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Micro level realities and policy coherence for enhancing climate change resilience in Asia[1]

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Abstract

The climate change has been recognized by the world community as a potential threat to environment, ecosystem, and development. The impacts are not spatially similar and Asia's rural poor are more challenged of its consequences. ICRISAT with support of ADB have tracked the climatic trends, identified vulnerable regions to climate change and ascertained the farmer's perception through quantitative and qualitative means for deciphering the adaptation strategies and constraints to adaptation in South Asia (Bangladesh, India, Sri Lanka), South East Asia (Thailand, Vietnam) and China. A comprehensive approach (Q^2) was designed to imbibe the information at different levels of its significance. Climatic analysis to understand the trends in climate and climate change vulnerability assessment of the regions and sub-regions was carried and later 22 villages were selected from these vulnerable regions for understanding ground level realities of climate change impacts and adaptation strategies.

The study revealed a very high variability in distribution of rainfall, with marginal change in quantum of rainfall. The frequent occurrences of extreme events viz., droughts (India, Sri Lanka, China), floods (Bangladesh, Thailand and Vietnam) were other notable features making the region highly vulnerable. The farmers' perceptions and practices at the grassroots level revealed that farmers are adjusting their agricultural operations in response to the external stimuli of uncertainty and variability of rainfall not only to the climatic factors but also to several other factors like market dynamics, profitability, infrastructure development and government policies. The strategies followed by farmers include shifting from cereals to cash crops and adapting short duration and drought tolerant cultivars and adjustment in the sowing and planting dates. Across the study countries in Asia, farmers have been diversifying their sources of income into non-farm sources (43-87% of total income) to cover the risk of income loss due to variability and uncertainty in rainfall. The study further revealed that the worst affected is the marginal and small farmers and with increased frequency of drought, poor and marginal farmers get into perpetual debt traps.

The analysis also revealed various constraints/limitations that existed among farmers hindering effective adaptation. The non-availability of seeds, lack of access to information, weak institutional capacities and inability of access to formal credit were some of the constraints that emanated from the villagers. In order to address the complex issues at the grass root level, it is imperative to formulate appropriate recommendations /promote approaches and options to harness the opportunities in the changing economic, technological and institutional opportunities, having locally-focused contexts. These results have paved way for a set of specific recommendations to be mainstreamed into the country specific policies for improving the livelihood of the rural households and building climate resilient agriculture.

[1] Study countries are Bangladesh, China, India, Sri Lanka, Thailand and Vietnam

Introduction

Climate change has emerged as the biggest threat to livelihood sustainability of our times, posing an imminent danger to food security, livelihood and development. Until recently, the center of attention has been on the actual or potential impact of climate change and mitigation options. The focus is now shifting to the ways that different socio-economic groups are attempting to cope and adapt to climate variability in particular and climate change in general. International developmental agency are inclined towards in improving their understanding of climate change science, impacts and mitigation of climate change at the global and regional levels (ADB 2009). This re-orient focus towards the growing recognition that, climate change is inevitable; its effects can be largely extenuated by undertaking better understanding of adaptation and coping strategies.
The Human Development Report (2008) states that climate change is one of the greatest challenges humanity faces and/or will be facing, and it is the world's most vulnerable populations who are immediately at risk. In the future the climate change associated impacts are imminent with the anticipated vagaries of weather. Inter-Governmental Panel on Climate Change is authoritative body is being entrusted with the task of reviewing and assessing, and to understand different manifestation of climate change globally. According to the latest Assessment Synthesis Report 4, AR4 (IPCC 2007) the projected changes are summarized as follows:

- The surface air temperature increased over the globe and is greater at higher latitudes. Annual average temperature is projected to rise to 0.6-4.1^{o}C by the end of this century.
- Observed significant increase in precipitation in eastern parts of North and South America, Northern Europe and Northern and central Asia but reduction in Sahel, the Mediterranean, Sothern Africa and parts of South Asia.
- Likely increase in extreme events viz., heat waves, heavy precipitation, cyclone and very likely that the precipitation increase in higher latitudes and decrease in most sub-tropical land regions.
- The water resource will be in crisis due to changes in rainfall and increased evapotranspiration in major dry regions in mid latitude and including the dry tropics. Thereby agriculture will be affected due to limited water availability. Africa and Asia due to a large population and low adaptive capacity are projected to be highly vulnerable to climate change.

Reducing vulnerability by adaptation and mitigation process require identification of different potential options that may be selected depending on the local contexts. It has been mentioned that "A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to climate change. There are barriers, limits and costs, which are not fully understood" in the latest version of the synthesis report (IPCC 2007). Nature, land, water and associated ecosystems are being degraded in a tremendous pace posing capricious threatening call which can degrade food security and rural livelihood options. The United Nations have called for comprehensive framework for action from the high level task force on global food security and asked for addressing climatic impacts threatening future food and nutritional security (United Nations 2011).

Several coordinated studies including the research conducted by the climate Institute (Washington DC) with cooperation with Asian countries and support from the Asian Development Bank (ADB), pointed out that the Asian continent is likely to be hardest hit by the consequence of global warming and climate change leading to serious implication on the livelihood of poor farmers in the most vulnerable countries like India, China, Sri Lanka, Bangladesh, Indonesia, Malaysia, Vietnam,

Philippines etc. A coordinated study conducted by Climate Change, Agriculture and Food Security (CCAFS) identified future poverty hotspots as India, Bangladesh and other south-east Asian countries (Ericksen et al. 2010). The South Asian region has been clearly grouped under chronically food insecure regions along with the African continent. These impacts will pose great challenge on the sustainability of the livelihood among the poor farmers of Asia who greatly depend on agriculture for their sustenance. Hence, the prognosis for Asia particularly her farmers and the poor is especially bleak if this situation continues unabated, calling for awareness and engagement at all levels of stakeholders

In 2000's Asian countries including India, Bangladesh, Vietnam and Asian pacific countries where significant number of people were affected by various climatological and hydrological disasters such as Tsunami, Cyclones, Typhoons, Flood, Droughts, Landslides, Hurricanes etc. Agriculture being the mainstay of the majority of people in Asia is crucial and any adverse impact on it will definitely affect socio economic well-being, increasing poverty and reducing food security. Food security is affected in two ways: - (i) being the direct sources of food people eat; and (ii) it provides the primary source of income. This is the case for around 40% of the world population and an estimated 65% of the Asian population. Therefore, if the food production is depleted, it has profound impact on rural livelihoods and food insecurity. According to the latest developmental statistics, averages of 25-30% of the Asian population are already below poverty line. Among several factors climate change or variability and associated changes have a direct impact and indirect effects on rural livelihood and food security (Sanchez, 2000). Low income and most vulnerable population are the one who are expected to feel the effects of climate change and increase in the incidence of extreme events and natural disaster. As the result, climate change is most likely to increase the vulnerability of poor farmers who are already struggling with land degradation, price and other social risk (ADB 2009).

