Vulnerability to climate change:
Adaptation Strategies and Layers of Resilience

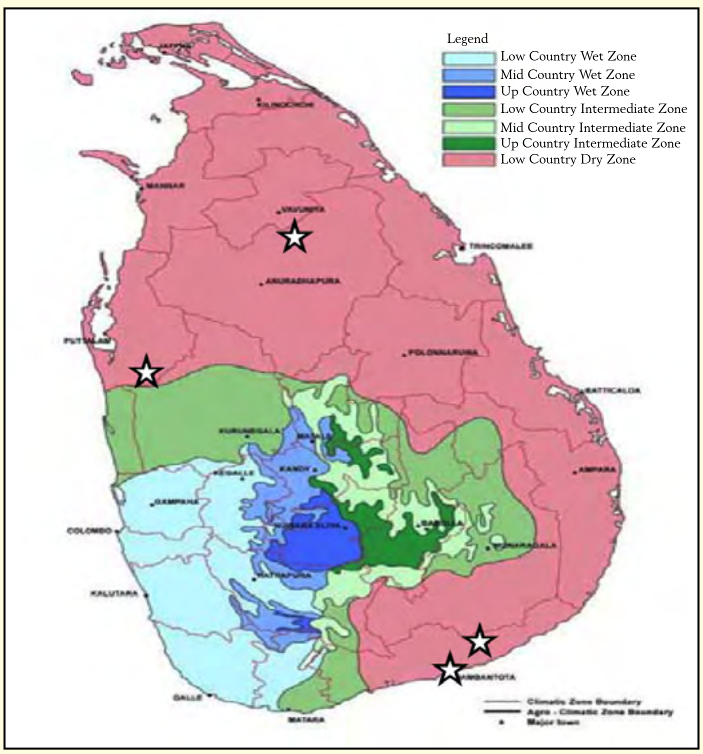
Policy Brief No. 20 February 2013

Mainstreaming Grassroots Adaptation and Building Climate Resilient Agriculture in Sri Lanka

Frank Niranjan, Wijaya Jayatilaka, Naveen P Singh and MCS Bantilan

Background

Climate change in recent decades has become a major concern of the global community. The Inter-Governmental Panel on Climate Change (IPCC) established in 1988 by the United Nations has highlighted alarming trends in changes in global temperatures, shifts in rainfall patterns, rising sea levels and the impact of these changes on the livelihoods of people, especially the poor. The changes will affect sub-Saharan Africa the greatest and also Asia with its very large population, most of whom are dependent on agriculture. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India, implemented a research project in 2008, spanning seven countries in Asia, namely Bangladesh, China, India, Pakistan, Sri Lanka, Thailand and Viet Nam to understand climate change and its effects on rural farmers in semi-arid locations. The studies were designed to help develop policy directives to enable governments and other agencies take required actions to improve farmers adaptive capacities and resilience to climate change. The Asian Development Bank provided the financial assistance to undertake the seven-country research project.



Map 1. Agro-climatological map of Sri Lanka showing the four study villages in Puttalam, Anuradhapura and Hambantota districts.

In Sri Lanka the study was undertaken by the Sri Lanka Council for Agriculture Research Policy (SL-CARP). Following the standardized research protocol developed by ICRISAT for all seven countries, four villages were selected from two districts for in-depth studies survey. The studies analyzed long term climate data collected by the government and also primary data on famers' perceptions and experiential knowledge on climate related risks. Climate data from the early 1960s were obtained from the Department of Meteorology,

Agro-climatic heterogeneity in Sri Lanka

Seasons:
(i) First inter-monsoon (March–April)
(ii) Southwest monsoon (May–September)
(iii) Second inter-monsoon (October–November)
(iv) Northeast monsoon (December–February).

Cultivation seasons:
(i) *Yala* from March to August (first Inter-monsoon and southwest monsoon)
(ii) *Maha*, from September to February (second inter-monsoon and northeast Monsoon).

Agro-climate zones:
(i) Wet zone (total rainfall > 2500)
(ii) Intermediate zone (total rainfall between 1750 and 2500)
(iii) Dry zone (Total Rainfall <1250)

Colombo to undertake trend analysis for rainfall and temperature. Further, based on three indicators (i) exposure (ii) sensitivity and (iii) adaptive capacity, a composite index of vulnerability was developed and the level of vulnerability to climate change was assessed for seven time periods. Assessing vulnerability in districts was done to identify variability and various interventions.

