal husbandry related emissions have shown an increasing trend since 2003 owing to relative increase in animal population.⁸

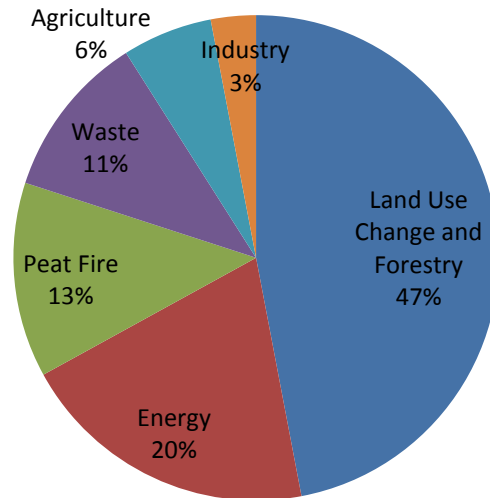


Fig. 1. GHG emissions from various sectors in Indonesia.⁵

Other contributing factors: There are several other trends that would enhance emissions from agriculture sector in the future, if unhindered. These trends include from forces operating within the sector and outside the sector. Within the agriculture sector, changes in the source and amount of on-farm energy consumption, reducing organic matter application, and burning of paddy straw. Though the energy related emissions, including the energy used in 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, increasing monoculture, 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.¹² Other forces include those of increasing population pressure on agriculture that limit the choice to certain forms of agriculture with high GHG emissions, increasing deforestation and related land use changes converting to agriculture and non-agriculture uses of land with limited carbon sequestration possibilities.

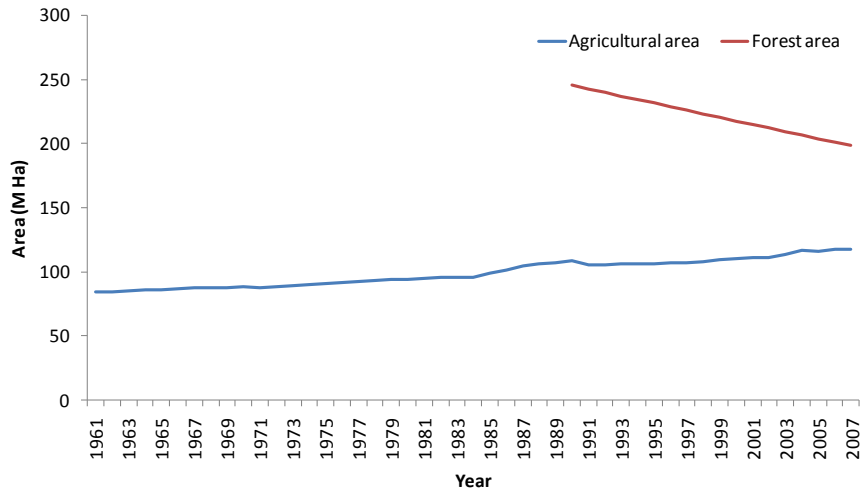


Fig. 2. Expansion of area under agriculture with concomitant decline in area under forests in Southeast Asia.¹¹