Over the years there has been improvement in the rural economy and also implementing relief measures against climatic extremes and financing to overcome losses. However, climate change is expected to exacerbate with increased frequency of extreme events, so relief measures and the financing might not sustain for a longer term. So there should be a clear cut strategy along with fiscal commitment and development oriented to strengthen climate resilience of rural economy to address specifically root causes of vulnerability. Several studies have been undertaken to gain insight on micro level opportunities and constraints; along with understanding how the farmer perceive the impact of CCV and elasticity of degree of resilience among the farmers strata etc., Although studies have been undertaken in West African (Mertz et al. 2009), and Eastern Africa (Bunce et al. 2010) there have been less focus on Asian countries, with a sociological perspective.

These studies are highly recommended to be successfully to cope against climate change particularly targeting the most vulnerable group (Adger et al. 2005, Adger 2003). This study attempts to capture the way rural folk are affected by climate change and understand their coping strategies and constraints faced if any. These field level insights and findings could be a stimulus to the policy makers in formulating programs for the target regions and improving and developing strategies against climatic risk. The overall objective of this multi-national piloted study is aimed to provide science-based solutions and with a pro-poor approach for adaptation of agricultural systems to climate change for the rural poor and most vulnerable farmers in semi-arid regions of Asia especially of India, Sri Lanka, Bangladesh, Thailand and Vietnam, Peoples' Republic of China (PRC). The study takes to consideration the context variability among the within the countries and how best to facto this into analysis by identifying the elements of an ideal governance framework where adaptation can be optimized.

Methodology

The study involved six countries with varying institutional capacity for climate and socio-economic data collection and analysis. A summary of the methodology adopted for each of the key research outputs are presented below (Table 1). A systematic planned methodology was adopted for this study and it was uniformly followed in all the study countries. The activities followed (i) Analysis in identifying vulnerable regions to climate change and variability (ii) Climate data and socio-economic quantitative and qualitative data collection and analysis at macro and micro level (iii) Crop-environmental modeling iv) Econometric modeling to asses' climatic impact on net revenue. The methodology was adopted in the different country to have a regional perceptive of the study findings. The research approach encompasses all the three components of climate agenda, namely exposure, sensitivity and adaptive capacity. The micro level study locations (villages) of different countries are given in Table 2.Both quantitative and qualitative data and related analytical methods were used to understand biophysical inter-linkages and social relationships with reference to drivers of change i.e., using data available on socio-economic, institutional and political factors.

Table 1. Summary of methodology

	Research outputs	**Methods**
1	Trends in: • Rainfall	Longitudinal data analysis of all six countries for last 40 years. In each country the met / climate data were collected from all available government sources from met and agriculture departments.
	• Temperature	Longitudinal data analysis of all six countries for last 40 years.
	• Shifts in onset and conclusion of cropping seasons	Based on Rainfall data analysis
	• Occurrence of extreme events	Assessing linear trends and any deviations in Rainfall and Temperature
2	Vulnerability assessment: Identify regions and population that are at risk due to climate change	Indexing drawing from – lyengar and Sudarshan's (1982) method or IPCC method – i.e., exposure, sensitivity and adaptive capacity. In each country depending on availability of data appropriate measures were used.
3	Adaptation strategies • At household level • Collective • Governance context changes	House hold surveys in villages in the climate high risk locations in each country. • Bangladesh (4 villages) • India (6 villages) • China (2 villages) • Sri Lanka (4 villages) • Thailand (4 villages) • Vietnam (2 villages) Survey of households based on two questionnaires – quantitative and qualitative Focus Group Discussion in each study village Key informants interviews
		While in all countries the locations were chosen from the semi-arid zones, in Bangladesh 2 villages were from flood prone areas.
4	Understand the social dynamics of adaptation	Drawn from the FGDs, household survey, key informants and published sources
5	Catalogue of adaptation strategies that may be applied in Asian context	
6	Asia region and country specific	Policy inferences drawn from studies, reviewed by panels

policy briefs	within the country and at a regional plenary session and finalized with in-country stakeholder participation.

Table 2. List of study villages in South, South East Asia and China

Country	Province/District	Village chosen for study	Number of households sampled
South Asia			
India	Andhra Pradesh/Mahabubnagar	Aurepalle	30
		Dokur	30
	Maharashtra/Akola	Kanzara	30
		Kinkheda	30
	Maharashtra /Solapur	Kalman	30
		Shirapur	30
Sri Lanka	Puttalam	Mangalapura	50
	Anuradhapura	Galahitiyagama	60
	Hambanthota	Bata-Atha Mahagalwewa	50 50
Bangladesh	Mymensingh	Nishaiganj	30
	Thakurgaon	Boikunthapur	30
	Madaripur	Paschim Bahadurpur	30
	Chaudanga	Khudaikhali	30
Southeast Asia			
Thailand	Chok Chai	Don Plai	40
	Nakorn Ratchasima	Kudsawai	40
	Chatturat	Tha Taeng	40
	Chaiyaphum	Nong Muang	40
Vietnam	Phuoc Nam	Vu Bon	80
	PhuocDinh	Nho Lam	80
China			
China	Guizhou	Lucheba	30
	Guizhou	Dajiang	30

Findings and Discussion

Climatic characteristics and Vulnerability to Climate Change

As an initial step to understand climatic trends long term data sets were analyzed at various levels (country/regional/district) to ascertain the trends that prevailed in these countries. The country level analysis showed that the annual average temperature is rising significantly in all countries. Even though a majority of countries have not experienced substantial long term trends (positive or negative) in rainfall, the variability in rainfall and occurrence of extreme events has increased in the recent years. Regional level analysis too followed a similar trend in temperature and rainfall. However, an exception is seen with a decreasing trend in rainfall and rainy days in the drought and flood prone areas of Bangladesh, and Guizhou province of China. In India, the annual rainfall increased in Andhra Pradesh with no significant trend was found in Maharashtra. Analysis at an even more dis-aggregated (district) level demonstrated some differences from aggregated level. In the districts, rising trends in temperature and increasing rainfall variability *i.e.,* change in onset of monsoon; intra-seasonal droughts, flood occurrence, high rainfall events and higher probability of occurrence of drought etc. are the main features. In Bangladesh, rainy days showed a decreasing trend in drought prone regions and an increasing trend in flood prone regions and in Vietnam, rainfall increased significantly in NinhPhuoc district over the years. In general, floods in Bangladesh and Thailand, droughts in India, Sri Lanka, and China and sea water intrusion in Vietnam are some of the distinct climate related issues confronted by these countries.

