



AgEcon SEARCH

RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

**Australian Agricultural and Resource Economics Society (AARES)
55th Annual National Conference, 8-11 February 2011, Melbourne, Victoria**

**Coping with Climatic Variability by Rain-fed Farmers in Dry
Zone, Sri Lanka: Towards Understanding Adaptation to Climate
Change**

Athula Senaratne and Helen Scarborough

School of Accounting, Economics and Finance
Faculty of Business and Law
Deakin University

Coping with Climatic Variability by Rain-fed Farmers in Dry Zone, Sri Lanka: Towards Understanding Adaptation to Climate Change

Athula Senaratne and Helen Scarborough

School of Accounting, Economics and Finance
Faculty of Business and Law
Deakin University

Climate change introduces numerous uncertainties over the livelihoods of farming communities that depend heavily on weather and climate. Rain-fed farmers in developing countries are among the most vulnerable communities. However, climate risks are not new to farmers. Coping with 'natural variability' of climate has been a constant challenge faced by farmers even though broad sweeping change in climate due to anthropogenic causes is a relatively new prospect. Some argue 'climate change' could be significantly different from 'climatic variability' known to and experienced by farmers. In spite of this it is widely accepted that understanding farmers' behavior towards adapting to climatic variability could generate useful insights in facing the risk of climate change.

In Sri Lanka, the village tank farming community in the dry zone is one of the most vulnerable communities thereby deserving the priority attention of policy makers. This study is based on information gathered in Anuradhapura district of Sri Lanka. It depends mainly on information from secondary sources supplemented by qualitative primary information. Analysis was guided by recently introduced behavioral economics concepts of decisions based on experience. Accordingly adaptation is viewed as a response to the climate perceptions of farmers' aided by judgments based on heuristics.

Farmers' adaptation decisions can be explained on the basis of their perception of climate variability with two major components. Firstly, farmers perceive climatic variability as an average annual pattern with variable probabilities of seasonal distribution of precipitation. Farmers base their long-term adaptation responses on this perceived average pattern and many of the choices made by them in the existing farming system and resource management practices can be explained accordingly. The average pattern of variability is largely a shared perception and therefore enables the option of joint adaptation. The land allocation practice popularly known as 'Bethma' provides a fine example for this. Secondly, farmers also perceive feasibility of random shocks with variable probabilities across the average pattern. This gives rise to short-term responses in the farming system activities. Such responses seem to be more individually oriented and reflect the variations in individual perceptions of climate risks.

Key words: Adaptation, Climatic variability, Climate change, Rain-fed farmers, Village tanks

1. Introduction

Climate change introduces numerous uncertainties over the livelihoods of farming communities all over the world that depend heavily on weather and climate. Many studies suggest that developing countries are likely to face more severe consequences of climate change (Bierbaum, et al., 2007; IPCC, 2007; Stern, 2007; UNDP, 2007). Based on the level of climate sensitivity, agriculture in developing countries can broadly be divided into two categories, rain-fed farming and irrigated agriculture. Livelihoods of rain-fed farmers are naturally more sensitive and vulnerable to climate uncertainty. Being dependent fully or partially on fluctuating local rainfall, the main limiting factor that affects rain-fed farmers is water stress (Wani et al., 2009). According to the available statistics, a vast majority of developing country farmers live under rain-fed conditions in arid, semi-arid or dry sub-humid agro-climatic environments. This can be high as over 90% of farmers in Sub Saharan Africa to around 60-75% in Asia, near East and Latin America (Wani et al., 2009). Many of these developing regions are located around the tropical belt, which have warm climatic conditions. Global circulation models (GCM) have projected a decrease in precipitation for many of these regions (with few exceptions in some areas in Asia), indicating an overall rise in water stress conditions in the future (Mertz et al., 2009). Therefore, rain-fed farmers throughout the developing world, already in a constant struggle for survival, are likely to face more severe conditions of water stress in the future due to climate change.

However, climate risks are not new to farmers. Coping with natural ‘variability’ of climate has been a constant challenge faced by farmers even though rapid, broad sweeping ‘change’ of climate due to anthropogenic causes is relatively a new prospect. Adaptation has been the key strategy that has helped farmers face climatic variability (Risbey et.al., 1999; Smit and Wandel, 2006). Adaptation constitutes actions that are taken to moderate, cope with or take advantage of actual or expected change of climate and related shocks (IPCC, 2001 and 2007). It is a dynamic process of adjustment that involves decisions under risk and uncertainty (Prato, 2008; Smit et al., 2000). Adaptation decisions are taken by individuals as well as groups and comprise a strong component of social learning (Adger et al., 2003; Pelling and High, 2005; Tschakert and Dietrich; 2010).