Sri Lanka has developed several key instruments to prepare for the imminent impact of climate change by the Ministries of Environment and Agriculture, which include:

1. The National Environment Policy (2003)
2. The National Climate Change Adaptation Policy for Sri Lanka 2011 to 2016 (2010) NCCAP
3. The National Action Plan on Climate Change (2010)

The Ministry of Environmental Affairs is responsible for developing policies related to the environment. Several directives have been initiated to address environmental concerns. The NCCP has focused on (a) vulnerability, (b) adaptation, (c) mitigation, (d) sustainable consumption and production, (e) knowledge management and (f) institutional support. The policy makes provision to assess vulnerability including the adverse impacts, recognizing the need for information dissemination to enhance adaptation and mitigation. Further, the policy draft provides for (i) disaster management, (ii) food production and food security (iii) conservation of water resources and biodiversity (iv) education, awareness and capacity building (v) cooperation and partnerships and (vi) creating a "climate change sensitive" generation, among others. However, the emphasis placed on follow-up action on formulated policies, their monitoring and evaluation has not been strong. The relevant ministries, the Department of National Planning, Ministry of Finance also take initiatives to draft policies and laws.

While the experience of Sri Lanka in developing policies and related laws is commendable, implementation and state funding remains poor (TISL 2011). This situation calls for strengthening policy formulation, implementation and public scrutiny and monitoring to improve effectiveness.

The major income avenue of the majority of people is agriculture. Almost all consumer needs of rice and vegetable crops are grown in Sri Lanka during the two cultivation seasons *Yala* and *Maha*. The Dry Zone which has over two-thirds of the land mass with the largest extent of cultivable land, is the most vulnerable to drought. The Intermediate Zone also has agricultural lands, while the Wet Zone is densely populated. Farmers in the Dry Zone will be adversely affected by climate change and will need targetted interventions and support.

Key changes across the country

- Annual average rainfall over Sri Lanka has decreased by 144 mm during the 1961 to 1990 period compared to the 1931 to 1960 period (Chandrapala 1997) with the standard deviation increasing from 234 to 263 mm.
- The Northeast monsoon rainfall over Sri Lanka has decreased from the 1931-1960 to the 1961-1990 periods, with an increased variability.
- The Southwest monsoon rainfall has not shown any significant change during these two periods; however variability has decreased during 1961-1990 compared to 1931-1960.

Time series analysis for 1951-2008 shows a decreasing trend for rainfall in every district (ICRISAT a. In press). The Dry Zone is vulnerable to high rainfall vulnerability. Further, the occurrence of consecutive dry spells has increased in most of the Wet Zone.

- The one day high rainfall events, especially in the Wet Zone in the western slopes in the central hills, has increased (Premalal 2009).
- The total rainfall decreased by an average of 8 mm per year and it varies between a minimum of 2 mm per year in Jaffna (Dry Zone) and a maximum of 17 mm per year in Kegalle (Wet Zone). Heavy and highly intense rainfall was experienced in the period 1961-2008.
- The annual average number of rainy days in the Dry Zone is generally less than 100 days, with some locations reporting less than 60. The number of rainy days in the Intermediate Zone ranges from 100 days to 180 days, while it is around 180 days or above in the Wet Zone districts.
- Annual mean air temperature showed significant increase during the recent few decades (Basnayake 2007). The annual mean temperature has increased by 0.2°C in 1951-2006 and 0.3° in 1981-2006. The rate of increase of mean air temperature for the 1961-1990 period is in the order of 0.016°C per year (Chandrapala 1997).
- Both Tmax and Tmin has shown an increasing trend. Highest increase is seen in Tmin in high elevations and in Tmax in the coastal areas (ICRISAT a. In press). Annual mean maximum air temperatures have shown increasing trends in almost all stations with the maximum rate of increase of 0.021°C per year at Puttalam (Figure 1). Night time annual mean minimum air temperatures have also shown increasing trends with higher gradients.

