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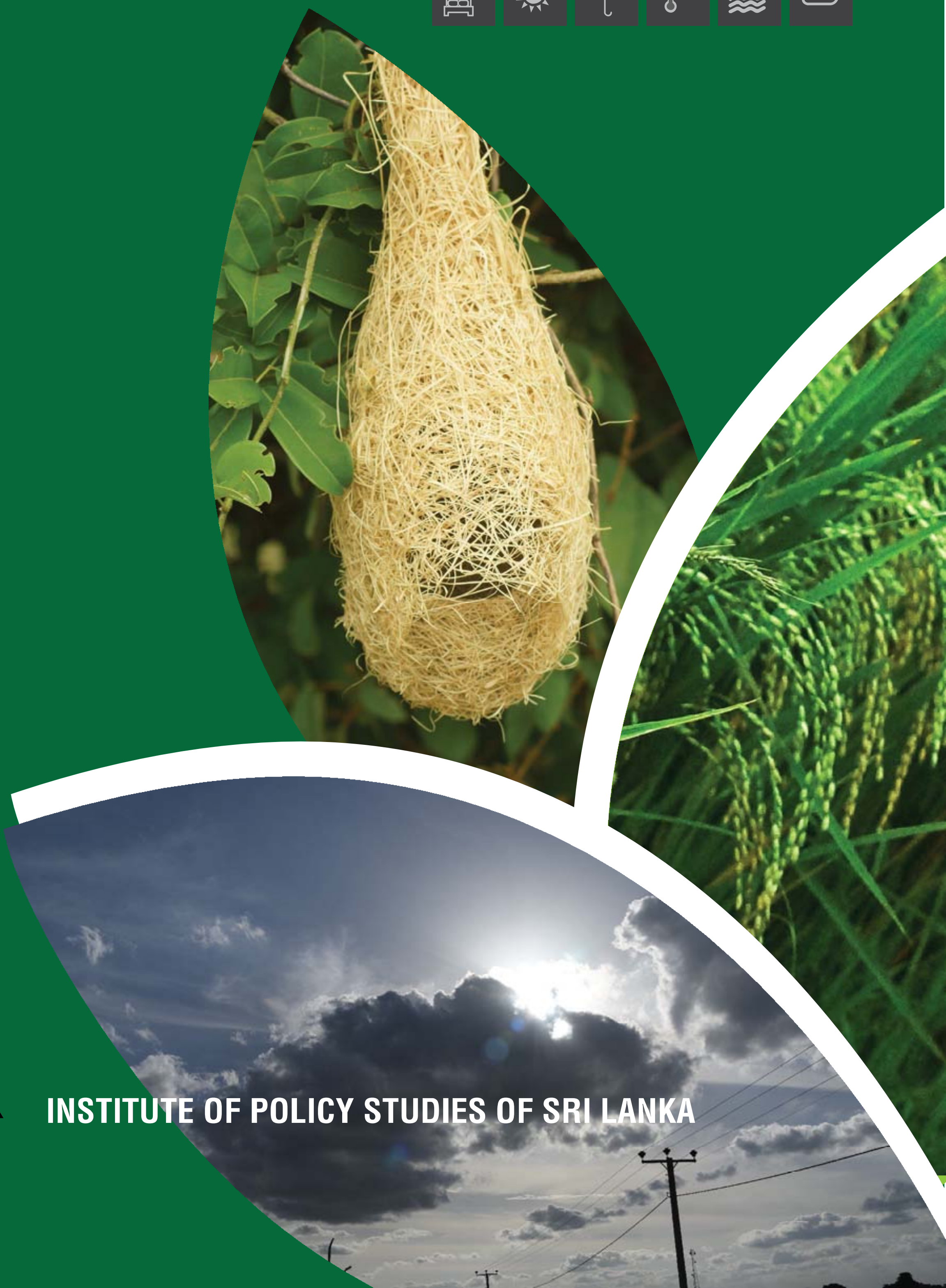
How to Bridge the Climate Information and Communication Gaps for Farmers: Integrated Climate Information Management Systems (ICIMS)