1.1. Village tank farmers in dry zone Sri Lanka

Sri Lanka is a tropical island located in the lower latitude region of South Asia, a region that frequently experiences disaster prone weather extremes. It is a developing nation with a significant poor population. A majority of poor living in rural areas is dependent on livelihoods relating to agriculture and fisheries. According to spatial distribution of the rainfall (RF), the country is broadly divided into wet zone and dry zone areas. The majority of agricultural lands are located in the dry zone. In the wet zone where high annual RF is received, export-oriented perennial plantation crops, namely, tea, rubber and coconut are the major forms of agriculture. In contrast, in the dry zone, where limited annual RF is received, agriculture is primarily small-scale peasant farming enterprises.

Dry zone farming can be divided into two major categories, namely, major irrigation schemes and village tank systems¹. In major irrigation schemes, farmers carry out paddy farming, the main farming system activity, using the water supplied from large irrigation reservoirs on year round basis. Village tank systems are semi-rain-fed systems, which depend heavily on local RF. Being dependant on local RF without access to any substantial sources of supplementary water, village tank farmers are naturally more vulnerable to climate uncertainty than farmers in irrigated schemes. They are in a continuous struggle for livelihood security under water stress conditions due to RF uncertainty.

Village tanks are manmade small reservoirs for capturing and storing water from direct fall and runoff flow of local precipitation. They are a type of community owned rainwater-harvesting devices, covering a shallow water area that varies widely over a range of about 5-80 ha. It has been estimated that over 18,000 village tanks are scattered in dry zone areas of the country (Panabokke et.al., 2001). The highest densities of tanks are reported from Anuradhapura and Kurunegala districts. Village tanks are common property resources with an elaborate system of institutional arrangements. Currently, village tanks are managed by 'Farmer Organizations', which have been legally sanctioned by the Agrarian Development Act of 2000.

¹ Sometimes village tanks are also referred to as minor irrigation schemes. This is a misnomer given the tanks are dependent solely on local RF with no additional supply of water from surplus sources and farming systems practiced under village tanks have predominantly rain-fed characteristics.

Village tanks play an important role in adaptation efforts of farmers against climatic variability. Unlike in the wet zone with abundant RF, rain-fed farming in the dry zone under poorly distributed low RF conditions is a challenging task. Village tanks increase the efficiency of utilization of the limited local supply of water by storing the surplus from short rainy season so that it can be used in the lengthy dry season that follows. Hence, they help farmers to minimize and even out the risk of seasonal water scarcity through community management of harvested rainwater. This has enabled a practicing farming system, which is based on lowland paddy farming and cultivation of highland seasonal crops.

The threat of future uncertainties due to the global climate change introduces new challenges to the ongoing struggle by farmers dependent upon village tanks. According to some scholars, 'climate change' could be significantly different from 'climatic variability', known to and experienced by farmers regularly in their livelihoods due to the potential for irreversible, rapid and catastrophic hazards (Adger, et.al, 2003; Weitzman, 2008). As a result, the unforeseen effects of global climate change enter as a new element of uncertainty into farmers' decisions on adaptation. Farmers alone may not be able to overcome this challenge through their own efforts. They need the assistance of an 'adaptation policy' which could facilitate the voluntary efforts of farmers (individual and joint). The major role of adaptation policy is to enhance farmers' 'adaptive capacity' to face the changes that are beyond their experienced range of coping capacity (Adger et.al., 2003). In addition, there is a need for policy makers to introduce appropriate policies, institutions and incentive schemes that can facilitate farmers' voluntary efforts of private and community adaptation.

The first step towards sound policy is to understand the farmers' behavior in making adaptation choices against the existing climatic variability (Cooper et al., 2008). This requires knowledge of farmers' perception of climatic variability, their behavior in making adaptation decisions, types of adaptation responses, role of local institutions in climate adaptation and gaps created due to ongoing climatic changes as well as socio-economic conditions. Understanding these aspects will help to identify adaptation policies and institutional supports that can enhance the adaptive capacity of farmers against the future uncertainties of the climate change.

1.2. Objectives

This paper attempts to examine the adaptation behavior of village tank farmers against climatic variability, especially the fluctuation of local RF. The broad objective of the study is to identify important policy implications that can enhance farmers' adaptation responses against the pending threat of global climate change. It attempts to reach this broad goal through achieving the following narrow objectives.

1. Examine the farmers perception of the risks posed by variability of local RF
2. Identify the key adaptation strategies taken up by farmers against the perceived risks
3. Identify important policy implications emanating from current experience on adaptation to face the future impacts of climate change

2. Conceptual framework

The fundamental theoretical issue involved in economic analysis of adaptation behavior is choice under risk and uncertainty. Recent advances in behavioral economics and decision theory suggest that a variety of decisions are taken on the basis of personal experience (Rackow and Newell, 2010; Hau et al., 2010). Such decisions are assisted by experiential processing of information that closely involves affective (feeling) faculties of the mind in addition to cognitive skills (Hertwig et al., 2007; Slovic et al., 2004). Researchers have identified that decision contexts described by these findings more closely approximate the decision context faced by farmers and other stakeholders when they make adaptation decisions against climatic variability and change (Hansen et al., 2004; Marx et al., 2007; Weber, 2006; Weber, 2010). The analytical framework of this study is guided by these recent developments in decision theory relating to experienced based decisions and experiential processing of information.