Implications

- *Year-round cultivation is possible if the rainfall received is optimally utilized. This may require technology for more effective conservation, rainwater harvesting, storage and replenishing groundwater.*
- *Need to increase the availability of supplementary irrigation especially during Yala.*

Regional variance in rainfall trends

Total annual rainfall distribution for Puttalam and Hambantota (1961-2009) indicated a slight decrease. But the polynomial trend shows a slight increasing trend after 1994. Even though the long term trend shows a decrease, the short term trend is not so in both districts (Figures 1 & 2). However for Anuradhapura, the rainfall pattern shows a decreasing trend after the 1950s, before which it does not show any change. After 2000, the decreasing trend is higher in this district (Figure 3).

Regional variance in temperature trends

Even though the minimum temperature has increased for the same period, the maximum temperature has

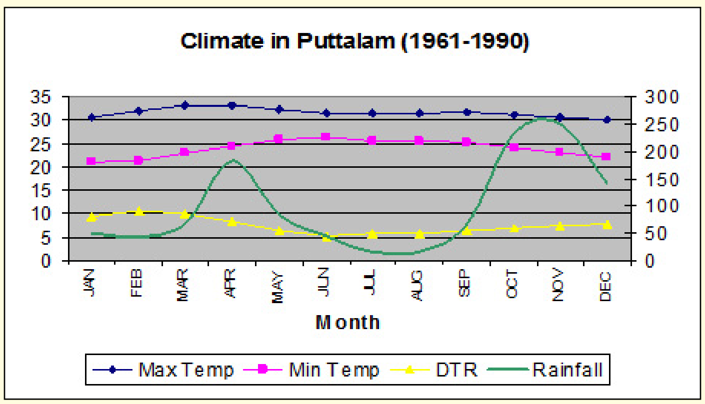


Figure 1. Monthly average trends for period 1961-1990 for rainfall, maximum and minimum temperature and diurnal temperature range – Puttalam district.

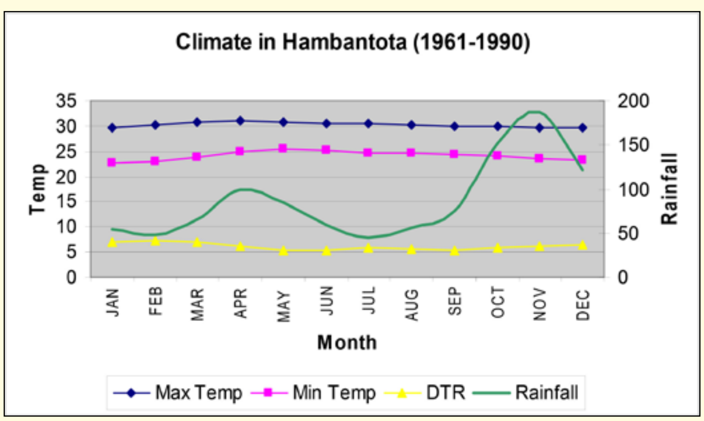


Figure 2. Monthly average trends for period 1961-1990 for rainfall, maximum and minimum temperature and diurnal temperature range – Anuradhapura district.

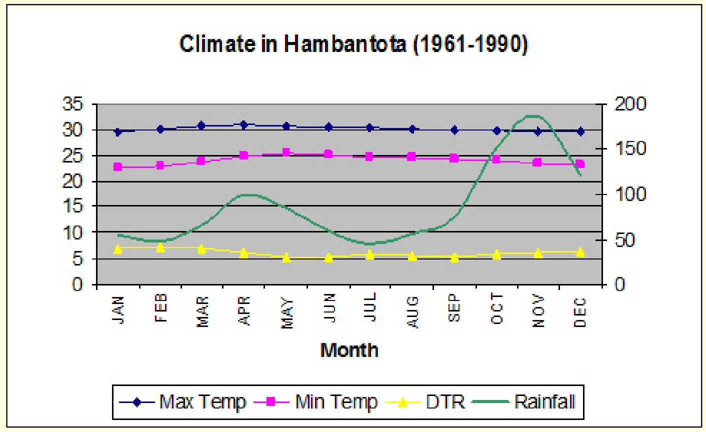


Figure 3. Monthly average trends for period 1961-1990 for rainfall, maximum and minimum temperature and diurnal temperature range – Hambantota district.

increased by 0.0331°C /year. Further, the minimum temperature during 1990-2007 shows a decreasing trend for Puttalam.