Divergence in macro and micro level information

National climate related policies and programs are often formulated using the aggregated/macro level information, projections, modeled scenarios etc. They seldom consider the micro level context on response behavior, existing situation, trends outlook and coping capacity mainly due to lack of information. The study demonstrated as to how observed rainfall data varied at different levels (National→ State→District→Mandal/Tehsil→Village) with an example from India (Fig. 1). A clear divergence of trend was distinctly visible and a huge disconnects between macro and micro level information/rainfall pattern was found. In most of the developing countries, absence of infrastructure for gathering information on micro level context often limit the policy machinery to utilize macro level information for formulating policies for micro level impacts and thereby missing targeted need based approach. This could only be overcome by acquiring micro/village level information through institutionalizing an efficient mechanism for collecting, collating, and channelizing micro level information especially related to weather/climate indicators to the policy machinery to formulate climate related policies.

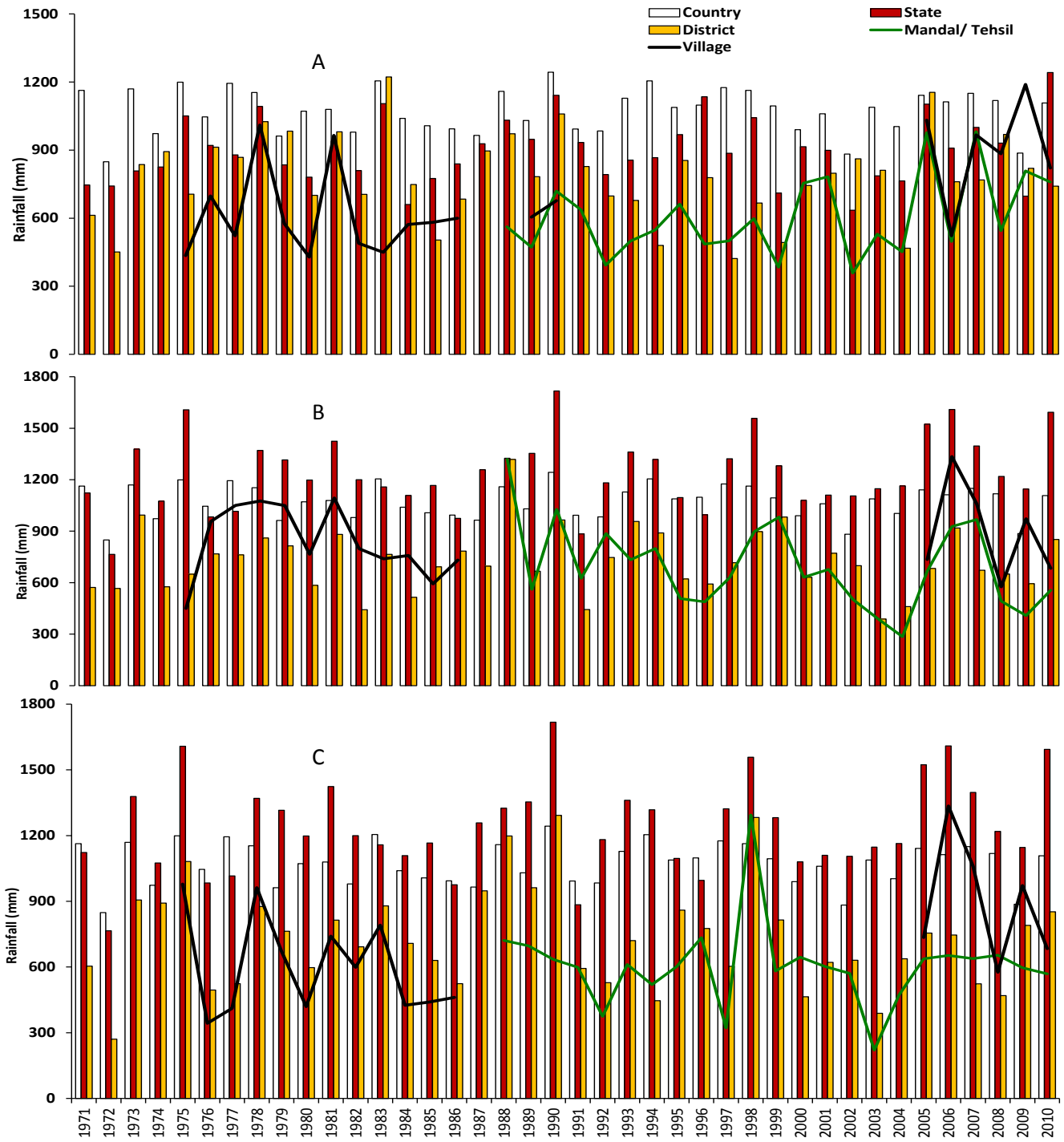

Figure 1. Divergence in the observed climate from macro to micro level (Country → State→District→Mandal/Tehsil→Village) in Indian SAT region A) Aurepalle, Andhra Pradesh B) Kanzara, Maharashtra & C) Shirapur, Maharashtra, India

Climate Change Vulnerability

In India, Majority of the districts (>60%) in both Andhra Pradesh and Maharashtra fall under vulnerable to very highly vulnerable category (Table 3).During the decadal analysis, the degree of vulnerability fluctuated highly in both states. Particularly, in Maharashtra, the number of districts accrued from vulnerable to very highly vulnerable groups. The southern districts of Sri Lanka, most flood prone and tidal prone districts of Bangladesh, North east region of Thailand (12 provinces), 5 out of 8 agro-ecological zones and arid and semi-arid zones of northwestern china etc. are falling with in the category of vulnerable to highly vulnerable. In Vietnam, five out of 8 agro-ecological zones are comparatively highly vulnerable to climate change impacts. Hence, these identified vulnerable regions are to be prioritized for in depth study (macro and micro) and then actions should be formulated for improving resilience.

