Adaptation to Climate Change in Agriculture in Selected Asian Countries

Insights from micro-level studies and implications for policy

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Background

Climate change is a big challenge to the agricultural sector especially in the semi-arid tropic (SAT) areas in Asia. Billions of people worldwide, including the poor, mainly depend on agriculture as a major source of livelihood. However, since agriculture is highly vulnerable to climate change farmers need to take up essential adaptation measures to face this challenge. In recent times, adaptation to climate change has been given increasing international attention as confidence in climate change projections is getting higher (Ole Mertz et al. 2009). In fact, each developing country will experience the effects of climate change in a different way, not only because of differences in the projected change of climate parameters, but also because of vulnerabilities and adaptive capacities that vary between nations and regions. Adaptation strategies for the vulnerable groups are crucial because failure to adapt could lead them to suffer from 'significant deprivation, social disruption and population displacement, and even morbidity and mortality' (Downing et al. 1997). There has been a significant rise in the frequency of extreme events in recent years affecting farm level productivity and impacting staple food grain availability at the national and regional levels. Within a season, severe droughts and floods are being experienced in the same region posing serious problems to farmers, agricultural scientists and extension staff. As a result, climate change will place an additional burden on the efforts to meet long-term development goals in Asia (ADB and IFPRI 2009) and will have serious impacts on agriculture in developing countries (Pearce et al. 1996; Tol 2002; Mendelsohn et al. 2006). The large adverse impact on agricultural productivity and smallholders (who depend on farm productivity for livelihood and subsistence opportunities) is that climate change can lead to a rise in poverty levels (World Bank 2003). Therefore, the challenge of adapting to climate change is widely thought to be of utmost importance in developing countries (Tol et al. 2004; Mendelsohn et al. 2006).

The policy brief discusses micro-level adaptation strategies assessed from Asian agricultural farmers' key findings from South Asia (India, Bangladesh, Sri Lanka), Southeast Asia (Thailand, Vietnam) and China; potential adaptation strategies to climate change in rice cultivation; economic impact assessment in three selected rice farming case studies including India, Sri Lanka and Thailand; describes the adoption pattern of different technological practices; unique adaptation measures; and finally the policy recommendations.

Farmers' micro-level adaptation strategies

Adaptation measures were elicited from interactions with farmers through various means. Most of these adaptation measures are autonomous and the farmers chose them to address the changing situations, ie, they may not necessarily be due only to climate variability but quite often due to a complex situation arising out of a combination of reasons. According to the IPCC (2001), adaptability through changes in 'processes, practices or structures' is a crucial element in reducing potential adverse impacts or enhancing beneficial impacts of climate change. Adaptation is regarded as a vital component of vulnerability assessment and climate change impacts (Skinner et al. 2001). Adaptation is viewed as a crucial step to strengthen local capacity to deal with forecasted and unexpected climatic conditions (Smith et al. 1996; Smit et al. 1999). These opportunities emerged from understanding the perceptions of the farmers that were elicited in the 22 study villages (ICRISAT- RETA-6439, 2012) across South Asia, Southeast Asia and China in the Asian region. The following adaptation options will empower farmers by enhancing the

income and livelihoods, thus cushioning them from various shocks and weather aberrations.

South Asia

India

- Improved technologies such as climate smart crops that will be more profitable, which are shorter in duration and require less water, improved water and crop management options, will help farmers to stabilize their production.
- Farmers, particularly the smallholder and marginal farmers, are being given credit/loan on easy terms and a high subsidy on the interest that they have to pay on the loans. This needs to be continued as it helps the resource-poor farmers to succeed in practicing suitable adaptation measures.
- Establishment of efficient co-operatives and associations/groups to tackle the critical needs of farmers such as resource mobilization, marketing their outputs and efficient natural resource management. Creating opportunities in the non-farm sector in and around the villages to help the farmers diversify their incomes.
- The present governance structures that monitor and administer the welfare activities are perceived by farmers to be more bureaucratic, difficult to approach and less transparent. These need to be reformed for smooth flow of funds and information to farmers.
- In many villages there is no direct market access for the outputs of the farmers. Usually, either the local agents act as middlemen, or the farmers have to go a long distance to sell their produce. A better access will facilitate the farmers in earning more margins (Shiferaw et al. 2009). Creating institutional arrangements will encourage farmers towards collective action in management and use of natural resources.