- The maximum temperature has been increasing by about 0.0272°C/ year during the period 1961-1990 in Hambantota. But it does not show a significant trend during the recent two decades (1900-2007).
- The long term behavior of minimum temperature was rather different for other districts. It shows a decreasing trend during the early 5 decades (1900-1940), but after 1950, the temperature has increased
- In Anuradhapura, the minimum temperature has increased by about 0.0243°C/ year during the period 1961-1990, while recent years showed a decrease. However, the present trend (1990–2009) of increasing minimum temperature is 0.039°C/ year. It indicates that the increasing trend is higher during the recent past.
- Rice yields are known to decrease by 9% for each 1°C increase in seasonal average temperature (Kropff et al. 1993). Similar reductions may be the outcome for various other agricultural produce. However, increase in temperature may also make it possible for certain crops hitherto not cultivated in colder climates to be grown.
- There is evidence of decreasing trends in rainfall patterns, although not statistically significant in some instances, whereas in other locations the evidence is stronger. The short term rainfall trends are erratic and unpredictable while there is high regional variability (Jayawardene et al. 2005).
- The minimum and maximum temperatures have been increasing. Extreme temperatures as reported in number of high temperature days has also increased.

> ### *Implications*
> - *Increasing temperatures will have bearing on farming calling for heat resistant varieties of crops and also livestock and aquaculture breeds.*
> - *The erratic rainfall gives reason for more flexible and rapid ways of optimizing use of available rainfall.*
> - *Devolved planning and response mechanisms are required to ensure local climate related needs are met.*
> - *Further research is required on responsiveness of important crops to climate change.*

Cultivating seasons

The onset and termination of monsoons determine the farmers crop work calendar and also ability to respond effectively to optimize use of rainfall.

In all four study locations a similar pattern of delay in onset of the monsoon was reported. For example, in Eluwankulama, Puttalam, the *Yala* and *Maha* seasons (1977 to 2008) were delayed by 3 to 4 weeks (Figure 4).

The rainfall data also showed that agricultural drought has occurred 19 times during the *Yala* season and twice in the *Maha* season during the 1977-2008 period. However, meteorological droughts were not experienced.

Vulnerability assessment

The changes occurring in climate is not uniform across the regions in Sri Lanka. The very wide differentiation of Sri Lanka into 46 agro-ecological regions (Punyawardene et al. 2003) and the demographic characteristics make locations and people vulnerable to climate change at different levels. Poverty mapping for Sri Lanka has shown considerable variation across the districts (Department of Census and Statistics 2005). However, in this study, vulnerability to climate change was estimated for the different districts by using a vulnerability index based on three indicators, adopting the IPCC methodology (ICRISAT c. In press). Colombo district was identified as the most vulnerable and Nuwara Eliya as least vulnerable during 1977. The level of vulnerability and changes over time for the three study districts are presented in Table 1.

Iyengar and Sudarshan's (1982) method was used to classify the study districts by vulnerability where five categories of vulnerability were used. The study districts showed variability among themselves as well as across the years (Table 1). The picture for the entire country (Figure 5) was also complex with the level of measured vulnerability varying over time and across the different districts.

Given the high variability in agro-ecological and demographic characteristics as well as development parameters, variability in vulnerability is most likely and must be studied in order to target interventions for optimum beneficiary support.

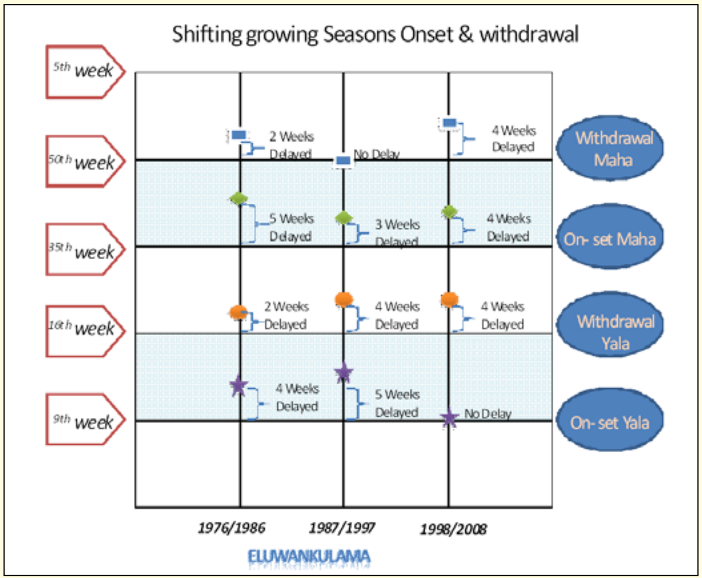


Figure 4. Changing patterns of Southwest monsoons in Eluwankulama, Puttalam District, 1976-2008.