Climatic variability and change are sources of uncertainty that can lead to climatic events with a probability for many outcomes. At any given point of time, decision-makers face the choice among options that could lead to different outcomes under many probable climatic events. Hence, adaptation responses are essentially decisions taken under risk and uncertainty.

Adaptation responses by definition are choice decisions. The choice is among the options that can either moderate losses or take advantage of the impacts of climatic events (different states of the world) in specific domains of human activity (e.g. agriculture, coastal, disaster). Farmers make adaptation choices based on their perceptions of climatic variability. Perceptions are about climate events and their probabilities. Farmers develop their perceptions through experiential processing of mental samples (experience) gathered over a long period of time. Farmers' perception of variability involves heuristics (mental short cuts) and therefore are also subject to cognitive biases (Tversky and Kahneman, 1974).

We assert farmers' perception of variability of local RF has two major elements, namely, a seasonal pattern of RF perceived over an annual cycle and sensibility to randomness (inter annual variability) associated with RF in the seasonal cycle. This perception of the seasonal pattern of RF over an annual cycle is a shared knowledge and usually encoded in a locally recognized system of agricultural seasons, which can be considered as a local model of climatic variability. The shared nature of the seasonal model allows it to be refined and updated through the continuous interaction of farmers.

Like any other model, the farmers' model is also a simplification of the complex reality. Through this model farmers try to capture the complex behavior of climatic variables (in this case RF). This is achieved through two stages of simplification. Firstly, farmers break the continuous variability into annual cycles and then within the annual cycle into seasons. Hence seasons are the unit of variability. This can be considered as a simplification assisted by heuristics. A gross structure of farmers' perception of the season can be shown as in the table 1. Accordingly, farmers are presumed to recognize RF outcomes relative to water requirements of farming activities. This is a simple structure and it can assume more refined forms.

Table 1: A representation of RF seasons

	RF Likelihood		
	Insufficient RF	Sufficient RF	Excessive RF
Season 1	high		
Season 2		high	
Season 3			high

The dual element perception is presumed to guide farmers' decisions as follows. The perceived seasonal pattern of RF variability helps farmers to form expectations of probable RF outcomes in a given period of time (season) in the year. Farmers decide their adaptation responses accordingly. However, farmers' use the guidance provided by the seasonal model subject to their sensibility to randomness of RF. Farmers recognize random outcomes as 'shocks' relative to the expectations they have formed according to the seasonal model for the given period of time. Accordingly failure of rains, erratic distribution, unexpected rains in the time of harvesting etc. are identified as shocks. Unlike the shared perception of the seasonal pattern of RF, perception of random shocks is individually oriented. It is a personal trait relating to an individual sense of risk perception and readiness to respond to shocks. We can identify it as 'risk alertness' in a similar sense as we identify risk attitudes. Alert farmers sense random shocks more readily than less alert farmers and respond quickly and effectively.

Adaptation decisions come as a response to an interaction between these dual elements of the perception of RF variability. In the light of this understanding of farmers' perception of local RF variability, three major forms of adaptation responses can be identified. They are:

- Short run adaptation responses by adjusting farming system activities, especially the timing of activities, according to the perceived seasonal pattern of RF variability
- Urgent responses to random shocks based on the individual alertness to shocks. Even well-timed farming activities may have to face random shocks and farmers make quick adjustments to fine tune their choices

- Long-term structural adaptations to fill gaps and deficits observed in the existing strategies and to harness opportunities detected through long-term practical experience. This is based on the updates of seasonal pattern.

3. Method

3.1. Study area

This study was carried out in the Anuradhapura district of the North Central Province of Sri Lanka. Primary data was collected from farmers and local officers from 6 Divisional Officer (DO)² areas, namely; Thirappane, Sivalakulama, Mihinthale, Galenbindunuwewa, Kahatagasdigiliya and Andiyagala. Table 2 gives a comparative profile of Anuradhapura district.

Table 2: A profile of water and land resources in Anuradhapura district

Parameter	Sri Lanka	Anuradhapura district (%)
Land area (km ²)	65,610	7,179 (11%)
Inland waters (km ²)	2,905	515 (18%)
Average annual rainfall (mm)	1861	1368
Equivalent water volume (b m ³)	120	9.6 (8%)

Sources: Department of Census and Statistics (2007) and Imbulana et.al. (2006)

² Divisional Officers are the local agents of the Department of Agrarian Development (DAD). DAD is the implementation body of Agrarian Development Act of 2000, which sanctions 'Farmer Organizations (FO)' of village tanks. Besides, DAD is the government agency entrusted with all state responsibilities pertaining to village tanks below 200 ac of command areas. FOs seek DAD assistance mainly for major rehabilitations of tanks.

3.2. Data and methods

Both primary and secondary data were collected in the study.