Bangladesh

- Development and diffusion of new varieties that are drought tolerant, short duration in nature, flood and salinity tolerant rice cultivars are needed. Farmers perceive that more efficient and increased irrigation potential through surface and groundwater sources will improve their production sustainability and productivity.
- At present, a credit facility is not available to cover the risks of extreme events such as droughts and floods. This leads the farmers into perpetual debt traps. Creating easy access to credit and a high component of subsidy on the interest will help the resource poor farmers.
- Farmers feel that crop insurance will help them cover the risks, but the present scheme of Crop Insurance is with private players and the farmers perceive that it is not universal in its coverage. A universal Crop Insurance scheme that covers all crops will be of great help to the farmers.
- A better extension infrastructure that will improve the access by farmers, which is transparent and proactive in its reach to the farmers in every village particularly the most vulnerable villages, is the need of the hour. Farmers have identified the need for better infrastructure such as roads and marketing.

Sri Lanka

- Farmers are shifting from annual crops to perennial drought tolerant plantations like cashew, particularly in rainfed areas where the potential for irrigation is not available. This move is mainly driven by the urge to avoid the risk of crop failure.
- Farmers are also moving towards the use of short duration varieties, hybrids and drought tolerant varieties wherever seed is available. Another important adaptation strategy is diversification of the means of livelihood by marginal and smallholder farmers.
- Farmers experience difficulty in accessing inputs and this is probably an impediment to effective adaptation of any improved management practice. Establishing kinship ties to aid at difficult times is another adaptation strategy that the farmers perceive as important.
- Farmers have diversified their incomes into non-farm sectors and business. Outward migration and earnings from service are the major sources of diversification. In recent times, income diversification has reduced the risk of rainfall variability through reduced dependence on agricultural incomes.

Southeast Asia

Thailand

- Farmers do not adopt practices like organic matter incorporation due to lack of immediate returns. A suitable incentive mechanism must be in place to motivate farmers to adopt such practices that will help in enhancing soil fertility and improve water holding capacities.
- Farmers perceive that their land holdings are small and the risks associated with adopting new adaptation practices deter them from accepting change. Suitable technology demonstrations on the farmers' field will help in improving farmers knowledge and their decision making process. Innovations in alternate sources of income that will help the farmers to diversify their incomes are needed.
- The upland villages need drought tolerant short duration rice varieties as well as water harvesting technologies that will help in increasing supplementary irrigation potential. Development of rice varieties that are flood tolerant and suitable for local conditions are needed for the lowlands.

Vietnam

- Farmers feel that lower profits and higher risk of crop failures due to uncertainty in rainfall discourage them from investing in crop cultivation. It will be appropriate to introduce crop insurance schemes and subsidize the premiums of resource poor farmers. This will give them an assurance that in the event of a crop failure a minimum return is guaranteed and that they would be able to venture into practicing better adaptation practices.
- Subsidies to the farmers to go for better adaptation of technologies such as improved varieties will help the resource poor farmers, particularly the smallholder farmers.
- Farmers do not have access to credit through formal channels as collaterals are a precondition for loans. Access to loans on easy terms and a subsidy on the interest on loans will help the farmers to go for a higher rate of adoption.
- It is perceived that the smallholder farmers are neglected by the system because they are resource poor and are usually not able to get into the mainstream to be able to afford any incentive. Preconditions for availing of any type of benefits should be relaxed liberally in case of smallholder farmers, so that they are able to get the help.

China

- Providing water supply and drainage systems, better agricultural machinery on subsidized terms and ecosystem protection methods on state subsidies will go a long way in helping the farmers. Developing alternate sources of power and subsidizing it for the farmers will help in adapting climate friendly technology by the farmers.
- Development and introduction of new drought tolerant varieties and water saving technologies will help the farmers in better adaptation.