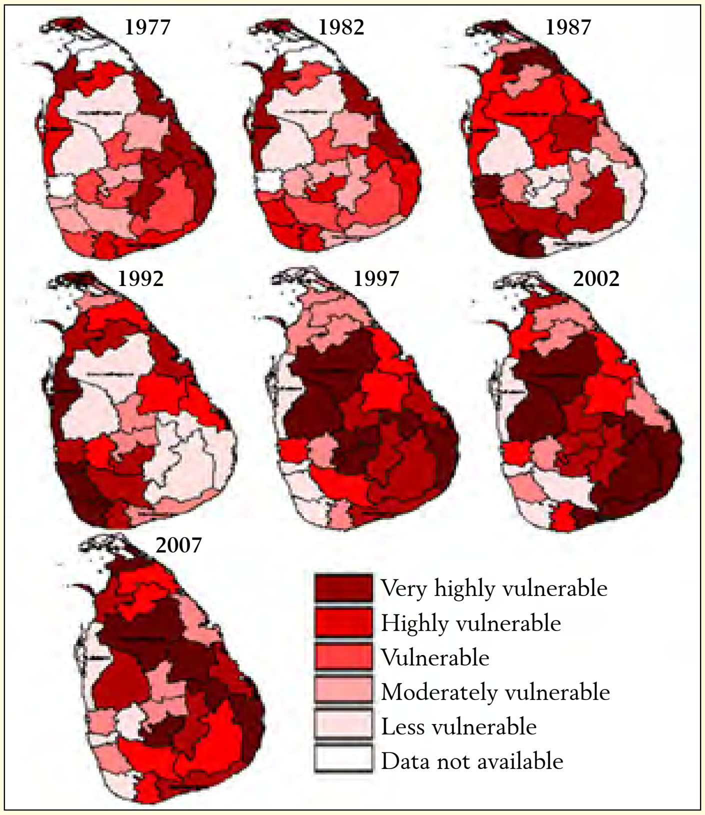


Figure 5. Distribution of district-level overall vulnerability of Sri Lanka, 1977-2007.

Table 1. Changes in level of overall vulnerability assessment in the study districts 1977-2007.							
Districts	Year						
	1977	1982	1987	1992	1997	2002	2007
Puttalam	Highly vulnerable	Moderately vulnerable	Less vulnerable	Moderately vulnerable	Moderately vulnerable	Less vulnerable	Moderately vulnerable
Hambantota	Highly vulnerable	Very highly vulnerable	Vulnerable	Very highly vulnerable	Very highly vulnerable	Very highly vulnerable	Very highly vulnerable
Anuradhapura	Less vulnerable	Less vulnerable	Vulnerable	Less vulnerable	Less vulnerable	Less vulnerable	Less vulnerable

Source: ICRISAT (c).

Farmers' perceptions of climate change

Experiential knowledge of farmers spans several generations to the past and is time tested. While practices and techniques may be many generations old, the ability to recall events and trends accurately will be inversely related to the duration of recall.

The perceptions of farmers assessed through information elicited from the household survey and focus group discussions (FGDs) were compared with analysis of the long term climate data of the meteorological and agro-climatic stations. In each village the participants drew climate maps, timelines to recall key events and trends, institutional web diagrams and used many qualitative data gathering techniques to record their knowledge and experience in relation to climate change.

Implications

- *The level of vulnerability to climate change varies across the different districts as well as over time, suggesting the need for close monitoring and periodic revival.*
- *Any intervention support provided to cushion vulnerability should not be a blanket national policy but have flexibility and provisions for regional differences.*
- *There is need to assess variability in vulnerability at sub-district levels in order to better target interventions.*