Secondary data

Secondary data was collected from the following sources:

- Past studies on village tank systems, climatic conditions and farming systems in the dry zone
- Organizations, which undertake mandatory institutional responsibilities relating to the village tanks (e.g. Department of Agrarian Development)
- The Department of Meteorology

The information on hydrological and physiographic details and rainfall data were mainly collected from these sources.

Primary Data

The information on Socio-economic conditions and adaptation behaviors of farmers was collected from primary sources. The following methods were used to collect the primary data.

Focus group discussions: Focus group discussions (FGDs) were conducted with farmer groups of the size of 10-15 from the selected DO areas. Discussions were held using a semi-structured focus guide. In the discussions, usually conducted for about 1-2 hours, the following aspects relating to farmers' livelihoods were discussed.

- Profile of village resources and farmers' access to them
- Farming system practices and water management
- Experience in local climate and adaptation measures to face the variability
- Formal and informal institutional arrangements

Key informant interviews: In addition, few key informant interviews (KII) were conducted with local officers and experienced farmers. Local officers included divisional and village level

officers. Information from KII helped to supplement and clarify certain information gathered in FGDs and from secondary sources. They also helped to elicit the views held by local officers.

3.3. Analysis

The data collected from the above sources was mainly of qualitative nature with limited scope for application of quantitative methods except the local RF data. Therefore qualitative methods were used to analyze the data from the various sources. This basically involved tabulation of information obtained from different primary and secondary sources and examination of them for identification of behavioral relationships inferred by the conceptual framework. Descriptive statistical tools such as means and coefficient of variation (CV) were used to recognize the local patterns of RF variability.

4. Results and Discussion

4.1. RF pattern and water availability

The key to understanding the climate adaptation strategy of village tank farmers is to examine the pattern of RF variability and resultant outcome of water availability in the area. Figure 1 indicates that the area has a bi-modal RF pattern with prominent peak during the October-December period followed by a minor crest in the month of April. On average, 74% of annual RF is received during the period from October to March. The second chart (figure 2) shows the net water availability, the difference between monthly average RF and potential evapotranspiration (PET), on a monthly basis. It indicates that the area records a water surplus only during the months of October-January and April.

Figure 1: Variation of monthly average RF

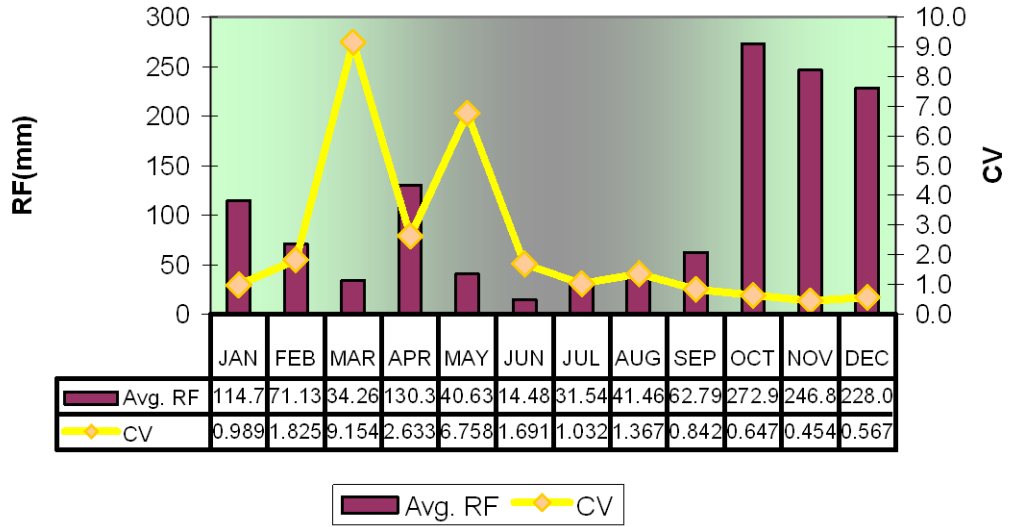
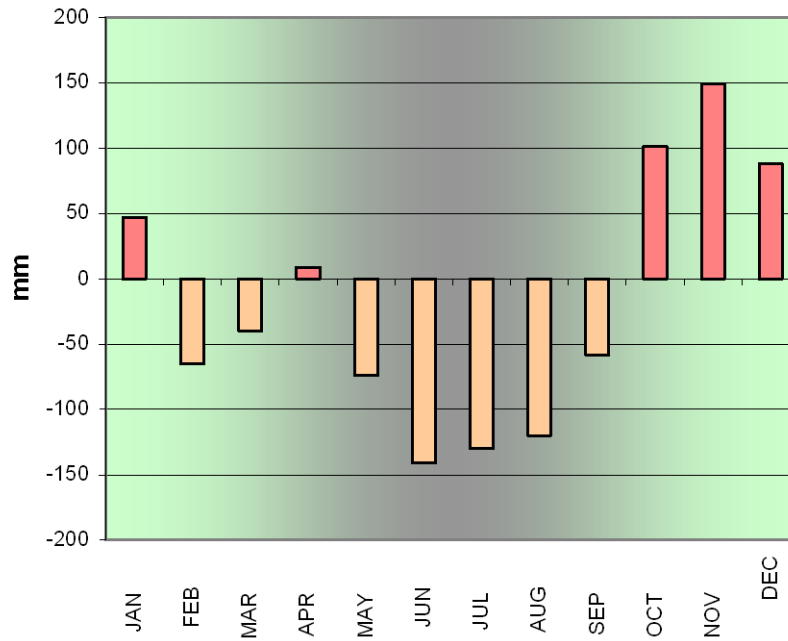