Potential adaptation strategies for rice cultivation – Selected case studies

Climatic variability and changes are perceived by the surveyed households. According to the outcome of the survey, farmers have noticed changes in rainfall over the past years, reduced number of rainy days, irregularity of rains, and unexpected rains during the harvest time. The survey indicates that farmers in each country adapt in several ways to the change in temperature and rainfall (see Table 1). They build lines of stones, dikes, windbreaks, and adopt improved irrigation technologies. They also adopt diverse cropping practices and other economic activities, such as short cycle cultivation, operating small businesses, practicing truck farming and livestock rearing. This includes the use of improved rice varieties, mainly those varieties that allow for early planting and harvesting, are high yielding and adaptable. Cropping techniques are adjusted for better application of technology and following the advice provided by the agricultural officers about such matters as ploughing before sowing, timely sowing, applying fertilizer, early sowing, flat ploughing and sowing, and rotating crops. They adopt fertilizer application, composting and placing of livestock in the fields. Reforestation activity is another strategy, either communally or individually, for improving rainfall intensity. Explicit erosion control is aimed at protecting the environment and natural resources, for example, fighting bush fires, stopping animals from wandering and preventing excessive cutting of wood. Others follow spatial management

Table 1. Household-level rice farmers' strategies for adapting to climate change.

Adaptation strategies to climate change	Thailand (sample size-300)	India (sample size-250)	Sri Lanka (sample size-250)
Temperature (%)	---------- Percentage of farmers' response ----------		
Water and soil management	46.9(2)	20.2(3)	76.0(1)
Agro-forestry technique	18.2(8)	22.5(1)	62.8(2)
Improved variety of crops	33.1(3)	14.2(7)	28.8(3)
Good application of cropping techniques	29.5(5)	13.8(8)	28.8(4)
Equipment/mechanization of the farm	12.4(10)	13.4(9)	25.2(5)
Environment and natural resource protection	32.7(4)	15.8(5)	22.0(6)
Organic fertilizer amendment	74.9(1)	20.6(2)	21.2(7)
Reforestation	16.4(9)	15.8(6)	14.4(8)
Space occupation	21.5(6)	18.6(4)	10.0(9)
Diversification	21.1(7)	11.5(10)	1.2(10)
Modifications to Livestock size, Composition and Husbandry	11.6(11)	5.5(11)	0.8(11)
Precipitation (%)			
Water and soil management	81.1(2)	14.2(5)	82(1)
Agro-forestry technique	31.3(7)	16.2(4)	68.8(2)
Improved variety of crops	48.0(3)	16.6(2)	30.4(3)
Good application of cropping techniques	45.8(5)	17.4(1)	26.0(4)
Environment and natural resource protection	46.6(4)	11.1(8)	24.8(5)
Equipment/mechanization of the farm	17.5(11)	11.5(7)	21.6(6)
Organic fertilizer amendment	83.6(1)	16.2(3)	21.2(7)
Reforestation	20.4(10)	9.5(10)	10.4(8)
Space occupation	25.1(8)	13.8(6)	7.2(9)
Diversification	37.8(6)	10.3(9)	2.4(10)
Modifications to Livestock size, Composition and Husbandry	24.0(9)	5.1(11)	1.2(11)

Source: Field Survey (Feb 2010–June 2012), author calculations.
Note: Figures in parenthesis are ranks and indicate the level of importance given.

such as using lowlands, extending the cultivated areas, changing the production site and the fields and practicing transhumance as far as animal husbandry is concerned. Finally some farmers make use of new equipment/mechanization of the farm particularly the use of animal traction.

Among these strategies, adaptation through organic fertilizer amendment and water and soil management dominate, followed by improved crop varieties; environment and natural resource protection are being adopted in Thailand to adapt to changing temperature and rainfall. In India, farmers are adapting to changes in temperature and precipitation through application of annual cropping and agro-forestry techniques, followed by improved crop varieties, organic fertilizer amendment and water and soil management. On the other hand, Sri Lankan farmers prefer to adapt to the changes in temperature and precipitation through water and soil management and agro-forestry techniques, followed by organic fertilizer amendment and improved crop varieties.