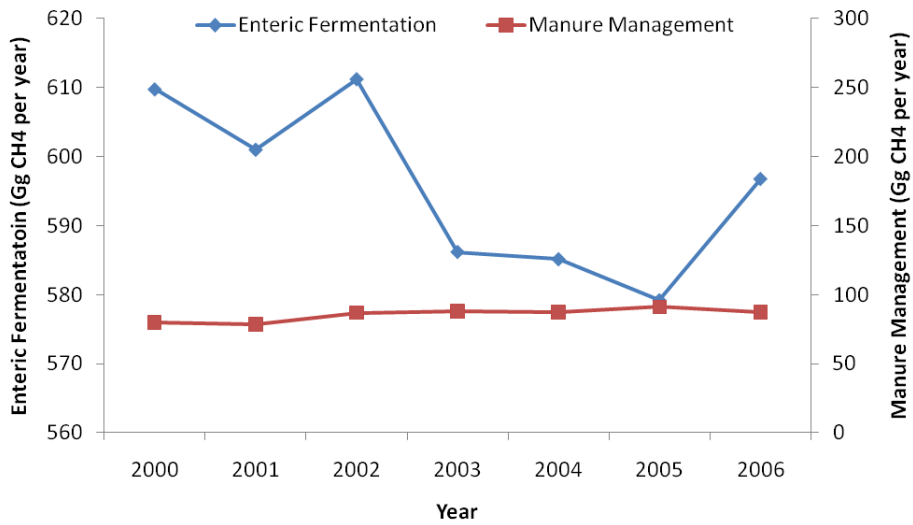


Fig. 3. Indonesian Methane Emission (Giga Grams, Gg) from Livestock in 2000-2006.⁸

If no corrective measures are taken, the above trends may continue in the future as well. Most available future projections indicate that the non-CO₂ emissions will continue to increase in agriculture sector at global and regional levels^{13,14,15} and projections for Indonesia indicate an increase in agricultural emissions from 0.17 GtCO₂e in 2005 to 0.25 GtCO₂e by 2020. Methane emissions from the animal husbandry sector in a BAU scenario indicate

similar increase in GHG emissions.⁸ This suggest that Indonesia need to undertake substantial efforts for it to limit the GHG emissions in the near future and ignoring agriculture sector would not help it in reaching the objective of mitigating GHG emissions.

3. Synergistic Agriculture for Indonesia

From the foregone discussion, it is can be concluded that aspects such as historical and current agro-economic situation, the observed and future projected emissions from agriculture, and climate change vulnerability pose a challenging task of mitigating GHG emissions 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 not contributing to the climate change. As simple as it may look, the task could be difficult looking at the food and nutritional insecurity of the country.

Solving the above puzzle requires Indonesia identifying and promoting agro-technologies those will satisfy the following conditions: 1. provide yield and income advantages contributing to rural development and national food security, 2. provide significant GHG mitigation advantage, and 3. Facilitate the above two at lower costs. One of the means to attain these benefits is through focusing on the synergistic agriculture, the form of agriculture that provides significant increase in food productivity and production, and reduce GHG emissions at least possible costs. Hence, promoting synergistic agriculture in Indonesia require a two-pronged approach that identifies and scales up GHG mitigation technologies that do not impact the food production, and putting in place an enabling policy environment that helps in scaling up of these synergistic agro-technologies.

3.1 Current state of synergistic 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.^{16,17} To site an example, the agriculture input subsidies that have been in existence for long time have been known leading to the fertilizer imbalance, pesticide overconsumption and decline in factor productivity. 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. As a result, the area under low-input and organic agriculture has been growing at a steady rate, with an estimated area of 17783ha in 2005.¹⁸ However, 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.¹⁹ 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.⁵ Though there are no statistical figures available on the extent of adoption of these technologies, the ongoing engagement with various stakeholders by authors of this paper indicate significant efforts being invested by both the government and the non-governmental organizations in the spread of these technologies using farmer field schools and climate field schools with limited success in adoption rates.

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.⁵ This includes 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 greenhouse 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 countries. 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.⁵

3.2 Prioritizing synergistic technologies for Indonesian agriculture

The research in Indonesia and elsewhere has already identified several technologies with the potential to mitigate GHG emissions in agriculture (Table 1) and animal husbandry (Table 2). These technologies have already been either developed or are being adopted by farmers, indicating that there is no dearth of mitigation technologies in agriculture and animal husbandry. However, what is lacking is a strategy to prioritize these technologies and creating enabling environment to promote policies in an aggressive manner.