Figure 2: Net water availability (RF – PET)



The pattern of RF identified on the basis of monthly average represents the possible outcome set faced by farmers in their adaptation decisions. However, farmers need not only the outcomes but their probabilities as well. Some idea of the probability of RF throughout the year is provided by the co-efficient of variation (CV) graphed in the top chart of the figure 1. Accordingly, it shows that CV remains very low during the eight months from June-January indicating that the variability of RF during these months is quite low. In other words, there is a high likelihood for receiving the RF indicated by the monthly averages during these months. In contrast, variability of RF during the four months from Feb-May is relatively high as indicated by the high values of CV during these 4 months. Therefore, the bi-model pattern indicated by monthly averages seems somewhat illusory since chances for a minor peak around April are low.

Based on the above information, we can recognize a probable pattern of RF likelihood or temporal distribution of water availability in a given year, upon which farmers have to base their decisions as follows.

- Four month period of high average RF with low variability extending from October-January
- Four month period of low average RF with low variability extending from June-September
- Four month period of moderate RF with high variability extending from February-May

Low variability implies high likelihood (probability) for getting the average. From the point of view of farmers' decisions, not only the RF outcomes but their probability also matters. This can be understood by comparing two periods from June-September and February-May. In the former period, average RF is low but farmers can form their expectations with higher confidence and make their decisions accordingly. In the latter, farmers cannot make their decisions with the same confidence even though average RF is relatively higher than the former.

4.2. Farmers' perception of RF variability and expectations of water availability

Discussions with farmers and information gathered on the farming system suggest that farmers have a reasonably accurate perception about the above-described general pattern. Information gathered on the local model perceived by farmers can be summarized as follows. The period from mid September to mid March is recognized as the main cultivation season, which is locally known as *Maha* (major) season. The period between mid May to mid August, despite the low water availability, is also identified as a cultivation season known as *Yala* season. The Period between mid March to mid May is not recognized as a main cultivation period. Information gathered in the discussions further suggests that farmers' perception about the distribution of RF is quite subtle and they have specific local names even to recognize the RF durations in specific months that are associated with different cultivation purposes. Hence the local model of climatic variability appears to be a detailed and reasonably accurate representation of the average pattern indicated by the systematically gathered RF data.

4.3. Farmers' adaptation strategies against climatic variability

Based on the conceptual framework, we discuss the adaptation strategies under three categories of responses.

- Short run adaptation by adjusting farming system activities
- Urgent responses to intra-seasonal random shocks
- Long-term structural adaptations

4.3.1. Short run adaptation by adjusting farming system activities

Three major forms of adjustment of farming system activities can be identified in village tank systems.

- Timing of activities to carry out farming under direct RF
- Making use of water supplied from facilities that alter the time and space availability
- Gambling with the weather

Timing of activities to carry out farming under direct RF

Farming under direct rainfall is the least cost option available for supply of water in the area. Table 3 provides an outline of the current farming system and water supply strategies evolved in the village tank systems. Accordingly, two major components of the farming system, namely, upland cash crop farming in de-facto common lands (encroached state lands) and paddy farming in command areas of village tanks, both are carried out during the *Maha* season under the rain-fed conditions. The upland cash crop farming is purely rain-fed. Major requirements of the water demanding paddy crop at the crop establishment stage also is covered from the *Maha* RF. According to farmers' accounts, these farming activities that are carried out in high rainfall *Maha* season are the stable and the most important components of the farming system.

Table 3: Existing farming system with water management strategy

Farming system activity	Crops	Seasonality		Water supply		Location	Economic status
		Maha	Yala	Maha	Yala		
Lowland farming	Paddy	All plots in the field	Limited area	Rain-fed + tank water	Tank water	Command area of village tanks.	Mainly subsistence with limited sales if a surplus available
Upland farming	Maize, Other coarse grains, Grain legumes, Pulses, Vegetables, Condiments, Gingelly	1-5 ac avg. by all HH	Gingelly	Fully rain-fed	Fully Rain-fed	De-facto common lands in tank catcments	Maize is commercial. Others mainly subsistence with few cash crops
Permanent crops	Coconut, fruits, multi purpose trees	No seasonality		Rain-fed + retained moisture in soil		Home gardens	Mainly subsistence with few cash crops

Making use of water supplied from facilities that help to alter the time and space availability