INSTITUTE OF POLICY STUDIES OF SRI LANKA

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Foreword

Climate uncertainty has become a major economic challenge to Sri Lanka. While disturbances caused by extreme climate events affect everyone; the farming community whose livelihood depends heavily on climate, faces more severe consequences. They encounter economic losses owing to frequent floods, storms, and droughts as well as due to slow-onset impacts of climate change, such as rising temperatures and erratic changes in familiar patterns of rainfall. Scientists are now convinced that increasing climate turbulences in local areas are closely associated with global climate change caused by human actions.

Climate uncertainty has to be countered through appropriate adaptation strategies. The Institute of Policy Studies of Sri Lanka (IPS) recognised the importance of mainstreaming climate adaptation for sustainable development in Sri Lanka more than a decade ago and initiated a policy research programme on climate change to assist the national efforts. This programme was launched with the support of a UNESCO grant that also helped to establish the CLIMTEnet web portal, a platform created to exchange views and share information and knowledge on climate change issues, with other researchers and policymakers. 'Climate Change Issues in Sri Lanka', a periodic IPS publication, is published based on blog articles published in CLIMATEnet. Two issues of Climate Change Issues in Sri Lanka have been published so far, covering diverse issues of climate change in the country.

The IPS has identified climate information—lack of appropriate climate information products (CIPs) to assist vulnerable communities affected by climate change— as a critical area for policy research. This gap poses a major challenge for making correct adaptation choices. As a measure of overcoming this challenge, IPS developed a partnership with the Department of Meteorology of Sri Lanka (DOM) and Janathakshan Gte Ltd. to implement an action research programme to pilot test models of 'Integrated Climate Information Management Systems' (ICIMS). This project was financially supported by the Opportunity Fund of the Think Tank Initiative (TTI) of International Development Research Council, Canada.

The third issue of IPS' climate change magazine is a special issue, focusing on "Bridging Information and Communication Gaps for Effective Adaptation Decisions: Integrated Climate Information Management System (ICIMS)". It shares the experience and knowledge gathered from the joint project on ICIMS. The core content of the current issue is made up of eight blog articles, either published already or awaiting publication in CLIMATEnet, written by the team members of the IPS, DOM, and Janathakshan. These articles discuss diverse issues covered in the research project, such as climate information products, indigenous climate knowledge and predictions, scientific weather forecast products, framers' climate information needs and demand-side issues, community-based rainfall stations and index-based insurance, technical challenges of communication of CIPs, and the importance of climate-smart agriculture for ensuring food security. In addition, two previous knowledge products by IPS researchers, a chapter on CIPs from the State of the Economy report and a conference article on farmers' climate knowledge, are reproduced here, considering their topical relevance. This issue also provides details about project methodology and key project interventions, including a photo gallery.

Overall, it has been designed to offer a comprehensive coverage on issues relating to climate information and communication gaps faced by vulnerable groups of farmers. We hope that the content of this special issue of Climate Change Issues in Sri Lanka would help enlightening interested readers on this very important yet relatively less explored area of knowledge in Sri Lanka.

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Bridging the Climate Information and Communication Gaps for Effective Adaptation Decisions: An Integrated Climate Information Management System

Climate information and communication gap

Developing country farmers in dry and arid regions are among the most vulnerable to impacts of climate change (Collier et al., 2008; Jarvis et al., 2011; Lobell et al., 2008; UNDP, 2007). Adaptation, defined as adjustments in the behaviour in response to actual or expected variability or change in climate to moderate and cope with harmful impacts or to take advantage of opportunities is the key to face rising climatic uncertainty (IPCC, 2007; Smit et al., 2000). Two broad forms of adaptation can be identified; these are policy-induced adaptation and autonomous adaptation (Smit et al., 2000). While policy-induced adaptation has received the wide attention of researchers and policymakers recently. In practice, adaptation usually takes place through an autonomous process of voluntary adjustments by farmers. Farmers are inherently adaptive and in many dry and arid regions and they possess enduring adaptive experiences that evolved long before the present concerns about global warming appeared.