Table 3. Vulnerability to climate change of major countries of Asia

	South Asia			South East Asia		
	India	**Sri Lanka**	**Bangladesh**	**Thailand**	**Vietnam***	**China**
Vulnerability to climate change	1. Majority districts of Andhra Pradesh and Maharashtra falls under (Vulnerable, Highly vulnerable and very Highly vulnerable). 2. The extent of vulnerability of districts varied over the decades.	1. Over the past 25 years there is no significant improvement in the vulnerability status of the study districts of Sri Lanka. Southern districts are identified as moderately to highly vulnerable 2. The vulnerability ranking fluctuated bi-dimensionally over the years.	1. Most flood prone and tidal prone districts are highly vulnerable 2. Vulnerability of coastal districts has increased over the years.	1. North east region of Thailand is highly vulnerable among other regions; and these regions are drier compared to other parts of the country. 2. Twelve provinces in the north east region falls under vulnerable, highly vulnerable and very highly vulnerable category	1. Out of 8 agro-ecological zones 5 zones are comparatively 'Very Highly Vulnerable' (NWM, RRD, CHR, SER, MRD, 2 are 'Highly Vulnerable' (NCR, SCR) and NEM is 'Vulnerable'. 2. Mekong river delta, major rice bowl falls under very highly vulnerable zone.	The highly vulnerable the arid and semi-arid region of northwest (most parts of eastern Xinjiang, northern Qinghai, Gansu, Ningxia, Shaanxi, western Inner Mongolia); the Tibet-Qinghai plateau; the Karst uplands of southwest China (parts of Guizhou, Sichuan, Chongqing); and densely populated peri-urban coastal. Zones (IDRC and DFID, 2008)

* NWM-North West Mountainous area; RRD- Red River Delta; CHR- Central High Land; SER- South East Region; MRD – Mekong River Delta; NCR- North Central Coast; SCR – South Central Coast; NEM- North East Mountainous.

Micro-level findings

a) Dynamic changes in cropping patterns at micro level

Across the South and South East Asian countries, farmers are trying out new short duration varieties and varieties that are less water demanding. Farmers are also replacing more water demanding crops with drought tolerant cash crops to optimize their incomes as well as reduce their water needs. They are changing their crop calendar to adjust to the uncertainties of rainfall.

India

Among the farmers in South Asian Countries, farmers in rainfed regions of India during the last four decades, shifted from cereal cultivation to short duration drought tolerant or less water demanding crops such as soybean-or castor etc. In places where new irrigation potential has been created like canals in Maharashtra study villages, sugarcane has replaced many other prevalent crops which led to increased incomes. Mixed cropping is being practiced in selected villages in Andhra Pradesh as a measure to reduce the risk of income failure. Fodder crops such as maize, grasses and fodder sorghum has gained importance of late as the dairy industry started to grow in some villages like study village in Andhra Pradesh and Maharashtra.

Other Countries

In Sri Lanka cultivation of finger millets, blackgram and oil seeds have decreased in recent times while fine cereals and vegetables are increasing. Cotton cultivation is decreasing in most of the villages. Cultivation of annual crops is being reduced in the last few decades and farmers are shifting to perennial crops in rain fed villages like Mangalapura in Puttalam district. The shifting to perennial crops in Mangalapura is mainly in response to the increased uncertainty of rainfall and farmers were not being able to cope with the crop losses; weather proofing mechanisms like development of irrigation potential was not taking place and thus the farmers perceived that perennial plantations like cashew will fare better over time under these harsh rainfed environments. In Sri Lankan village, over the period in the Yala (March – August) season, cotton cultivation has decreased. Cultivated area for crops, such as finger millet, green gram, and cowpea has decreased. Paddy cultivation increased from 36% in the seventies to 41.4% in recent decades. In Maha season (September – February), more areas were used to grow crops in the recent years, particularly paddy, increasing from 31-44% of total area. Cotton cultivation disappeared in the recent times from as much as 17% of the area in the seventies.

In South East Asian countries rice is the main crop. In Thailand, both the upland and lowland villages grow rice and cassava as the main crops. The rice area reduced from 60 to 31% and the cassava area increased from 30 to 49% and it is increasing at the expense of rice. Farmers are feeling that even in the lowland villages cassava is giving a more stable yield in the mid lowlands where the standing water does not accumulate. Traditional water intensive crops like Kenaf/Roselle are slowly disappearing. In Vietnam hybrid maize is being replaced by inbred maize due to its low water requirements. In some communes like Phuoc Nam in NinhThuan province, rice area is decreased drastically due to non-availability of water. In the coastal villages like in PhoucDinh commune, farmers are switching to aquaculture due to salt water intrusions. In the PhuocDinh commune, rice area is very small and farmers switched over to aquaculture twenty years ago. Tobacco and legumes occupy a significant area, and about 27% of the area is under tobacco and 13% is under legumes. In the coastal areas where farmers perceived salt water intrusions that altered their soil properties, farmers have shifted to aquaculture in their traditional rice lands over the last four decades. Boikunthapur district in Bangladesh and PhuocDinh commune

in NinhThuan province in Vietnam are examples of the study. The case of China's south west region, Guizhou province is different than other countries. The government is focusing on the development of irrigation infrastructure. Most of the traditional crops like cereals and oilseeds are slowly replaced by vegetables by the farmers. Farmers are now cultivating four vegetable crops a year in villages like Lucheba. By increasing the crop intensity to 400 %, farmers are aiming to increase their profits.

In the study domain, there have been significant changes in cropping pattern, crop management practices and farm as well as enterprise diversification which was mostly autonomous driven by several factors, both price and non-price including changes in climate and dwindling irrigation potential, salt water intrusion and floods etc. Adoption of improved varieties, short duration cash crops, drought tolerant crops, mono culture, shifting method of rice cultivation etc. are some of the major strategies adopted by the small holder farmers.

b) Livestock developments an integral part of livelihood

Across the countries a common feature that farmers perceived is that, with time, mechanization of farm operations have increased. This saw a reduction in the number of bullocks and other farm animals that are involved in farm operations. One of the adverse fallouts is the reduction in the availability of organic manures for soil incorporation.

India

In South Asia only, in India livestock is perceived as an option for diversification of incomes through milk production. In India, farmers in selected study villages like Aurepalle and Shirapur have progressed by diversifying their incomes from milk production. These villages have developed milk collection centers and are on the path of commercializing their dairy outputs. Farmers perceive that about 70% of the feed requirement of local cows is dependent on grazing. About 60% (for bullocks) and 50% (for buffalos) feed requirement is met by grazing. This indicates that relatively more stall feeding and supplementation with concentrates etc., is done for buffaloes and bullocks as compared to local cows. However, there is a scope for improving the milk yield by improving feed management. Goats are reared entirely by grazing in the common lands.