As discussed earlier, farmers identify the dry period extending from the May-August as a cultivation season (*Yala* season) in spite of the fact that there is no sufficient RF for rain-fed farming during this period. Farming activities in this period are adjusted in such a way that they are carried out subject to water availability from village tanks and agro-wells. Village tanks and agro-wells are facilities that help to alter the space and time availability of water received from local RF, especially during the *Maha* season. Village tanks help to minimize and even out the risk of seasonal water scarcity during the *Yala* season to a certain extent depending on the storage available. Available water storage is a function of RF intensity of the past rainy season and PET of the ongoing dry season. Compared with the relatively costless supply of water from direct rainfall, this has to be attained at the expense of some transaction costs. Common ownership of village tanks has enabled unique arrangements of joint adaptation to minimize the transaction costs. Under the joint adaptation scheme popularly known as *Bethma* (division), community members collectively decide the total area of paddy land that can be physically supplied by the limited water available in the tank and divide the command area accordingly among all members regardless of the ownership of the respective land plots.

In addition, farmers cultivate cash earning seasonal crops of onion, chilli and vegetables by pumping water from agro-wells during the *Yala* season. Agro-wells enable farmers to tap the shallow groundwater storage in addition to surface storage in tanks thereby further reducing the risk of water scarcity. Despite the fact that the groundwater aquifer is a 'common pool' resource, access to groundwater is determined by the ownership of land plots above the aquifer. Compared with the historical village tanks, extraction of groundwater through agro-wells is a recently adopted private adaptation measure that has become popular during the last 2-3 decades. It has largely been facilitated by the introduction of small, low-cost pumps operated by diesel and kerosene (Kikuchi et.al, 2003).

Gambling with weather

While more dominant and stable farming activities are timed to align with periods of low variability of RF, the opposite is applied for periods with high rainfall variability. Some farmers choose to gamble with weather in such periods. In the study area, a reasonable number of farmers sowed gingelly (sesame) seeds after harvesting the maize crop around mid March in the same fields to coincide with uncertain RF in the March-April period. This they do with minimum aftercare operations and undertake harvesting around May-June period only if the crop becomes successful with sufficient RF during the period. If rains fail, they abandon the crop and leave the fields to fallow until the next rainy season. Farmers used words with the meaning of ‘gamble’ or ‘lottery’ to describe this activity indicating it as a high-risk activity. They do not consider it a stable component of the farming system and it seems to be practiced by more commercially oriented risk-taking farmers. However, it was reported as capable of earning substantial cash returns in successful years.

4.3.2. Urgent responses to intra-seasonal random shocks

According to Handawala (2004), in the dry zone, the intensity of daily rainfall and distribution of rainy days within the season have more influence over determining the performance of farming activities than the total rainfall within a season. Every season farmers adjust their activities, responding to intra-seasonal variability of RF to a certain extent. Unlike overall adjustment of farming activities according to the general pattern of seasonal variability, which is a perception shared by all farmers, intra-seasonal adjustments to face random shocks seem to be more individually oriented for the reasons explained in the conceptual framework. Given the individual nature of responses involved, the information gathered in the present study is inadequate to make a detailed account on this aspect, since it did not employ any data-gathering tool aimed at collecting household information. Therefore, only a limited anecdotal evidence gathered from FGDs is provided.

- Cultivation of highland paddy is the first rain-fed crop to be established in the *Maha* season in certain areas. Decisions on this activity is highly dependent on the observations on intensity and duration of early rains in the season
- Varietal selection of a number of crops is dependent on the starting dates and intensity of RF during the early period of the season. For instance if rains delay farmers switch from long maturing (4-5 months) to short maturing (3 months) varieties. Similarly, low intensity rains during the early period lead to selection of tolerant varieties.
- If untimely rains occur in the *Yala* season, farmers harvest the chilli crop as fresh chilli. Otherwise fruits are allowed to ripen and dried before marketing, which is the more lucrative option.

4.3.3. Long-term structural adaptation

While decisions to make use of water from facilities such as village tanks and agro-wells can be considered as short-term adaptations, decisions to invest in such facilities are essentially long-term structural adaptations. Such decisions are aimed at filling gaps and deficits observed in the existing strategies and harnessing opportunities detected through long-term practical experience.

Village tanks for rainwater harvesting

Small village tanks have been constructed historically to fill the observed gap of temporal scarcity of water during the lengthy annual dry spell. In the local farming system tanks seem to fulfill two major functions. Firstly, they supplement later season water needs of *Maha* season paddy crop, which usually is established with north-east monsoon rainfall. Secondly, tanks enable at least a part of paddy lands to be cultivated in the dry season also, depending on the level of water availability in tanks. In addition village tanks are identified as a unique type of wetland eco-system that offers a multitude of ecological and livelihood services to the community other than water for agriculture (Panabokke, 2001; Tennakoon, 2004). Based on

these facts, village tanks can be identified as the most important ‘adaptation support facility’ available to farmers.