Having identified a list of technologies, the next step is to prioritize these technologies for wider dissemination and adoption, both through the government driven policy initiatives and by the individual players. As discussed earlier, such a prioritization should not only consider GHG mitigation potential but also consider yield and income advantage to the

farmers. This is possible through employing methods such as marginal abatement cost curves, benefit-cost analysis, and abatement cost per unit production.

Table 1. List of agro-technologies that have mitigation benefits.²⁰

Technology	Major Benefits
1. Zero-tillage	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 1. Saving in irrigation water 2. Higher yields 3. Reduced pests and diseases 4. Reduced labor costs 5. Higher income
4. Aerobic composting	<ol style="list-style-type: none"> 1. Does not contribute to CO₂ emissions 2. Eliminates CH₄ and N₂O emissions 3. Considered as a natural cycle
5. Alternative nutrient management strategies through altering sources	<ol style="list-style-type: none"> 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 N₂O emissions

Table 2. List of mitigation technologies that are either currently at adoption or development stage in Indonesia (adopted from Suryahadi and Permana 2010).

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

Techniques	Methane Reduction (%)	Feed Efficiency	Animal Production	Strengths	Weaknesses
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

3.2.1 Marginal abatement cost (MAC)

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 1).²⁰

$$MAC = \frac{Mc}{M_{GHG}} ; Mc = C_a - C_b ; M_{GHG} = GHG_a - GHG_b ;$$

$$GHG_a = Activity \times Ef \times Sf \quad (1)$$

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*; *GHG_a* is GHG emissions from technology *a*; and *GHG_b* 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 analysis carried out by authors 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);

Fig. 4). 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 and need for investing in precise water control operations. These per hectare benefits can be multiplied several times depending on the adoption rate of these technologies. As an example,

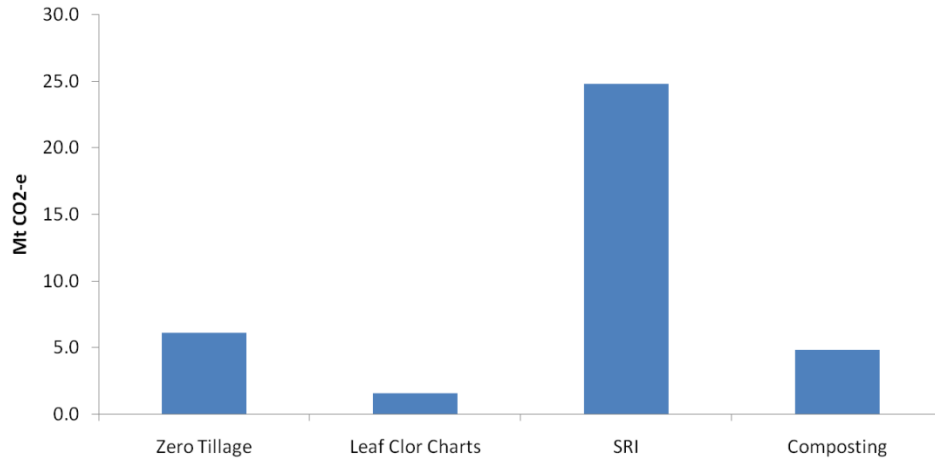


Fig. 5 shows the cumulative GHG mitigation benefits of expanding all the technologies depicted in Fig. 4 to the entire paddy area in Indonesia. It shows that SRI provides highest mitigation potential when compared to other technologies. The cumulative benefit could be as much as 37.3 Mt CO₂e per annum which is 49.5 % of the total GHG emissions in 2000 (75.42 MtCO₂e).