Other Countries

In the rest of the countries like Sri Lanka the importance of livestock in their income earnings activities has come down. In Sri Lanka livestock rearing has decreased from the seventies except for one village. This is due to lack of breeding improvement strategies. However in some villages poultry is gaining popularity as an industry. The decrease in livestock numbers in villages in the recent times is attributed to decreased grazing land and bad maintenance of existing ones. In South East Asia, farmers in Thailand raise livestock for personal consumption and as insurance in the event of distress sale. In Vietnam cows and buffaloes are popular in villages and farmers rear them as a means of income. In China's Guizhou province, cows and buffaloes are reared in villages like Lucheba and Dajiang for commercial purposes. Buffaloes are used for farm operations like tillage etc. Farmers perceived that the draught buffalo numbers decreased in the recent times. This was mainly due to increased mechanization and introduction of mini tractors and tillers. Farmers perceived that the number of goats increased in the mountainous areas like Dajiang village thereby increasing the income of the farmers.

It was observed that livestock rearing and earning from livestock as an important cushioning occupation to supplement the income apart from crops. However, in the countries like Sri Lanka

the importance of livestock have reduced, possibly due to lack of improved breeds and depleting natural resources viz., grazing lands, water availability are major factors attributed for the decline.

c) Farm Income-Tracking diversification at micro level

India

Farmers in India are keener in diversifying their income sources to reduce their risk of income loss due to variability and uncertainty in rainfall and associated increased dry spells. The share of agriculture ranged from 57 to just 13 % of their total income across the villages. Farm work varies between 3 to 16 % while business has a share of 10 to 19 %; livestock has a share of 4 to 10 % and very less per cent on out migration and caste occupations.

Other countries

Farmers across South, South East Asian countries and China are diversifying their incomes within agriculture sector by expanding non-farm enterprise and income sources. This diversification is mainly dictated by the opportunities that they have and the infrastructural and governance environments. Among the South Asian countries, Sri Lankan farmers too have diversified sources of income but their major source of income is still agriculture, dairy and poultry and non-farm sources.

In Vietnam, farmer's income from livestock is highest and ranged between 26 to 60 % followed by crop production (10 to 23 %) and salaried services and non-farm sectors (17 to 63 %). Farmers in China have also diversified their income to cover the risks in agricultural production; income from crop production has a share of 52 to 54 %; income from livestock has a share of 17 to 36 % followed by non-farm income that has a share of 9 to 31 %. There is a marked shift towards non-farm source of income in all the study locations. Though, non-farm income provides a succor during the crop failures, the large scale shift in acreage under staples will have consequential bearing on food security in stabilizing the price stability.

d) Farmer's perception of climate variability

Farmer's perception of climate variability echoed many similar observations in all the studies. Across all the selected villages, farmers perceived that there was a decrease in annual rainfall and that the distribution of rainfall was erratic with evidence in decrease in number of rainy days (Table 4). Farmers in most of the countries except Sri Lanka perceived a delay in the arrival of monsoon, and an increase in the annual temperature. Majority of the sampled farmers in Sri Lanka perceived an early arrival of South West and North East monsoons and also an increase in dry spells in both Yala and Maha agricultural seasons. In general farmer's perception about the variability was nearer to the actual observations in the recent times. They were able to recall their latest observations in the recent two decades correctly. Rainfall has been highly variable across the years but district level rainfall data does not reveal any decreasing trend of annual rainfall. In India the actual Mandal level data that was collected to represent villages like Dokur shows that there was a delay in the arrival of monsoon in the last two decades by about 10 days. Similarly there was a slight decrease in the number of rainy days. The actual temperature increased over time. These findings mostly concur with the farmers perceptions.

Table 4.Farmers perception on trends in climatic parameter from the study region

	Bangladesh	India	Sri Lanka	Thailand	Vietnam	China
Annual Temperature	MII	MI	MII	MII	MID	MII
Rainfall	MID	MD	MID	MID	MII	MID
No. of rainy days	MID	MD	MID	MII	MID	-
Onset of Monsoon	Erratic	Delayed	Slightly delayed	-	-	Delayed
Distribution of seasonal rainfall	Rise in erraticness					

In China the actual annual rainfall increased by 2 % in the recent times and farmers also perceived an increase in the rainfall. This study throws light on the fact that there is a need for rainfall data collection and its availability at village level for micro level planning. Hence, it was evident that there is congruence in the farmer's perception about climatic indicators and the professional's inferences through in depth analysis. Through these "schools of learning" which are often touted as naïve, need based adaptation strategies can be promoted and validated.

e) Land management practices-What farmers are doing at micro level

Land management measures through incorporation of organic matter like green manuring and composting practice of incorporating crop residues into the soil decreased while bunding the fields to conserve rain water and creating drainage channels is followed by varying degrees across the villages in India and Sri Lanka. In India, More than 30% of the farmers in the village used green manure and incorporated crop residues in the soil during the early period but there is a major decrease in the practice during recent years. The practice of bunding the field has increased recently. One of the major factors that emerge out of this information is that most of the farmers were not aware of organic input methods to the soil and whatever meager measures were followed earlier were reduced over the years This is adversely affecting the soil and subsequently this will lead to unsustainable productivity growth. In Thailand, mulching (which is not practiced much in India), green manuring, composting and incorporating crop residues are popular in the upland villages as seen in Tha Taeng and Nong Muang villages where more than 50 % of the farmers practice them. These practices are not popular with the Lowland farmers. The reason for incorporation of organic sources in upland soils in Thailand is due to government interventions in terms of imparting training in organic agriculture to improve soil fertility and water holding capacity in these villages. Adoption of improved land management is a must for long term sustainability and concerted efforts through different institutional innovations be pursued in adopting these locally proven practices.

f) Dynamics of sources and availability of water for irrigation

India

Water for irrigation is the single most important factor that will neutralize the risk of variability and uncertainty of rainfall. In the seventies, across the villages farmers in semi-arid regions of India were dependent on tanks and open wells for irrigation. During the 90's, in the study villages

(Kanzara, Shirapur and Kinkhed) in India, got infrastructure in terms of canals and surface water for cultivation. Similarly in the nineties, the installation of tube wells was started and in the recent decade most of the villages saw a significant increase in number of tube wells, thereby exploiting the ground water to insulate their crop production from uncertainty of rainfall. Farmers are aware that in these marginal environments, development of irrigation sources is the key driver of change. One adverse result of this development is that most of the open dug wells started drying up due to lowering of ground water table. Many of the tanks are also drying up due to reduced runoff from the catchments. The case of selected Indian villages is unique in the sense that nineties saw a development of water resources due to government interventions in the form of incentives and investments in infrastructure development in some cases. In Sri Lanka most of the selected study villages are rainfed and very little area is irrigated and a few open wells and tanks are the sources of irrigation. Partial supplementary irrigation is practiced during the post rainy season.