It has been estimated that there are over 12,000 village tanks, scattered throughout the dry zone areas of the country (Panabokke, 2001). In Anuradhapura district alone, there are over 2500 small village tanks scattered all over the district. A large proportion of these inland water bodies are seasonal in their nature with water available only for a limited period of around 6-10 months per year (Chakrabarty and Samaranayake, 1983). Tennakoon (2001) provides a detailed account on the evolution of village tank systems under the specific geo-morphological and socio-economic conditions found in the dry zone. Some of them date from the earliest era of the country’s human settlement (Siriweera, 1994).

Agro-wells for groundwater extraction

Agro-wells opened up the opportunity for the farming of cash crops during the dry season thereby making a significant contribution to the farm income (Nagarajah and Gamage, 1998; Karunaratne and Padmarajah, 2002). Agro-wells require substantial capital investment for construction and high recurrent expenditure for regular pumping. Although, incentives provided by the state agencies such as the Agriculture Development Authority has played an important role in popularizing agro-wells, many farmers subsequently invested on wells without any external support (Karunaratne and Pathmarajh, 2002; Panabokke, 2005). Compared with water from direct rainfall or community-managed tanks, this is the most expensive option for the supply of water and the cost is borne privately by individual farmers. As a result, agro-wells are an option selectively available only for farmers who can afford it. Therefore, water extracted from agro-wells is utilized only for high value cash crops (such as chilli and onion) and the level of extraction of water is highly determined by the price of fuel.

5. Policy Implications

Unforeseen effects of global climate change introduce a new element of uncertainty to ongoing process of climate adaptation in dry zone areas. From the perspective of adaptation policy

against global climate change, the idea of adaptation responses based on a shared seasonal model and individual risk alertness has several implications. The shared seasonal model is a result of long-term individual experience. If climate change takes place as a gradual long-term shift of the current pattern of variability as assumed under certain scenarios, it implies farmers will be capable of perceiving such changes by updating their models and responding accordingly. In such a scenario, farmers may need little policy support for adaptation to climate change unless shifts involve the crossing of critical thresholds. On the other hand, if changes are sudden and catastrophic as suggested by certain scholars, farmers will find themselves in a helpless situation. In such a scenario, farmers will face difficulties in updating their perceptions quickly enough and making successful adjustments. In such scenarios farmers may need strong policy assistance. Major areas of policy support will include information (e.g. climate forecasts) and enhancing the risk alertness.

REFERENCES

- Adger, W.N. (2003). Social capital, collective action and adaptation to climate change. *Economic Geography*, 79: 387-404
- Adger, W.N., Huq, S., Brown, K., Conway, D. and Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies*. 3(3): 179-195
- Bierbaum, R., J.P. Holdren, M. MacCracken, R.H. Moss, and P.H. Raven (2007). *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*. United Nations Foundation and Sigma Xi, the United States.
- Chakrabarty, R. D., and Samaranayake, R. A. D. B. (1983). Fish culture in seasonal tanks in Sri Lanka. *Journal of Inland Fisheries*. 2: 125-140.
- Cooper, P.J.M., J. Dimes, K.P.C. Rao, B. Shapiro, B. Shiferaw and S. Twomlow. (2008). Coping better with current climatic variability in the rain-fed farming systems in sub-Saharan Africa: An essential first step in adapting to future climate change. *Agriculture, Ecosystems and Environment*, 126:24-35
- Department of Census and Statistics (2007). *Statistical Abstract*, Colombo, Sri Lanka
- Handawala, J.(2004). Understanding rainfall as a first pre-requisite to tank management and rehabilitation'. In Aheeyar, M.M.M.(ed). *Small tank Settlements in Sri Lanka*. HARTI, Colombo, Sri Lanka: 31-39.
- Hansen, J., S. Marx and E. Weber. (2004). The role of climate perceptions, expectations and forecasts in farmer decision making. *IRI Technical Report 04-01*. International Research Institute for Climate Prediction, The Earth Institute, Columbia University, Palisades, New York: 55 pp