Both types of adaptation, autonomous and policy-induced, involve risky choice decisions. In the case of autonomous adaptive responses, farmers make risky decisions based on their subjective expectations of climate events (e.g. rainfall events). Evidence from literature suggests that their decisions are assisted by experience acquired over repeated choices of adaptation over several years (Hansen et al., 2004; Marx et al., 2007; Weber, 1997, 2006) and shared beliefs accumulated in collective memory over generations (Orlove et al. 2007; Roncoli et al., 2002; Sanchez-Cortes and Chavero 2011; Senaratne, 2013; Slegers, 2008) that help to form climate expectations. Recent behavioural research suggests that farmers' expectations are usually associated with experiential processing of climate observations and affect-based mechanisms (Hansen et al., 2004; Marx et al., 2007; Slovic et al., 2004, 2005; Weber, 2006). Being heuristically aided products of mind, farmers' beliefs and expectations are prone to various biases also that can be identified as 'cognitive illusions' (Nicholls, 1999). In contrast, policy-induced adaptation efforts are largely inspired by the climate information products (CIPs) generated by the analytical processing of weather data by experts, usually available in abstract formats such as probabilistic climate projections and forecasts (Marx et al., 2007). These abstract formats lack the power of motivation and trigger for action, which are usually associated with affect-based decision mechanisms and shared beliefs held in concrete formats that guide farmers' autonomous adaptive actions (Hansen et al., 2004; Weber, 2006).

Besides, there are issues of effective communication of information in probabilistic formats produced by analytical processing methods (CRED, 2009). Some studies carried out in developing countries, especially in Central and West Africa have highlighted this (Hansen et al., 2011; Lybbert et al., 2007; Mertz et al., 2009; Patt et al., 2005; Roncoli, 2006; Tschakert, 2007; Ziervogel and Opere, 2010). Studies conducted under Climate Change Adaptation in Africa (CCAA) program have shown that interpreting probability-based forecasts is difficult for farmers and other local stakeholders (Ziervogel and Opere, 2010). Even the timing of broadcast of climate information could affect their usefulness. As a result, when confronted with choice amongst different approaches, lay decision-makers (e.g. farmers) usually tend to rely on affect-based approaches despite the share of biases associated with them (Weber, 2006).

Asymmetry in decision approaches in autonomous and policy-induced adaptation processes result in gaps that could lead to inefficiencies in the overall process of adaptation. Among the major gaps are information gap and communication gap and key questions associated with these gaps which can be highlighted as follows:

Information gap: What are the climate information needs of farmers? ; How farmers use local knowledge and probabilistic weather/climate forecasts for adaptation decisions?; What are the strengths and weaknesses of farmers' climate observations and locally held beliefs?; What are the key CIPs available for farmers for making adaptation choices? ; How farmers determine good/bad, reliable/unreliable climate information? ; How the local knowledge and beliefs correspond with probabilistic forecasts? ; How to tap farmers' traditional beliefs/knowledge on local climate to bridge the climate information gap?

Communication gap: What are the barriers that prevent communities from accessing reliable climate information products (CIPs)? ; What channels are involved in offering climate information products to farmers on a regular basis? ; Who are the key stakeholders and what role do they play in communication of different CIPs? ; What are the preferred delivery mechanisms for climate information?