Other Countries

In South East Asia, lowland villages from Thailand, a major share of irrigation is through surface water from rivers, canals and ponds. Besides these, ground water sources like open wells and tube wells cater to the irrigation needs to a limited extent. The case of lowland villages in Thailand is similar to Indian conditions. In the upland villages very little land is irrigated. Very few open wells and a pond are the only sources of irrigation. Unlike Indian villages the development of ground water resources through investment by the farmers is difficult as the ground water table has gone down significantly. In Vietnam, canal system and wells and tanks are common in the villages and more than 80 % of the irrigation needs are met from the canal system and the rest from open wells and tanks. The dependence on the canal system has increased in the recent times. In China, one of the villages has met 50 % of the irrigation needs through a series of about 500 small tanks and the rest of the area is irrigated by a pipeline system and a reservoir that was built recently in the year 2009. While in another village, just only 5 % of the area is irrigated through tanks and 33 % area is irrigated by pumping water from a nearby river depicting a contrasting situation in the village settings. Overall, it was inferred that of late traditional sources of irrigation have weakened due to the side effects of other factors viz., market, policy, governance structure and demographic changes. Hence, there is a need of strengthening of the indigenous knowledge and traditional mechanisms especially for conserving natural resource base.

Adaptation measures-How the farmers are practicing at micro level

Adaptation to any change in the system is essential to sustain the productivity and profitability for the farmers. Across the South and South East Asian countries farmers adopted a number of alternatives to reduce the negative effects associated changes in climate (Table 5). That includes shifting to short duration cultivars to cope with the increased variability in rainfall and to adjust the crop calendars. Another common feature is the adoption of less water demanding cash crops to replace traditional coarse and fine cereals. Diversification of incomes is another strategy that the farmers are adapting across the countries to reduce their risk from rainfed crop production. There are other adaptation strategies that are specific to each country and are governed by the contextual situations created by socio-economic environments as well as the government policies.

Ground water exploitation has rapidly increased in all the study villages in India in the recent decades. Farmers perceive that on-demand water availability is the best way of adaptation as the risk associated with the uncertainty of rainfall is neutralized by irrigation potential. Farmers are shifting from cereal cultivation to short duration cash crops mainly to reduce risk from uncertain rainfall and stabilize incomes. Mixed cropping is also seen as an effective adaptation measure to

address crop loss due to uncertainty of rainfall as this is an indigenous adaptation method most prevalent in the rainfed agriculture with associated dry spells. This was elicited during the farm level investigation particularly in villages like Kinkheda and Dokur villages in India. This practice ensures some returns in the event of failure of monsoon or occurrence of a drought.

Another unique adaptation measure evinced in Indian farm settings is the growth of different Self-help groups (SHGs). These SHGs provide hassle free and easy access to credit to the farmers for their farm operations. This is being perceived as an effective adaptation measure by the farmers. In the recent decade several new milk collection centers have come up in some villages especially in Aurepalle, Shirapur and Kalman in Indian SAT and this is seen as evidence of increased diversification of incomes away from the traditional crop production. This is an adaptive measure that will reduce the risk of income loss due to increased variability of rainfall and droughts. In Sri Lanka farmers are shifting from annual crops to perennial drought tolerant plantations like cashew etc. more particularly in rainfed villages where irrigation potential is not available and this move is mainly driven by the urge to avoid the risk of crop failure. Establishing kinship ties to aid at difficult times is another adaptation strategy that the farmers perceive as important. In Bangladesh, farmers are diversifying their incomes to reduce the risk associated with the vagaries of rainfall on agricultural production. Partial shifting from cultivation of cereals and oilseeds to short duration or perennial cash crops like betel leaf is another adaptation strategy that the farmers are practicing. In the flood prone areas of Bangladesh, farmers are shifting from traditional rice growing to aquaculture activities to reduce the risk and improve their incomes. Jute cultivation is being slowly replaced by pulses and vegetables to reduce the water demand. Better access to micro-finance is also seen as an adaptation measure by the farmers.

Among the South East Asian countries, farmers in Thailand are diversifying their income into non-farm sector. They are shifting to less water demanding crops like cassava or short duration crops like maize. They are changing crop management practices like shifting from rice transplanting to broadcasting method to reduce water demand. In lowland villages delayed planting of rice to synchronize the delay in monsoon is becoming common. Replacing rice by cassava in the marginal lowlands is seen as another adaptation strategy. Accessing loans to invest in increasing irrigation potential is followed by small and large farmers. Soil improvement using organic matter and crop residues is practiced by farmers among the upland villages; which was introduced by the government to enable the farmers to improve soil fertility and soil moisture retention. Increasing crop intensity to improve farm incomes is another measure practiced by resource rich farmers. The upland farmers are shifting from growing Kenaf to less water intensive crops like cassava. Digging and deepening of wells for irrigation is another adaptation measure for conserving water. In Vietnam, shift to less water demanding crops and investment in cash crops and increasing irrigation potential by large farmers and working as farm laborers to supplement the farm income (specially marginal and small farmers) are some of the adaptation measures followed by the farmers. Farmers in the coastal regions are shifting from crop cultivation to aquaculture. They are also diversifying into part time business and salaried services to supplement income and reduce the risk in agriculture and improving and developing new water sources for supplementary irrigation.

In china, villagers are practicing unique adaptation measures. In a way the government is shaping up these measures. In China, protection and increase in the forest cover around the villages, saving power and developing several alternate renewable power sources and enhancing infrastructure development are some of the measures that the government is enabling and farmers are adopting. Construction of small water tanks and changing cropping system by increasing the cropping intensity are some of the adaptation measures that the farmers are also practicing in China.