Highlights of the analysis

- ♦ In all four study locations, farmers perceived that the rainfall had declined over the years. This was more valid to the recent past than the long term. Most farmers felt that the climate situation had drastically deteriorated. However, there was no empirical evidence to support this view other than the increase in temperature and rainfall in recent decades.
- ♦ However, there was no consensus on the perceptions when the household data was analyzed, although there was a clear majority view. During the FGD there was debate and a final consensual position was derived. Community level debate and search for consensual positions, critical discourse and agreed and shared knowledge, was not a normal occurrence in the villages.
- ♦ The majority of farmers were of the opinion that the onset of the main Southwest monsoons (*Maha* rains) were now delayed. However, the meteorological data analysis shows an increasingly erratic behavior of the onset of rains than a consistent delay.
- ♦ Further, the delay in onset of the monsoons and unpredictability of the rainfall pattern was a main concern.
- ♦ In all locations, farmers stated that the daytime temperatures had increased over the years. This perception to a great degree matches the empirical data analysis.
- ♦ Increased temperatures were felt to cause great personal discomfort. None were able to relate it to agricultural productivity.
- ♦ Increased temperatures and decreased diurnal variation has greater implications to farmers. This will result in reduction in agricultural productivity and crop yields for many of the crops cultivated. Such a situation will affect all farmers equally; however, their ability to respond and adapt will vary depending on their capacities and resourcefulness.
- ♦ The farmers were able to recall extreme events more accurately than the trends in climate changes. When the occurrence of extreme events such as droughts and floods recalled by farmers were compared with the empirical date, there was a perfect match.

Farmers adaptation strategies

Resource endowment and social capital are two key factors that will determine a farmers capacity to adapt to the deleterious effects of climate change or shocks. While these will differentiate the farmers, even the poorer farmers do survive and make a living by adapting to the shocks and changes in climate experienced by farmers. Given the variability in the agro-climatic

> **Implications**
>
> - *Being oblivious to the finer changes in climate and the implications to farming due to changes in rainfall patterns and increase in ambient temperature impairs farmers capacity to adapt.*
> - *In the context of limited community level discourse, opportunity for interaction with experts and access to user-friendly information and knowhow on climate change, a wide gap in knowledge exists between the beneficiary and the scientific and professional elites associated with climate change. Bridging this divide is a prerequisite to meaningful adaptation.*
> - *Yield and productivity reductions due to increases in temperature or variability in diurnal temperatures will be a direct result of climate change that must be identified by scientists. Further, this knowledge must be better managed to benefit the key stakeholders.*

as well as socio-economic and political contexts of farming, the diversity of adaptive strategies adopted by famers were identified for possible up-scaling and replication.

Farm communities have survived the uncertainties as well as the extremes of climate while making optimum use of good seasons.

Field level analysis shows that the villagers are able to adapt to the climate shocks quite effectively (ICRISAT b. In press). They are aware that response should be based on non-traditional ways of thinking.

The adapted as well as the preferred strategies were different among farmers according to their wealth, measured by farm size (Table 3). However, in times of crisis, all levels of farmers expected state interventions while recognizing their own ability to mobilize collective action. The best entities for delivery of services during times of climate related crisis in the opinion of many farmers (mostly men), were the state agency at village and local levels. However, the women preferred the village organizations to take a stronger role in these matters.

Adaptation strategies that enable farmers to cope with uncertainties of the onset of the seasons, rainfall duration and intensity, and extended drought situations are as follows:

- Adopting new crops that are drought tolerant
- Venturing into new enterprises or diversifying their livelihoods
- Being less dependent on rainfed farming
- Those with a low wealth base make adjustments by changing the types of crops they grow, adopting new irrigation technologies or moving out of farming to more stable sources of income such as fishing in coastal areas and off-farm wage work.
- Those with greater wealth and social networks adjust more rapidly and change their enterprises from seasonal crop farming to perennials and often moving to different regions for farming.

Changing the seasonal crop cultivation to short term cash crop cultivation was the main adaptation strategy at the farm level. New varieties of maize, water melon, etc, and new short duration drought resistant crops are grown. At the institutional level, the main adaptation strategy was providing subsidies during peak requirements. Use of new machineries and

Table 3. Adaptation strategies of farmers by farm size.

