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Agricultural Innovation: Options for Appropriate Technologies in Responding to Climate Change

Agriculture is a key sector providing economic and social development in Southeast Asian countries, where a majority of the region's population depend on agricultural production as a main source of household income. The implication of global environmental change has extended the agricultural agenda to respond to the drivers of climate change—in the context where agriculture is both a contributor to greenhouse gas (GHG) emissions and a possible mitigating factor through the adjustment of practices and the adoption of new technologies.

The role of agriculture in climate change is better appreciated in relation to the value agriculture contributes to the global economy. The 2010 World Development Report, drawing on analysis from the Intergovernmental Panel on Climate Change, calculates that agriculture directly accounts for 14 percent of global GHG emissions in CO₂ equivalent and indirectly accounts for another 17 percent of emissions from land use and conversion for crops and pasture. In contrast, the contribution of agriculture to the global GDP at four percent suggests that worldwide agricultural activity is highly GHG intensive (Lybbert and Sumner 2010).

Improvements in agricultural production are directly related to poverty reduction in all sectors of society (e.g., farmer-peasant, artisanal fisherfolk, workers in the formal sector and migrant workers, workers in the informal sector, IP and

cultural communities, women, among others), being twice more effective in growing GDP than any other sector (UNEP 2011).

As agriculture is highly sensitive to climate change—depending on both biodiversity and environmental conditions—maintaining the right balance is critical to a stable and productive agricultural activity, which is the foundation for food security and by extension the alleviation of poverty (UNEP 2011). In the Southeast Asian region, climate change is expected to bring about increased vulnerability in the agricultural sector from sea-level rise, greater rainfall variability, higher temperature, and decreased freshwater availability (Turrall et al. 2011).

As part of a broad strategy of solutions, **climate-smart agriculture** addresses the wider issues faced by agriculture in the face of global environmental change—the need to increase global food production by 60 percent by 2050 and to meet GHG emission reductions (Meybeck et al. 2012). Climate-smart agriculture is anchored on three pillars in the context of local stakeholders and focusing on sustainably increasing farm productivity and income, strengthening resilience to climate change and variability, and mitigating the contribution of agricultural practices to climate change—targeting the global objectives of 'carbon' (UNFCCC), 'species' (UNCBD), and 'calories' (WSFS) (Meybeck et al. 2012).



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In line with the push towards climate-smart agriculture is the growing alignment of research investments into innovations in agricultural technologies and their subsequent adoption in developing countries to enable them to adapt their agricultural systems to changing climate. Adaptation goes beyond the adoption of technologies but includes decision making over which technologies and strategies are appropriate for each local agricultural context. Appropriate technologies can help ensure that farmers are able to sustainably adapt to climate change by managing and maintaining themselves technologies which are wholly integrated into their local environmental, economic, and social context (UNEP 2011).

Appropriate Technologies

Technologies used in agriculture can be broadly classified into three types: hardware, software, and orgware. **Hardware** are tangible objects such as manufactured equipment, tools, and machinery. **Software** are processes associated with the production and use of hardware and include the gamut of agricultural practices. **Orgware** covers the institutional framework or organisation involved in the adoption and diffusion process of a technology.

Adopting technologies in a climate-smart context must result in producing more food, more efficiently, under more unpredictable production conditions, and with net reductions in GHG emissions (Lybbert and Sumner 2010). However, technologies must be appropriately selected for and by farmers to effectively realise their benefits in the long-term.

Technologies that target local stakeholder needs and are globally relevant must address both local legal, political, and cultural barriers to diffusion and global issues on access and benefit sharing, genetic biodiversity, and carbon

mitigation. A participatory process of decision making for technological selection and diffusion will allow the full potential of technologies to be realised through ensuring access to these and related support technologies. Equal access and entitlement to agricultural technologies in poor communities are therefore critical in the consideration of what is appropriate for agricultural technological adoption (Meybeck et al. 2012).

With appropriate technologies considered, innovation should be targeted at areas with the largest impact. Some areas identified by the International Centre for Trade and Sustainable Development (ICTSD) and the International Food & Agricultural Trade Policy Council as agricultural technology innovation focus (Lybbert and Sumner 2010) are:

- New traits, varieties, and crops that increase productivity and are tolerant to a wide range of climate differences;
- Water management and irrigation systems that are more sensitive to greater rainfall variability and local infrastructure practices;
- Production, marketing, and supply chains management practices that increase the fertility of soil and decrease GHG emissions through efficient transportation and growing of crops;
- Information, including the role of information and communication technologies for development (ICT4D) in agriculture, that provides greater flexibility by stakeholders in farm decision making through improved weather forecast using local and timely methods such as SMS; and
- Insurance innovations which can help offset risks brought about by increased variability, allowing a farmer to increase his capacity to farm productively.

Technology and Practice Innovations in Southeast Asia

The ASEAN region is not without agricultural technological innovations. Outstanding examples of technological innovations—hardware, software, and orgware—are being adopted by ASEAN nations. These include old techniques used in a new context (Climate Field Schools, Indonesia), to the re-adoption of ancient techniques proving indigenous knowledge as an important source of climate change adaptation innovation (water pounding, Philippines), novel ways using financial instruments to enhance resilience of agricultural growth (insurance instruments, Malaysia), and the use of information and communication technology for agricultural development (rice leaf app, Thailand).



Indonesia : Climate Field Schools, production management practices

Coping with change means knowing the practical implications of change occurring at the local level. In Indonesia, Climate Field Schools (CFS) were established in 2003–2007 along

the lines of Farmer Field Schools (Meybeck et al. 2012). Their participatory nature allowed a focus on field problems to enhance resilience in agricultural practice. Over a thousand farmers worked in CFS with facilitators to understand decision making based on seasonal climate forecasts. Coping strategies were then made based on local variations of water availability. Climate science, seasonal forecasting, and rainfall recording became part of the skills of the farmer; however, more practical concerns hampered mainstreaming of these skills, such as the limited power of the community to adjust irrigation schemes to address water requirements and a limited choice for appropriate alternative crops to rice. Lessons learned included making socioeconomic practicalities integral to the learning curriculum.