One way to overcome these gaps for achieving more effective outcomes of adaptation decisions is combining the strengths of the decision-making process associated with two types of adaptation decisions by establishing *Integrated Climate Information Management Systems* (ICIMS). ICIMS refers to hybrid systems of decision-making that harness the strengths of local systems, while giving the benefits of advances in climate sciences to the groups vulnerable to climate risks. Importance of integrating local climate knowledge and scientific climate forecasts has been emphasized by a number of studies conducted under CCAA program (Ziervogel and Opere, 2010). It has been shown that such integration can bring in advantages such as reducing gaps in interpretation of forecast information, improving farmers' confidence in use of climate information, tailoring the information product to cater farmers' needs, increasing the acceptability of climate information to farmers and, decreasing the scepticism of experts on local knowledge systems. The ICIMS should be aimed at improving the overall effectiveness of adaptation decisions taken by farmers in day-to-day basis as well as broad policy decisions on adaptation taken by policymakers/experts. Hence the overall research problem of this proposal can be summarized as: *How the strengths of local climate knowledge systems and probabilistic CIPs can be integrated to enhance the effectiveness of both autonomous and policy-induced adaptation choices?*

Objectives

The overall aim of this research project is to reduce the vulnerability of farmers to climate risks and increasing their adaptive capacity to face them. This is to be achieved through enhancing the rational use of climate information products in order to improve the effectiveness of adaptation decisions taken by farmers and policymakers/experts in their respective decision-making spheres. The specific objectives of the project are:

- Pilot-test models of ICIMS intended to combine the strengths of decision criteria used by farmers, CIP providers and policymakers for successful outcomes of adaptation

- Undertake an action research programme to identify critical factors that determine the success and sustainability of models of ICIMS

- Build the capacity of climate information providers and farming community to jointly develop and communicate effective climate information products

- Identify replicable ICIMS models that can be applied in other parts of South Asia and the developing world for the benefit of vulnerable farming communities

Methodology

Method of the proposed study is based on an action research model that produces rigorous academic outputs and participatory policy outcomes simultaneously through a joint mechanism that implements research activities and development interventions together. It examines the issue from the side of all major stakeholders: vulnerable farming communities, climate information providers and policy makers. The action research model involves a socio-economic research component, technical capacity development component and regional knowledge sharing component.

The *Socio-economic Research Component* deals with assessing the specific climate risks faced by selected farmer communities, studying local systems of climate knowledge and belief systems, identifying viable institutional structures and suitable communication modes for ICIMS and designing appropriate monitoring and evaluation mechanisms through a participatory process involving the target communities. It also aims at identifying specific areas and gaps that need interventions through suitably designed adaptation policies, strategies, programs, and projects.

The *Capacity Development Component* focuses on technical aspects of establishing pilot scale ICIMS with selected local communities which are replicable with appropriate adjustments with other vulnerable regions in South Asia. It involves assessing the data requirements and availability; identifying the short, medium and long-term CIPs that cater to community climate information needs, designing appropriate CIP templates that complement local knowledge and practices, transferring necessary technical skills through training, and designing technical means of communicating information through identified modes of communication. Overall, this component pilot-tests models for developing and communicating reliable CIPs applicable in connection with the local knowledge systems and practices, together with appropriate communication channels accessible to local communities. A summary of intended capacity development needs for establishing ICIMS are provided in Table 1.

Outputs: The key output is establishing ICIMS and pilot-testing of them for better results. This leads to generate secondary outputs of building the capacity of the DOM for offering services to farming community more efficiently and organising and training members of farming community to make use of climate information on more effective manner. All these outputs will contribute to the long-term objectives of the project, namely, enhancing the adaptive capacity and reducing the vulnerability of farmers to climate risks.

Outcomes: Outcomes are behavioural changes of target groups and stakeholders involved. The research study integrates scientific information and local knowledge which enable farmers and policy makers to make better informed and more accurate decisions on climate adaptation. This would increase farmers' alertness to climate risks resulting in adjustments in farming calendars and adoption of innovative risk management strategies. The project also take measures to build the capacity of the DOM in producing and communicating climate information products through developing facilities, training and improving the skills. Capacity building and experience gained from involvement in pilot-testing of ICIMS would improve the efficiency and quality of DOM's services, offering more innovative CIPs that would be useful to farmers.