The key findings on grassroots perspectives that emanated from the gender-based social analysis revealed that women faced particular constraints in their capacity to adapt to existing and predicted impacts of climate change. Yet many women are adapting to the changing climate and are clear about their needs and priorities. Focus group meetings and participatory rural appraisals clearly showed that women in rural communities are adapting their practices in order to secure their livelihoods in the face of changes in the frequency, intensity and duration of droughts and dry spells. The women who took part in the surveys described various adaptation strategies such as changing cultivation to drought resistant crops, or to crops that can be harvested before the drought, *i.e.,* early maturing varieties in other words drought escape varieties

Table 5:- Summarized information on adaptation strategies or initiatives adopted at different level in the study countries

Sl. No.	Adaptation strategies adopted at different level of organization	India	Sri Lanka	Bangladesh	Thailand	Vietnam	China
	At the household level:						
1	**Intergenerational knowledge transfer based on primarily experiential learning:**						
	Adopt improved varieties and short duration crops	√	√	√			
	Substitute cash crops for cereals	√		√			
	Drought tolerant crops i.e. cotton, sorghum	√				√	
	Dug tube wells to supplement water supply.	√				√	
	Adaptation improved short varieties duration crops	√					
	Reduce high water requiring rice cultivation.	√					
	Adopt mixed cropping including glow??? less water required crops i.e castor & pigeon pea	√			√		
	Shifting to mono-cropping of soybeans	√					
	Increase sugar cane or other high value cultivation (canal irrigation)	√			√		
	Delayed cultivation to conserve rain water	√					
	Income diversification (Dairy, fish farming)	√	√	√		√	
	Wheat cultivation during Rabi with supplementary irrigation	√					
	Change from seasonal to perennial crops				√		
	Changing traditional / seasonal crops to short duration cash crops/high value cops		√				√
	Farm mechanization		√				
	Adaptation of hybrid varieties		√				
	Farm Labour					√	
	Diversification to non-farm income source	√			√		
	Migration	√		√			
	Enriching soil fertility through organic amendments				√		
2	**House hold resource base – savings, assets, wealth, skills and competencies, social contacts**						
	Reduction of personal expenses	√			√		
	Community Level						
3	**Leadership**	√	√				

4	**Collective ethos guiding action for community interests reflected in groups addressing common interests;**						
	Establish self-help micro-credit groups.	√	√		√		
	Kinship support systems		√		√		
5	**Penetration of external agencies**						
	Establishing milk collecting centers	√					
6	**Resource base – land, water, forests, infrastructure**						
	National/Governmental						
7	**State agencies with extended mandates to the periphery**	√			√		√
8	**Supporting legislation and institutions that enables household and communities to act considering local context**						√
							√
9	**Resource transfer to periphery**						
	Input subsidies during peak requirement periods		√				√
	Global / Regional						
10	International agreements and conventions	√	√	√	√	√	√
12	Regional initiatives and programs	√	√	√	√	√	√

Asian visual percept of micro level constraints to adaptation

The willingness to act together and collectively towards management and access to resources plays a vital role in increasing or decreasing community or individual capabilities which goes a long way in determining resilience level of the community. A key constraint to adaptation was the lack of institutional arrangements for providing access to input and output markets. The other important constraints to adaptation perceived by farmers in different countries are elaborated as- In India, non-availability of drought tolerant varieties and lack of access for supplementary irrigation, non-availability of potential technologies including improved varieties, no capacity for crop diversification by marginal farmers, access to credits against risk, efficient co-operatives/association tackling risks , efficient governance and lack of incentives to adopt soil and water conservation practices are the major constraints perceived by the farmers. In Bangladesh farmers perceived inadequate infrastructure, lack of suitable seeds, inadequate irrigation facilities, lack of credit facility and universal crop insurance as the major constraints to adaptation.

In Thailand, farmers perceived that small farm sizes, lack of water resource in the dry season, little innovation on alternate sources of income and lack of better crop management technologies are some of the major constraints to adaptation. In Vietnam farmers perceived that some of the technologies available are not effective, and lack of subsidies makes them inaccessible. Farmers felt that financing was available but for want of collateral, they were not able to access it. Low profits, high investment for adaptation and higher risk of crop failures deter them from adaptation. In China farmers perceived that lack of investment potential of the farmers, lack of technological advancements in terms of varieties and management practices and power sources, infrastructural constraints and some constraints in effective policy are the major barriers to adaptation. For example, in India, the qualitative assessment of quantifying adaptive capacity among the different socio-economic sect of the village population varied differentially (Table 6).

Table 6. Recovery period of Various Groups w.r.t Climate Shock/Bad Year in Indian village

Category of Respondents	**Time Span to recover**			
	Dokur	**Kanzara**	**Aurepalle**	**Shirapur**
Big Farmer	2-3 years	1-2 years	1-2 years	1-2 years
Medium Farmer	2-3 years	2-3 years	2-3 years	3-4 years
Small Farmer	3-4 years	4-5 years	2-3 years	3-4 years
Laborers	3-4 years	3-4 years [2]	2-3 years	3-4 years*
Women	Dependent on Household	Dependent on Household	Dependent on household	Dependent on household

Source: Banerjee et al. 2011;The values are by assuming only if the following year is a normal year or a favorable year; Source: Farmer FGD's in the study villages in 2009

Building resilience at the grassroots level – Way forward

Overall, the country level studies on adaptation strategies present evidences that reflect the farmers' adaptation strategies which portray spatial and temporal diversities. These strategies are highly dynamic and have potential including complementarities with agricultural development programs. In this regard, greater attention is needed on the following:

- Understand and promote adaptation strategies at the grassroots level that integrate climate change concerns into development strategies
- Learn and use the rationale of traditional adaptation measures as a part of the strategy
- Reorient approaches of public programs as well as responsible agencies i.e. practitioners and decision makers to implement the above

This regional analysis and the insights gain from this study resulted in formulation of recommendations for future orientation and line of action (Box 1). The actions for improving climate resiliency area tradeoff between ideal, actual and desired. The actions could be either specific to a region or with common deficiency and limitation featuring at macro level. These actions should be oriented towards different levels after imbibing lessons learnt from the analysis. As reiterated by Campbell et al. (2011), 'pursuing early action activities will result in country-specific data and knowledge as well as experience with agricultural practices and policies that could inform long term national strategies'. The insights from the six countries also clearly indicate that more research is needed on the adaptation strategies particularly for women in the face of existing climate change impacts on agricultural productivity and food security.

Data disaggregated by gender and in-depth qualitative studies into impacts – based on gender-sensitive participatory approaches to data collection, are essential to furthering the adaptation agenda and ensuring it is both efficient and equitable. The overarching recommendation is to diagnose and understand farmer's adaptation strategies to climate variability with a focus on the dynamics of adaptations, implying search for and promoting approaches and options to harness the opportunities in the changing economic, technological and institutional opportunities, which may even exceed the ones evolved by farmers in the subsistence-oriented, locally-focused contexts in the past. Dynamism, diversity and flexibility are essential for enhancement and reorientation of the capacities of the farmers and rural communities, as well as the institutional arrangements and innovations supporting them.