- Hau, R., T.J. Pleskac and R. Hertwig. (2010). Decisions from experience and statistical probabilities: Why they trigger different choices than a priori probabilities. *Journal of Behavioral Decision Making*, 23: 48-68
- Hertwig, R., G. Barron, E.U. Weber and I. Erev. (2004). Decision from experience and the effect of rare events in risky choice. *Psychological Science*, 15(8): 534-39
- Imbulana, K.A.U.S, Wijesekara, N.T.S and Neupane, B.R (Eds.). (1986). *Sri Lanka National Water Development Report*. Ministry of Agriculture, Irrigation and Mahaweli Development and UNESCO, Colombo, Sri Lanka
- IPCC (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK
- Karunaratne, A.D.M and Pathmarajah, S. (2002). 'Groundwater development through introduction of agro-wells and micro irrigation in Sri Lanka' In S. Pathmarajah (ed.), *Use of Groundwater for Agriculture in Sri Lanka*, Department of Agricultural Engineering, University of Peradeniya, Peradeniya, Sri Lanka
- Kikuchi, M., Weligamage, P., Barker, R., and Samad, M., Kono, H. And Somaratne, P.G. (2003). Agro-well and Pump Diffusion in the Dry Zone Sri Lanka, *Research Report 66*. IWMI, Colombo, Sri Lanka
- Marx, S.M., E.U. Weber, B.S. Orlove, A. Leiserowitz, D.H. Crants, C. Roncoli and J. Phillips. (2007). Communication and mental processes: Experiential and analytic processing of uncertain climate information. *Global Environmental Change*, 17: 47-58
- Mertz, O., K. Halsnaes, J.E. Olesen and K. Rasmussen. (2009). Adaptation to climate change in developing countries. *Environmental Management*, 43: 743-52
- Nagarajah, S., and Gamage, H. (1998). Groundwater utilization for crop production in the dDry Zone Sri Lanka. *Proceedings of a symposium held in Kand, Sri Lanka*. Natural Resources Management Center, Perdeniya, Sri Lanka
- Orlove, B., C. Roncoli, M. Kabugo and A. Majugu. (2009). Indigenous climate knowledge in southern Uganda: The multiple components of a dynamic regional system. *Climatic Change* (Published online with open access at springerlink.com)
- Panabokke, C. R (2001). Small tank systems in Sri Lanka: summing and issues. In H.P.M. Gunasena (ed.), *Proceedings of the Workshop on Food security and Small Tank Systems in Sri Lanka*. Colombo, Sri Lanka: National Science Foundation, 3-4.
- Panabokke, C.R., and Perera, A.P.G.R.L (2005). *Groundwater Resource of Sri Lanka*. Water Resources Board, Colombo, Sri Lanka
- Pelling, M. and C. High. (2004). Social learning and adaptation to climate change. *Paper presented at Wageningen Disaster Studies: International Work-Conference on Challenges of Complexity in Coping with Climate-Related Disasters*, 14-15 June, Dreibergen, Netherlands
- Prato, T. (2008). Accounting for risk and and uncertainty in determining preferred strategies for adapting to future climate change. *Mitigation and Adaptation Strategies for Global Change*, 13: 47-60
- Rakow, T. and B.R. Newell. (2010). Degrees of uncertainty: An overview and framework for future research on experience-based choice. *Journal of Behavioral Decision Making*, 23: 1-14

- Risbey, J., M. Kandlikar, H. Dowlatabadi and D. Graetz. (1999). Scale, context and decision making in agricultural adaptation to climate variability and change. *Mitigation and Adaptation Strategies for Global Change*, 4: 137-165
- Roncoli, C., K. Ingram and P. Krishen. (2002). Reading the rains: Local knowledge and rainfall forecasting among farmers of Burkina Faso. *Society and Natural Resources*, 15: 411-30
- Siriweera, W.I. (1994). *A Study of Economic History of Pre-Modern Sri Lanka*. Vikas Publishing House, New Delhi, India
- Slovic, P., M. Finucane, E. Peters and D.G. MacGregor. (2004). Risk as analysis and risk as feelings: Some thoughts about affect, risk and rationality. *Risk Analysis*, 24(2): 1-12
- Smit, B. and J. Wandel. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16: 282-292
- Smit, B., I. Burton and R.J.T. Klein. (2000). An anatomy of adaptation to climate change and variability. *Climatic Change*, 45: 223-251
- Stern, N. (2007). *Stern Review on the Economics of Climate Change*. Cambridge University Press, Cambridge, UK
- Tennakoon, M.U.A. (2001). 'Evolution and role of small tanks cascade systems in relation to the traditional settlement pattern of the Rajarata', In H. P. M. Gunasena (ed.), *Proceedings of the Workshop on Food security and Small Tank Systems in Sri Lanka*. Colombo, Sri Lanka: National Science Foundation, 64-78.
- Tennakoon, M.U.A. (2004). Tanks are not mono-functional: They are multi-functional. In Aheeyar, M.M.M.(ed). *Small tank Settlements in Sri Lanka*. HARTI, Colombo, Sri Lanka: 1-7.
- Tschakert, P. and K.A. Dietrich. (2010). Anticipatory learning for climate change adaptation and resilience. *Ecology and Society*, 15(2): 11 pp
- Tversky, A. and D. Kahneman (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185 (4157): 1124-31
- UNDP (2007). *Human Development Report 2007/2008*. UNDP, New York, USA
- Wani, S.P., T.K. Sreedevi, J. Rockstrom and Y.S. Ramakrishna. (2009). Rainfed agriculture: Past trends and future prospects. In S.P. Wani, J. Rockstrom and T. Oweis (Eds.) *Rainfed Agriculture: Unlocking the Potential*, CAB International, Oxfordshire, UK: 1-35
- Weber, E.U. (2006). Experience-based and description-based perceptions of long-term risk: Why global warming does not scare us (yet)? *Climatic Change*, 77: 103-120
- Weber, E.U. (2010). What shapes perceptions of climate change. *Advanced Review*, 1: 332-342
- Weitzman, M. (2008). On Modeling and interpreting the economics of catastrophic climate change.
(available at www.economics.harvard.edu/faculty/weitzman/papers_weitzman)