Adaptation strategies as reported by farmers with different size operations in the four study locations

Marginal Holdings (0-1 ha)	Small holdings (1-2 ha)
• Diversification • Drought tolerant crops • Fisheries • Improve watersheds • New irrigation methods • Non-farm wage labor, ie, masonry, carpentry, bricks making, etc. • Obtain consumption credit • Reduce consumption • Sell assets • Use of collected resources.	• Dig deeper wells • Diversify means of livelihoods • Grow drought tolerant crops • Improve watershed conservation measures • Limit agricultural practices • Obtain loans • Reduce consumption • Search for new water sources • Sell livestock • Sell assets for their day to day living • Wage work in carpentry, masonry, etc.
Medium holdings (2-4 ha)	**Large holdings (>4 ha)**
• Dig deeper wells • Diversification of the means of livelihoods • Improve watersheds • Reduce consumption • Search for new water sources • Sell assets • Sell livestock for their living • Switch to less water consumption crop • Use collected resources • Wage work - carpentry • Mobilization and use of collected resources.	• Diversification of crops by shifting seasonal crop cultivation to perennial crops • Diversifying means of livelihoods • Mobilization and use of collected resources • Search for new water sources • Switch to less water consuming crops • Use collected resources • Use water purchased from an outside source for irrigation.
General strategies	
• Collective action by the community (preferred) • Machinery to complete cultural practices early • Short duration high yielding varieties • Pitcher irrigation.	

Source: Household survey and focus group discussions. Frank and Jayatilaka (2010).

hybrid crop varieties were the adaptation strategies at the technological level. At the social level, most of the farmers have relied on kinship ties to assist each other and on also Government support during difficult situations.

Constraints faced by farmers

Farmers face many constraints in their efforts to adapt and build resilience to climate change. Most critical among them are as follows:

1. Limited availability and supply of location specific technologies and knowhow to cope with climate shocks and long term changes.
2. Lack of awareness of the complexities of climate change, the causal factors and implications of global warming.
3. Limited agency support to strengthen adaptive capacity through consistent professional service delivery such as information, credit, relief, insurance, training and technology transfer.
4. Limited local collective efforts, weak local organizations, networking and their engagement with agencies having State responsibility to assist communities cope with effects of climate change.

Systemic constraints

1. Limited coordination and integration of climate change with agriculture R&D for developing appropriate technology and knowhow for vulnerable farmers.
2. Inadequate resource allocation for R&D in climate resilient agriculture.
3. Limited professional human resources at required levels of competencies in national level and regional institutions.
4. Climate and weather information and knowledge management systems poorly linked to the final beneficiaries at community level.
5. Non-availability of village level climate data to analyze for local vulnerabilities, prioritization and targeting support to farmers.
6. Limited commitment and capacity to adopt participatory and inclusive approaches for planning and strategy development to address challenges related to climate change.

Key policy recommendations

I. Research and development

- Integrate farmers into the knowledge system related to climate change and agriculture by ensuring access to information and knowhow.
- Conserve traditional knowledge on adaptation, documentation and validation, and ensure wider application.
- Ensure that a climate change sensitive R&D program is established in agriculture and livestock research to ensure crops and livestock varieties and breeds that can be effective in future climate change scenarios, ie, high temperature, drought, erratic weather.
- Develop for adaptation of location specific techniques for water efficient agriculture.
- Enable investments in climate change related research and development at village level, which may include encouraging public-private partnerships, non-government and philanthropic organizations and international agencies.
- Identify regions vulnerable to climate change at district and sub-district levels and prepare comprehensive location specific agricultural crop contingency plans for effectively managing climate risks.

Table 4. Farmers' perceptions of a few climate indicators compared with the climate empirical data analysis.

Indicator of climate change opinion and actual	Puttalam District (Mangalapura)		Hambantota District (Mahagalwewa)	
	1970-2000	2000-2008	1970-2000	2000-2008
Quantum of rainfall - Majority opinion*	No change (58%)	Decrease 90%	Decrease (64%	Increase (78%)
Quantum of rainfall - Actual	Slight decrease in the long term. Slight increase after 1994		Long term decrease but no short term trends	
Rainfall days-Majority opinion*	No change (60%)	Decrease (98%)	Decrease (52%)	Decrease (50%)
Rainfall days-Actual	Variability in rainy days high up to 2000 and less after. No significant long term trend		High variability up to 1993 and less thereafter. No long term trend	
Dry spells-Majority opinion*	No change (66%)	Increase (78%)	Decrease (48%)	Increase (50%)
Dry spells - Actual	Increased		Increased	
Temperature Majority opinion*	No change (62%)	Increase (64%)	Increase (60%)	Increase (78%)
Temperature-Actual	No long term trend. Decreasing trend in recent years		Decreasing trend up to 1950 after which it has increased	

* Household data - Percentage majority of respondents. Information reported for *Maha* season.
Source: ICRISAT (c).