Economic impact assessment of climate change on selected rice farmers

This study investigates the impact of climate change on rice farms in three case studies: Khon Kaen in Thailand, Coastal districts of Andhra Pradesh in India, and Anuradhapura and Kurunegala districts in Sri Lanka. It uses primary household level data together with secondary climate and soil data to implement the Ricardian cross-sectional approach.

The primary data comes from a survey of selected sample households in three case studies across the provinces and region, which is used to measure the relationship between the net crop revenue and climate variables (temperature and precipitation), soil variables, and socio-economic variables (farmland, household size, animal power, machine power, extension services, livestock, irrigation and hired labor). It also explores the farmers' adaptation strategies to climate variability. It determines how the selected case study rice farms would respond to the IPCC (2007) and SRES climate change scenarios. Two regression models (with and without adaptation) and two farming systems (dryland farms and all farms including irrigated ones) are tested. The coefficients of determination (R2) are 26 % to 40 % for the models with and without adaptation in all farms and dry farms of three case studies. The results of the study show that climate affects crop net revenue in Khon Kaen. For an average annual rainfall increase by 1 mm, agricultural incomes will increase by US$3.5/ha on an average for all farms in the sample. The increase will be US$0.59/ha for rainfed farms. On the other hand, if the average temperatures increase by 1°C the net agricultural incomes will drop by US$16/ha for the model with adaptation of all farms and US$17.9/ha for farms without adaptation and for dry farms. In the case of Coastal Andhra Pradesh, if the average annual rainfall increases by 1 mm, agricultural incomes increase by US$2.6/ha on an average for all farms in the sample. The increase will be US$ 0.98/ha for rainfed farms. In the case study of Sri Lanka, when the average annual rainfall increases by 1 mm, the incomes of the rice farms increase by US$1.98/ha on an average for all farms in the sample. The increase will be US$0.75/ha on an average for rainfed farms.

When considering the predicted values of temperature and rainfall of selected regions from the three global climate change models for the years 2050 and 2100, all the three models projected increasing temperature levels for the years 2050 and 2100. With respect to rainfall, while the ECHAM50M model predicted increasing values for the year 2050 and decreasing values for 2100, both CGCM3T63 and CSIROMk3.5 models predicted decreasing rainfall over these years. Facing climate change and climatic variability, the surveyed rice farmers are adopting strategies including water and soil management, techniques of agro-forestry, crop management techniques, crop diversification, improved new rice varieties, improved organic fertilizer (traditional compost, leaves, straw and placing livestock and other animals in the fields); plantation, and increasing farm size.

Adoption pattern of different technological practices

Technological innovations have been prominent in agricultural production in the Asian countries over recent decades. The adoption of technological components provided opportunities for farmers to increase production as well as to improve the incomes and food security of farming households. But the adoption of different packages of technologies by farmers has been only partially successful in terms of implementing research and development outputs. A more important part of innovation from R&D occurs when farmers make effective use of the technology. In agricultural farming, it is rare that all farmers are able and willing to adopt new technologies, mainly because of the deterrents to adoption imposed by various socioeconomic, institutional and environmental factors (Mariano 2012). The emergence of the Green Revolution compelled many researchers to study the adoption technologies in Asian countries. Among the first empirical studies on the adoption of agricultural innovations are that of Ruttan (1977) and the extent of adoption of modern varieties are of Dalrymple (1978) and Herdt and Capule (1983), who investigated the adoption rates of inbred rice MVs at the global, regional and national levels. Understanding interrelationships among technological practices is important for successful technology planning in developing countries (Rauniyar and Frank 2002).

Table 2 clearly identifies improved irrigation (sprinkler and drip, tube wells, water pumps, agro-well and drainage) as one of the most important adoption patterns of technological practices for smallholder farmers across South Asia, Southeast Asia and China. The other adopted technological practices are improved mechanization (power sprayer, thresher, tractor, harvester and bio-gas), followed by improved cropping pattern (mixed cropping, cash crops, diversification, perennial crops, maize, aqua culture and plantation), improved cultivars (high yielding, drought tolerant, short-term, less water demanding, hybrid, new varieties), improved inputs (fertilizer, pesticide, organic, crop residue, bio-extract), improved extension services (micro-finance, easy

Table 2. Country-wise adoption pattern of technological practices.