Table 1: Summary of intended capacity development needs for establishing ICIMS

Projected capacity development needs	Receiver of capacity development support	Provider of capacity development support	Nature of capacity development
Upgrading the skills in developing and communication of suitable CIPs	DOM (Department of Meteorology)	A regional Centre of Excellence in CIPs	Technical training of skills
Enhancing the capacity for developing effective linkages with target users of CIPs	DOM	Project financial support	Essential hardware and software support for establishing communication linkages of ICIMs
Developing skills of interpreting and use of CIPs	Farming community	DOM Janathakshan	Participatory skills development tools
Enhancing the farmers capacity for timely access to CIPS	Farming community	Project financial support	Essential hardware support for establishing communication linkages of ICIMs
Building institutional capacity and motivation for ICIMS	Farming community	Janathakshan	Social mobilisation and adoption of best practices

The *Regional Knowledge Sharing Component* aims at borrowing from existing best practices in South Asia and other TTI supported regions (e.g. Africa, Latin America) to develop the action research module and share the lessons and success stories with the same stakeholders at the end of the project period.

Expected results

The project is expected to generate outputs, outcomes and impacts that cover short- and long-term time horizons.

Impacts: Above mentioned outputs and outcomes would lay the foundation of short- and long-term impacts of the project. They will help farmers to minimise the losses due to unexpected climate change events. Moreover, enhanced availability of information would also help to identify and exploit hitherto unnoticed opportunities. Losses avoided and opportunities captured will bring in direct private income benefits to farmers even in the short-term. On the other hand, informed policy decisions on adaptation will generate tangible long-term benefits that increase the adaptive capacity of communities, overall. There are other vulnerable communities that could possibly use the climate information products beneficially, such as fishermen and small scale tree crop cultivators. The project shall measure short-term tangible impacts, identify and list potential long-term impacts.

Collaborating institutions

Institute of Policy Studies (IPS) is the lead organisation of the research consortium. Other partners of the project are Department of Meteorology of Sri Lanka (DOM), the Janathakshan (formerly Practical Action Sri Lanka) and South Asian Network of Development and Environmental Economics (SANDEE).

- The Department of Meteorology (DOM) is the national provider of meteorological and early warning information in Sri Lanka and is the Focal Point in Sri Lanka for the World Meteorological Organisation (WMO) and Inter-governmental Panel on Climate Change (IPCC).

- Janathakshan—the successor to Practical Action Sri Lanka—is a regional nongovernmental organisation that aims to build the technical skills of people by enabling them to improve the quality of their lives.

- SANDEE is a regional network of research and dissemination in areas related to environmental economics. Climate adaptation is a theme area of research promoted by SANDEE.

The IPS bears the major responsibility for the *Socio-economic Research Component* while playing the coordinating role for other components as well. The DOM and Janathakshan jointly undertake the key responsibilities of the *Capacity Development Component* by helping to establish and functioning of pilot ICIMS models in selected locations from respective ends of climate information provider (i.e. DOM) and community mobilizer (i.e. Janathakshan). The SANDEE assists in the *Regional Knowledge Sharing Component* through its network of partners.

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Facing Climate Change Threats: The Importance of Better Information

by Athula Senaratne

This article was first published in the IPS flagship publication 'State of the Economy Report 2013'.

Introduction

Several thousand small farmers in the dry zone of Sri Lanka faced severe rainfall events with significant livelihood impacts in early 2011 and late 2012. More recently, there was a significant loss of life amongst the fishing community and damage to property in June 2013 as a result of stormy weather conditions. Against normal expectations of local climate conditions, these events undoubtedly took the affected farming and fishing communities by surprise, despite the fact that over the last few decades, such climate-related shocks have become more frequent and intense, impacting the livelihoods of many communities. Such adverse events have called public attention to the need for timely and reliable information on weather and climate. While various measures have been proposed to face such situations, their success depends largely on the availability of reliable climate information. Several studies and pilot projects undertaken in Sub-Saharan Africa and other developing countries, have underscored the importance of Climate Information Products (CIPs), such as seasonal forecasts as decision-support tools, to face rising incidents of climate shocks.