Box 1:- Recommendations for a Climate Resilient Agriculture in Asia

A. Tools, Technologies and Infrastructure for Resilient Agriculture

Develop required technology and knowhow to match local needs, based on local technology needs assessment to cope with climate change. These may include heat and or drought or even flood tolerant varieties, short term early maturing crop varieties, etc. Such technology development must be taking leads from the vulnerability analysis, prioritization and mapping, so that the local adaptation capacities are strengthened.

Identify adaptation strategies for up-scaling from among those that are location specific but have the potential for wider application for adaptation, especially by small and more vulnerable farmers who face more significant climate change challenges. These location specific models for adaptation considering specific vulnerability contexts can be developed and disseminated as technology/knowledge packs.

Promote improved use of climate information for local planning through scientific monitoring of weather patterns at local level, and making information readily available to smallholder farmers for decision making related to livelihoods. This may require increasing the density of weather observatories; establishing rain gauges at village level; enabling access and efficient management of weather related information (Remote sensing and GIS) and repository. Institutionalize mechanism to collect and analyze micro level information (climate, crops, socio-economic, natural resources, etc.) and efficiently transmit it to be used as an input in formalizing macro level policies.

Optimize the use of farmers' traditional, indigenous knowledge on resource conservation, coping strategies, etc., by evaluating, assessing scalability and integrating with advanced technological interventions that may consist of improved varieties, crop management, community resource conservation, rainwater harvesting and storage to maximize the outcome of knowledge management and developing models for dissemination.

Allocate resources for the research focusing on (i) developing local livelihood models to effectively adapt to climate change considering the intensity of vulnerability and the local socio-institutional and environmental conditions. (ii)identifying local technology requirements to enhance adaptation and improve household incomes (iii) identifying the most effective institutional management and governance models for effective and equitable adaptation.

Encourage the adoption of location specific conservation techniques (cover cropping, in situ moisture conservation, rainwater harvesting, groundwater recharge techniques, locally adapted cropping mixture, etc) for water efficient agriculture and demonstration of these available technologies in the farmers' fields.

Strengthen the weather based agro-advisory services to enable farmers manage climate risks effectively, and develop equally accessible weather insurance products.

B. Mainstream climate change perspectives into agriculture development planning and programs.

The impact of changing trends and consistent unpredictability of climate parameters on agriculture productivity, food production and storage, rural incomes and its distribution, migration, natural and common property, collective action must be considered in agricultural planning. Different programs implemented at the village level to enable farmers adapt to climate change should be coordinated to eliminate duplication and improve effectiveness. These may be related to relief, agriculture, livestock and fisheries, health, natural resource management and infrastructure as well as regional development.

Prioritize regions of climate change vulnerability in the arid and semi-arid tropics and flood-prone areas. The most vulnerable must be prioritized for implementation of comprehensive agriculture and livelihood contingency action plans for effectively coping with climate risks and to target relief. Intra community and variances in local vulnerability should be considered to ensure equitable distribution of relief or adaptation support to ensure equity.
Stimulate diversification of rural household incomes. Promote multi-enterprise household units incorporating context specific enterprise possibilities where livestock, cottage industries, trade or services or part time work, non-farm employment are available to enhance income opportunities. In locations where livestock enterprise will supplement incomes and cushion climate related shocks, strengthen location specific support for their promotion of livestock, fisheries, poultry and related enterprises among smallholder farmers.
Strengthen common property management by the communities especially for sustainable use of water sources.
Ensure equity in accessing government support and relief programs. These include relief, food, agricultural and enterprise subsidies, rural finances, poverty reduction programs and technology adoption support.

C. Financing and Partnerships for Transformational Change

Strengthen professional knowhow of officials to work effectively in a context of climate change sensitivity through increased awareness and training for development officials, scientists, extension workers and farmers. Interdisciplinary dialogues and programs to enable scientists, policy makers, development practitioners and farmers to discuss and share research findings and experiential knowledge is necessary.
Provide incentives to farmers to adopt natural resource conservation measures that enhance forest cover, replenish groundwater and use renewable energy.
Provide support to improve the existing indigenous technologies that are eco-friendly and sustainable, through research on efficacy, documentation and up-scaling.
Strengthen social and institutional capital engaged in improving adaptation and climate change preparedness.
Encourage the role of non-governmental organizations, public and philanthropic organizations working with local communities. This could also forge international or regional partnerships to develop technologies to suit local requirements by pooling finance and intellectual resources.
Improve infrastructure in vulnerable regions. Focus on adaptation to climate change in regional planning and infrastructure development ensures equity in regional development, especially in the climate vulnerable areas. The potential for wider application for adaptation, especially by small and more vulnerable farmers who face more significant climate change challenges. These location specific models for adaptation considering specific vulnerability contexts can be developed and disseminated as technology/knowledge packs.

Conclusion

The study is a comprehensive effort to understand and analyze the vulnerability to and impacts of climate change and the adaptation strategies of farmers in the selected regions. It is envisaged that the above issues centric to the agenda of climate change challenges in the marginal regions of Asia will be addressed well by providing suggestions on strategies and policies to reduce the vulnerability, strengthen adaptive capacity and opportunities, and options to the farmers to cope better with the impending climate change.

To facilitate effective adaptation to climate change, it is important to recognize the uncertainties and information gaps in the micro-level spatial contexts. There is a crucial need for collection, analysis and dissemination of reliable information on climate-response related variables (including farmers perceptions) in a diverse micro-level spatial contexts and preparation of area-specific inventories of indicative production and resource use options (possibilities) for dry land agriculture to match with the opportunities and constraints faced by the region.

Stemming from the grass root and need based approach, the study categorically elicited the farmer's perception and practices, their natural resource base, current and potential adaptation practices in the form of adjustment in their farming and non-farming systems and practices. In order to ameliorate the local level constraints and main stream adaptation in the developmental agenda, we need to facilitate the effective adaptation to climate change/variability keeping the following aspects in mind.

1. Adaptation strategies should have an element of diversification both horizontal and vertical
2. Since income sources, options, and opportunities to adapt are increasingly recognized, adaptation strategies have to have strong dynamic orientation.
3. In keeping with the emerging evidence on emerging convergence between development and adaptation process, adaptation should be integral part of development strategy (Halsnaes and Verhagen, 2007).
4. Requisite space for grass root level understanding of adaptation strategies helping in better and pragmatic bottom up approaches. This understanding is reinforced by details from field studies.
5. Adaptations to be effective not only call for individual households understanding and capacities, but strong element of collective action and institutional on the one hand and proactive approach of the formal public and private agencies.
6. Finally, the development policies for diverse agro-climatic regions need to have explicit and effective support for integrated adaptation strategies. The purpose of this study is also to sensitize and induce the same.

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