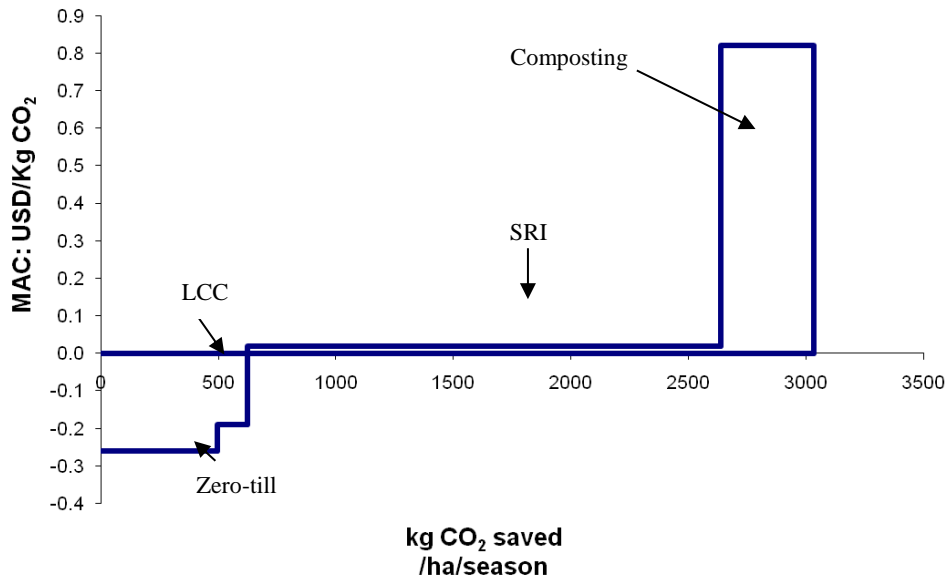


Fig. 4. Marginal abatement costs of various technologies for Indonesia.²⁰

3.2.2 Benefit-cost ratio

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 calculating the BCR for technologies depicted in Figure 4 are listed in Table 3. The field data on actual benefits and costs were obtained by interviewing paddy farmers in the village Jambenengan located in the Kebon Pedes sub-district of Sukabumi in the West Java province, Indonesia in 2010.

$$BCR = \frac{\text{Total Benefits}}{\text{Total Costs}} \quad (2)$$

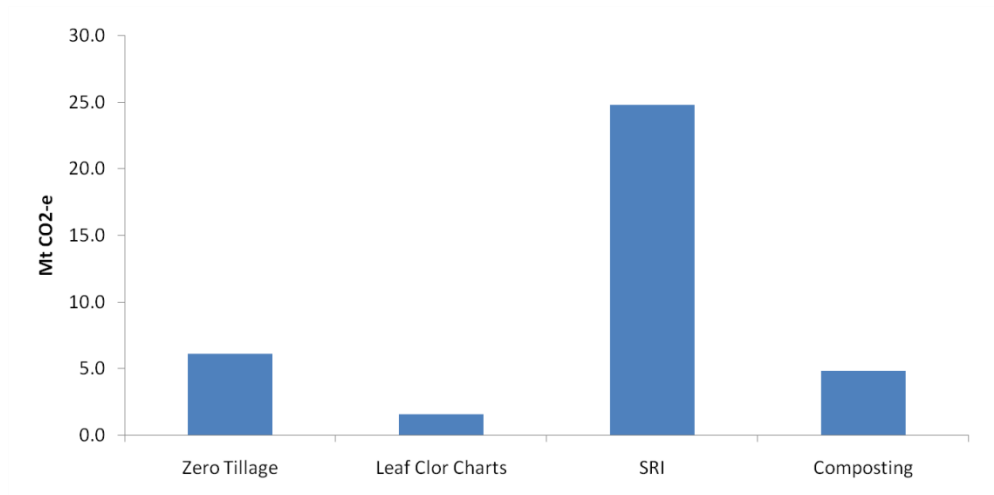


Fig. 5. National level cumulative mitigation benefits of mitigation technologies in Indonesia.

Table 3. List of costs and benefits considered for cost benefit analysis of various agro-technologies.²⁰

Total Costs	Total Benefits
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

In terms of BCR, 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 the outcomes of the marginal abatement cost analysis and cost-benefit analysis. Zero tillage proved to be a lucrative technology for farmers (high benefit cost ratio) 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 2. From the point of food self-sufficiency, SRI could prove to be a better option at the national level and the same may not work out to be at the farmer level where costs of these technologies assumes important criteria for technology adoption.