The threat of climate change, which is fast becoming a reality in day-to-day economic life, is increasingly becoming a key factor in emerging challenges that a developing country such as Sri Lanka faces. Adverse climatic events are a significant social and economic burden on a country. They are likely to be even more so when such events are precipitated as unanticipated shocks to an economy, with resultant disruptions and set-backs to growth and develop- ment targets. Whilst climatic related shocks cannot be subject to any degree of certainty, attention to developing tools and mechanism to be better informed of such impending threats is clearly the way forward.

Bridging the information gap on climate shocks can be considered as a priority issue in facing the threat of climate change

The threat of climate change is a phenomenon that ought to be dealt with through scientific knowledge – i.e., essentially by an information driven process. In this context, a gap in information is a major constraint that needs to be addressed in all aspects of meeting this global challenge. The effective use of appropriate climate information products has a major role to play here.

Climate is inherently variable across temporal and spatial dimensions. It has never been a matter of certainty, and coping with climatic 'variability' has remained an eternal challenge faced by humanity. Rapid, broad sweeping 'change' of climate, due to anthropogenic causes has the potential to compound this situation further. There are two major strategies involved in facing the threat of climate change mitigation and adaptation. Mitigation aims to reduce the level ofgreenhouse gas (GHG) emissions through cooperative actions. Adaptation constitutes actions that are taken to moderate, cope with, or take advantage of actual or expected change of climate and related shocks. It is a dynamic process of adjustment that involves decisions under risk and uncertainty.

The topic of climate information is examined here mainly from the perspective of adaptation decisions. For Sri Lanka, being a small island nation in the tropics with a high level of vulnerability to harmful impacts of climate change, it is logical to assert that the country's national climate change strategy should focus more on adaptation than mitigation.[1] As far as information on climate risks is concerned, countries like Sri Lanka are always at a disadvantage. The resolution of global circulation models (GCM) is still not sufficient to cover the details on small countries with complex topography, compared with larger geographic units. With limited scientific capacity to develop locally applied models or to downscale local effects from the global models, information on climate uncertainty is a major obstacle to be faced in making effective decisions on adaptation at all levels. Despite limitations in information availability, action against the rising threat of climate shocks cannot be delayed anymore. Therefore, bridging the information gap on climate shocks can be considered a priority issue in facing the threat of climate change. The primary purpose of this Chapter, therefore, is to examine the current situation with regards to climate information in Sri Lanka, and the measures that can be taken to bridge the existing information gap as the country strives to achieve its long term growth and development objectives.

Climate Information Products: An Economic Commodity

Information is an economic commodity with scarce supply relative to demand. Climate information is not an exception to this. There are a variety of CIPs that cater to demand originating from a wide range of users. In this section, a broad review on CIPs is presented from the perspective of an economic commodity. It begins with an account of the nature of CIPs with relation to their role in adaptation as decision-support tools.

Climatic variability and change are sourcesof uncertainty that can lead to climatic events with unanticipated outcomes. Hence, adaptation decisions are necessarily risky choices. The choice is among options that can either moderate losses, or take advantage of the impacts of climatic events in different domains of human activity (e.g., agriculture, coastal fisheries, and disaster prevention). 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 decisions are made with imperfect information, and decision-makers have to arrive at expectations regarding the likely climatic events (e.g., rainfall expectations) when they make choices. The CIPs have an important role to play here by helping to reduce the uncertainty associated with adaptation decisions made by various stake holders, that range from high level policy decision makers to grass root level actors such farmers and fishermen. The essential nature of risky decisions of adaptation is shown in Figure 1.