Technological Practices	India	Sri Lanka	Bangladesh	Thailand	Vietnam	China
Improved Cultivars	×	×		×	×	
Improved Inputs	×	×		×		×
Improved Irrigation	×	×	×	×	×	×
Improved Mechanization	×	×	×	×		×
Improved Cropping Pattern	×	×	×		×	×
Improved Extension Services			×	×	×	
Improved Livestock	×				×	
Improved Crop Management				×		
Improved Cropping Intensity				×		×
Migration			×	×		
Reduced Personal Expenses				×		

Source: ICRISAT-RETA-6439,2012; Note: '×' indicates farmers are adopting new technological practices

bank access, crop insurance and subsidies), improved livestock (cross bred livestock and poultry, local cow), improved crop management (date of planting), improved cropping intensity, migration and reduced personal expenses. Except improved irrigation, the other technological practices are adopted by smallholder farmers only in a few countries based on the availability of technology and economical and government support.

Unique adaptation measures were found during the survey in each selected Asian country. In case of South Asia, India has farm association and self-help groups (SHG), National Rural Employment Guarantee Scheme (NREGA), The Pradhan Mantri Gram Rojgaar Yojana (PMGRY) and Public Distribution System (PDS). The SHGs provide hassle free and easy access to credit to the farmers for their farm operations. The other schemes financially support farmers, especially in the agricultural off season. In fact, this is being perceived as an effective adaptation measure by farmers. For countries like Sri Lanka and Bangladesh, the unique adaptation practices are establishment of kinship ties to aid at difficult times, diversification of seasonal crop and perennial crop, micro-finance and migration to farm and non-farm activities. For Southeast Asia including Thailand and Vietnam, the unique adaptation practices are reduced personal expenses, changing crop management (date of planting), less water demanding crops, farmer groups, and crop insurance schemes and subsidies prior to the use of organic fertilizer for enhancing soil quality. In the case of China, the government will enable the measures that farmers are adopting such as increase in the forest cover around the villages, construction of small water tanks, saving power and developing several alternate renewable power sources and enhancing infrastructure development.

Policy Recommendations

The study confirms that Asian farmers are already using a broad variety of creative practices to cover risks due to climate change. The present study brought forth many observations which show that the farmers across Asia have been doing well through autonomous adaptations while engaging with the ever changing complex combinations of physical, economic, social and political environments. But it is very important that all the initiatives taken up to address adaptation and mitigation to climate change must be integrated with the government policies that address agriculture and food production (Klein et al. 2005).

It is essential to: take policy measures regarding concerned departments and governments to create an enabling environment for the farmers to take up adaptation strategies; create technological inputs and tools to develop appropriate adaptation measures; create and strengthen the existing institutional infrastructure to aid the farmers towards an equitable adaptive capacity and streamline the governance structures to smoothen the flow of information and resources to the farmers.

It is important to integrate climate change initiatives with the national agricultural policies, identify regions vulnerable to climate change and prepare comprehensive district-wise agricultural crop contingency plans for effectively managing climate risk.

Need for the Government to invest in training and providing incentives to farmers to conserve the resources and develop indigenous technologies that are eco-friendly and sustainable for a long period.

Introduce new crop insurance schemes and subsidize the premiums of resource poor smallholder farmers. This will help to assure them that in the event of a crop failure a minimum return is guaranteed and that they will be able to venture into practicing better adaptation practices.

Extensive research is essential for modern technologies or new crop varieties that promise to withstand the effects of adverse climatic conditions (Anni 2009).

Introduce new alternative sources/schemes of income that will help the farmers to diversify their incomes. For instance, self-help groups (SHG), farmers associations and government schemes that provide hassle free and easy access to credit, and other schemes such as NREGA, PDS, which financially support farmers especially in the agricultural off season.

Share existing information on adaptation measures for suitable climatic conditions between different countries. This will be very helpful to the governments and policy makers, and also prove to be useful for the farmers to adopt new types of strategies.

Establish / strengthen Agro meteorological Advisory Services at district and at sub-district levels and maximize ICT through mobile phones to help the farming community to take advantage of prognosticated weather conditions and thereby form a response strategy.

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