II Service delivery

- Improve access to agricultural credit and consumption loans.
- Develop decision support (DSS) for various agro-climatic regions and use of crop simulation models to study the impact of climate change and develop mitigation strategies.
- Ensure inclusion and gender sensitivity when planning for climate change related interventions at village level

III Strengthen local capacity

- Strengthen local watershed and common property management systems to improve climate resilience
- Strengthen local capacity of community collectives, social networks and institutional relations to be able to adapt and cope with climate change challenges.
- Manage climate risks effectively through weather-based agro-advisories and develop weather insurance products by encouraging weather-crop research program at different agro-climatic regions.
- Ensure effective participation of local agency in the management of climate change mitigation and adaptation measures through capacity development and empowerment.

References

Basnayake BRSB. 2007. Climate change: Present and future perspective of Sri Lanka, Climate change in Sri Lanka, Impact, Adaptation and Mitigation: Proceedings of the National Conference on Climate Change, Sri Lanka.

Chandrapala L. 1997. Comparison of areal precipitation of Sri Lanka on district basis during the period 1931–60 and 1961–90. *In* Proceedings of the National Symposium on Climate Change, March 1997, Colombo, Sri Lanka.

Department of Census and Statistics. 2005. Policy Note A poverty map for Sri Lanka - Findings and lessons. Colombo.

ICRISAT. a. Climate trends in Sri Lanka: Agro-climatic analysis. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. (In press).

ICRISAT. b. (a) Vulnerability to Climate Change: Adaptation Strategies and Layers of Resilience. Farmers Perceptions of Climate Change in Sri Lanka: Qualitative Analysis. (b) Vulnerability to Climate Change: Adaptation Strategies and Layers of Resilience. Farmers Perceptions of Climate Change in Sri Lanka: Quantitative Analysis. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. (In press).

ICRISAT. c. Vulnerability to Climate Change, Adaptation Strategies and Layers of Resilience: Quantitative Assessment of Vulnerability to Climate Change Working Paper. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). (In press).

Jayawardene HKWI, Sonnadara DUJ and **Jayawardene DR.** 2005. Trends of rainfall in Sri Lanka over the last century. Sri Lanka Journal of Physics Vol 6:7-19.

Kropff MJ, Centeno G, Bachelet D, Lee MH, Mohan Das S, Horie T, De Feng S, Singh S and **Penning de Vries FWT.** 1993. Predicting the impact of CO_2 and temperature on rice production.

Ministry of Environment and Natural Resources, Sri Lanka. 2010. Sector Vulnerability Profiles: Agriculture and Fisheries.

Niranjan Frank and **Jayatilaka Wijaya.** Vulnerability to Climate Change: A Comparative Study of Perceptions and Capacities of Selected villages in Sri Lanka. Working paper. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. (In press).

Premalal KHMS. 2009. Systematic Meteorological Observations in the Department of Meteorology and Climate change in Sri Lanka. Paper presented at the Ministry of Environment, Colombo, Sri Lanka.

Punyawardene BVR, Bandara TMJ, Munasinghe MAK, Bandara Nimal Jayantha and **Pushpakumara SMV.** 2003. Agro-ecological regions of Sri Lanka. Sri Lanka: Natural Resource Management Centre. Department of Agriculture. Peradeniya.

TISL. 2011. Sri Lanka Governance Report 2011. Colombo, Sri Lanka: Transparency International.

Acknowledgments: The authors would like to thank NS Jodha (ICIMOD, Nepal), KL Saharawat (ICRISAT, India), GGSN Rao (CRIDA, India), K Byjesh (ICRISAT, India), Geetha Mohan (University of Tokyo, Japan) for their comments and suggestions on the earlier draft of the policy brief. This policy brief was developed based on the findings from the project "Vulnerability to Climate Change: Adaptation Strategies and Layers of Resilience" supported by the Asian Development Bank (ADB) through RETA – 6439.

About the authors: **Frank Niranjan**, Sri Lanka Council for Agricultural Research Policy, Sri Lanka; **Wijaya Jayatilaka**, University of Peradeniya, Sri Lanka; **Naveen P Singh** and **MCS Bantilan**, Research Program on Markets, Institutions & Policies (RP-MIP), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India.

ICRISAT Science with a human face

Published by

International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

www.icrisat.org

CGIAR
ICRISAT is a member of the CGIAR Consortium