Figure 1
Nature of Adaptation Choices

Adaptation decisions → Climate events → Outcomes

There is a time gap between actual decisions and outcomes of decisions during which they are subject to uncertain climatic events. The CIPs have the potential to make positive contributions to decision outcomes by:

- Forewarning and helping to prepare for adverse events
- Enabling the potential to take advantage of favourable conditions

This can help to generate economic valueby minimizing the losses due to climate shocks, and/or by generating value addition by making use of favourable climate events. This way, CIPs can make a positive economic contribution by lowering uncertainty in decision making, if they are correctly formulated, assessed, communicated, understood, and successfully integrated into the decision making process.

Nature of Climate Information Products

Climate information could range from advanced information products generated with the help of sophisticated forecast models, to laymen's oral interactions about local weather conditions based on personal experience. From an economic perspective, what is important is the decision-support role of information contained in a given information product. In this connection, forecast products that make predictions about future climate events are the most important form of climate information. As a result, climate forecasts and projections have attracted the most attention of climate change researchers. Hence, climate information can broadly be categorized as:

- Climate forecasts and projections
- Other CIPs.

Other CIPs may include information products such as classifications of agro-climatic zones, cropping calendars, sowing/planting windows etc., that provide useful information for planning and management of activities. Such products are usually based on the analysis of long term weather data on selected climatic parameters.

[1] Sri Lanka's contribution to global GHG emissions is relatively low compared with industrial nations or emerging economic powers. Therefore, mitigation efforts have a limited role to play.

Climate Forecasts and Projections

Climate forecasts and projections provide useful decision support information, and therefore play an indispensable role in modern economies faced with rising incidents of climate shocks. The purpose of climate forecasts and projections is the prediction of the future state of climatic parameters. They predict future climatic conditions with specified periods of lead time – usually probabilistic predications about selected parameters such as precipitation, temperature, or wind. They could be available in categorical or continuous probability forecast formats. As information products, climate forecasts usually have characteristics of public goods: non-divisible, non-excludable, and non-rival in consumption.

While both forecasts and projections provide predictions about future climate conditions, they have certain technical differences also. Forecasts attempt to generate a picture about the actual future evolution of climate parameters over a specific time scale such as daily, weekly, monthly, seasonal, annual, or supra annual scales, with a certain level of confidence. The future time scale coered by a forecast is the lead time of a forecast. Typically, the level of confidence attached to predictions tends to decrease with the length of lead time. They are based on models which are abstract mathematical representations of the climate systems at varying levels of complexity. The most comprehensive models of the climate system are known as Atmosphere Ocean General Circulation Models (AOGCMs).

One of the most widely studied forms offorecasts is Seasonal Precipitation Forecasts (SPF). They are also known as seasonal rainfall outlooks. The SPFs are designed to predict seasonal variations of rainfall with lead times, usually in the range of 1-6 months. They are based on computer models on atmospheric oceanic circulation patterns that try to exploit ocean-atmospheric interdependencies, to predict the likely future events of rainfall. They particularly try to exploit anomalies caused by climatic phenomena such as El-Nino Southern Oscillation (ENSO), to recognized circulation patterns to make predictions about likely events of climate.

The Madden Julian Oscillation (MJO) and the Indian Ocean Dipole (IOD) are two other sources of anomalies that are being used for the prediction of climate in the tropics.

Projections also try to compute potential future evolution of climatic variables, but their predictions are subject to an identified set of assumptions about future conditions known as scenarios. Scenarios are based on assumptions about the future developments of technological /socio-economic conditions that could positively or negatively influence the levels of GHG emissions and atmospheric concentrations.[2] Such projections may provide vital information necessary for policy making. For instance, current concerns in climate change in small island nations such as the Maldives have largely originated from projections about the future sea level rise, under certain scenarios of GHG emissions. As in the case of climate forecasts, climate projections are also based on simu- lation models, and they usually try to cover longer term horizons (e.g., target projection years such as 2025, 2050, and 2100). The confidence levels attached to projections are described using a scale of likelihood connected to corresponding ranges of probabilities. Table 1 presents a scale of likelihood used by the Inter-Governmental Panel on Climate Change (IPCC) in global climate projections.