Philippines: Water pounding, water management

On-farm adaptation in irrigation technology and management is significantly dependent on a multifaceted set of biophysical and socioeconomic factors (Turrall et al. 2011). Indigenous practices,

which have long embedded these factors and are scaled to local needs, not only keep alive a culture of agricultural practice but also improve the sustainability of their use; they may also double as a flood protection mechanism when properly managed. In the Philippines, new strategies in rice farming such as alternate wetting and drying technologies are used to complement water pounding, as means to adapt to changing seasonal rainfall (Meybeck et al. 2012). Water pounding can also be combined with rainwater harvesting technologies and used to supplement other income generating livelihood such as livestock raising. Water pounding is combined with agriculture terracing systems in Ifugao, Philippines and ensures the availability of water and the prevention of weed development.



Malaysia : Transitioning from industrial crops, information, and insurance

Farmer attitude on the use of novel insurance systems to cover for losses in climate variability in Malaysia has been a subject of interest largely due to risk decision-making. In Malaysia,

crop insurance sufficiently covers plantation crops through an extension of a fire insurance policy mainly covering industrial crops such as palm and rubber oil. Meanwhile, agricultural insurance covering arable crops and animal husbandry is still lacking. A study on risk financing shows that crop insurance provides better risk financing mechanism to paddy producing farmers than other bank instruments (Prabhakar et al. 2013). Risk pooling at the local level combined with enhanced availability of risk information, public-private partnerships, and developing a market for insurance are some of several ways to move crop insurance into mainstream agriculture.



Thailand: BaiKhaoNK Rice Leaf App, ICT4D in agriculture

Leaf colour charts (LCCs) developed for rice cultivation in Asia are used by farmers in the field to determine how much nitrogen fertiliser a plant requires for efficient use and

maximal yields (Meybeck et al. 2012). Initially available as four and six panelled charts, the widespread use of mobile communication technologies such as smart phones has allowed the migration of the tool to mobile phones. The use of information and communication technology to adapt site-specific nutrient management in devices which have become widespread in Southeast Asia has allowed a potential large new cohort of adopters. In Thailand, the smartphone app BaiKhaoNK captures an image of a rice leaf to analyse its colour. Accuracy is achieved through comparing the leaf with a white reference, such as a piece of paper. A Thai research team has achieved over 93 percent accuracy in field tests estimating leaf colours. The researchers are now cooperating with the Department of Rice in Thailand's Ministry of Agriculture and Cooperatives and the National Center for Genetics Engineering and Biotechnology to promote the use of the app with farmers (Sumriddetchkajorn 2013).

Conclusion: Considerations for Policy Focus

The unique role of agriculture in development—our primary food source, significant potential for GHG mitigation, and its sensitivity to climate change—entails that innovations in technology and practice be enabled and diffused locally and appropriately to respond to climate change. Innovative technologies and practices may come from reinventing indigenous knowledge to suit the times or using new widespread and accepted media such as ICT. The possibilities of potentially relevant agricultural technologies is extensive and there is a vast pool of yet undiscovered technologies and practices that may be crucially important for agriculture in a globally changing environment. Several policy options are worth considering to stimulate increased innovation, transfer, and adoption of relevant agricultural technologies (Lybbert and Sumner 2010; UNEP 2011).

- Contextual adaptation of technological innovations that bridge innovation with indigenous practices
- Investing in better information and forecasts combining ICT4D;
- Support for competitive and responsive agricultural markets;
- Increasing private sector investment in public agricultural research and development through new market mechanism and partnerships;
- Increasing the reach of technological diffusion to the poorest of smallholders with technologies that are appropriate to their scale of agriculture;

- Strengthening policies that address both the protection of Intellectual Property and the fair exercise of traditional humanitarian rights of smallholder farmers; and
- Streamlining cooperation for technological diffusion and research with countries outside Southeast Asia but within the same agroecological zone.

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RESEARCHER: AARON JULIUS M. LECCIONES | LAYOUT ARTIST: MARK VINCENT P. ARANAS
PHOTO CREDITS: ZULKARNAEN SYRI LOKESWARA | TRAN VAN TUY | ADITIA NOVIANSYAH | ASIA RESEARCH NEWS | UWE ARANAS | JM MICAOD | DANILO VICTORIANO, JR.

SOUTHEAST ASIAN REGIONAL CENTER FOR GRADUATE STUDY AND RESEARCH IN AGRICULTURE (SEARCA)

SEARCA, College, Los Baños
Laguna 4031 Philippines
Tel.: (+63 49) 536 2361; 536 2363; 536 2365 to 67; 536 2290 ext 161/406
Fax: (+63 49) 536 7097; 536 2283
Email: post@agri.searca.org; kc3@agri.searca.org
Websites: www.searca.org; www.climatechange.searca.org

APAN SECRETARIAT

UNEP Regional Office
for Asia and the Pacific
2nd Floor, UN Building
Rajdamnern Nok Avenue
Bangkok 10200, Thailand
Phone: +662-288-1234
Fax: +662-280-3829
Email: uneproap@un.org

APAN REGIONAL HUB

IGES Regional Centre
Unit 604, SG Tower, 6th Floor
161/1 Soi Mahadlek Luang 3
Rajdamri Road, Patumwan
Bangkok 10330, Thailand
Phone: +662-651-8794
Fax: +662-651-8798
Email: info@asiapacificadapt.net