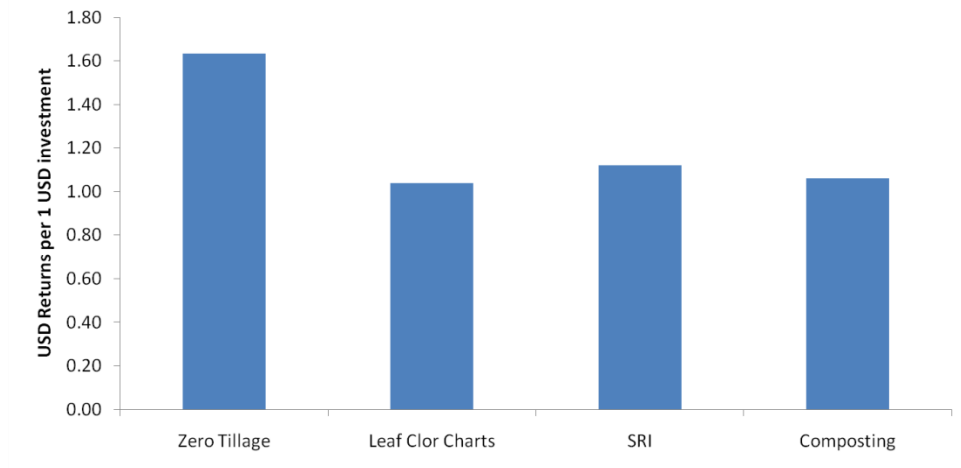


Fig. 6. Benefit-cost analysis of various agro technologies in Indonesia.²⁰

4. Technology Adoption and Need for Support Policies

From the above 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 to be

<15,000 ha, and substantial amount of paddy straw is still being burnt every year (based on interviews with various stakeholders involved in agriculture policy research in Indonesia. Please refer to the introductory section of this paper). This signifies that there is a huge gap between 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.²¹ 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 potential of different agro-technologies. The technology targeting could be done for e.g. by zoning based on irrigated, rain-fed lowland, upland, swampy and tidal swamp and peat eco systems, 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 (estimated by authors). This would be more than the land that is lost to deforestation in the last 15 years in South and South East Asia (According to Global Forest Resources Assessment of FAO, South and South East Asia lost 1.3 Mha of forests during 2000-2010).

5. 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 be undermined by the climate change impacts, if no policy interventions are made to adapt to the climate change impacts. At the same time, Indonesia has announced an economy-wide mitigation target of 20%. Meeting this GHG mitigation target while adapting to climate change is the dual challenge facing the country. Though the country has identified land use land use change and forestry as a potential area for GHG mitigation, a substantial amount of GHG emission reduction can also come from agriculture sector which has been the area of focus for adaptation in the country. Hence, identifying synergistic agro-technologies could provide win-win opportunity for Indonesia.

In this paper, an effort was made to compare four technologies in terms of marginal abatement costs and benefit cost ratio to prioritize technologies. Results indicate that the system of rice intensification provides maximum gross national GHG mitigation benefits and the zero-till provides the cheapest option of mitigating GHG emissions but falls short in terms of gross national GHG mitigation potential. Keeping in view the food security needs of the country, the system of rice intensification appears to be effective technology if costs involved could be reduced through some incentive mechanism. Introduction of carbon credits in agriculture could provide that incentive. 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 rural infrastructure including irrigation facilities for precise irrigation management, and additional investments in the research and development. There have already been efforts to enlist various GHG mitigation technologies within agriculture sector in Indonesia, several of which are already available either in a ready-to-adopt or at the early stages of adoption. The next stage is to prioritize and promote these technologies at the farmers' level through providing enabling environment.

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