Disregarding the type of CIP, a major challenge faced in climate predictions is forecast uncertainty, referring mainly to variability of observations. The variability of climate observations could originate due to natural causes, as well anthropogenic processes such as global warming. With greater uncertainty, the more difficult it is to forecast, which lowers predictability as a result. In forecast modelling, researchers attempt to exploit sources of predictability associated with non-stationary patterns of climatic parameters, such as tropical atmospheric circulation and recognized patterns of anomalies (e.g., ENSO, MJO, and IOD).

Table 1

A Scale of Likelihood Used to Assess the Uncertainty of Projections

Terminology	Likelihood of the Occurrence/OutcomeTerminology
Virtually certain	>99% probability of occurrence
Very likely	>90% probability
Likely	>66% probability
More likely than not	>50% probability
About as likely as not	33 to 66% probability
Unlikely	<33% probability
Very unlikely	<10% probability
Exceptionally unlikely	<1% probability

[2] For instance, the IPCC uses a standard set of scenarios known as Special Report Emission Scenarios (SRES) in climate projections.

Supply and Demand for Climate Information Products

As in the case of many economic commodities, value chains can be identified for CIPs based on supply and demand relations. The value chains of CIPs involve a range of stakeholders that include providers and users of information products. From the supply side, forecast providers represent the point of origin of CIPs in the value chain. There are global, regional, and national level providers of CIPs. Given the public good nature of CIPs, many providers are usually state, inter-governmental or non-profit agencies. At the national level, major providers of CIPs are national meteorological services (NMS) such as Meteorological Departments or Weather Bureaus (e.g., Department of Meteorology in Sri Lanka). Given the limited technical capacity of the NMS in developing countries, they usually have to depend on global and regional level information providers for the technical preparation of national and sub-national level CIPs. Such agencies include inter-governmental bodies [(e.g., IPCC, and World Meteorological Organization (WMO)], or technical agencies sponsored by developed nations. A few examples of such agencies are, the Commonwealth Scientific and Industrial Research Organization (CSIRO), National Centres for Environmental Prediction (NCEP) in the US, the Japan Meteorological Agency (JMA) and the International Research Institute for Climate and Society (IRI). Agencies and professionals involved in the provision of CIPs are sometimes known as the 'climate prediction community' (CPC). The CPC includes researchers on climate systems and forecast modelling, operational forecast providers, forecast application experts, and other aca- demic/technical persons involved in different aspects of climate prediction. Members of the CPC from different countries share the know how in forums, such as Regional Climate Outlook Forums (RCOF).

The demand for CIPs comes from users whoare decision makers at different levels. A range of users could be identified from grass root levels (e.g., rain-fed farmers, fishers, etc.) to national, regional, and global policy decision makers (e.g., climate change policies, disaster management policies, irrigation/agriculture/fisheries management policies, etc.). A few broad categories of decisions taken by those user groups can be identified as:

- Long term structural adaptation decisions
- Medium term strategic adaptation decisions
- Short term tactical adaptation decisions

Outcomes of decisions that extend over decades or more are those related to structural adaptations. Decisions that involve time horizons from one to a few years can be called as strategic adaptation responses. Decisions concerned with short term intervals seasonal or annual are the tactical responses. This classification is based ontime horizons usually attributed to human decision-making, rather than time horizons associated with impacts of climate change.

Different user categories typically need knowledge on the likely impacts of future climate events over short, medium, and long term horizons, when making decisions on adaptation, and their information needs may vary depending on the type of decisions they make. On the other hand, CIPs vary in terms of lead time of predictions. A crude matching of type of CIPS with different time horizons of adaptation decisions is given in Table 2.

Factors Determining Demand for Climate Information Products

The bottom line for demand of CIPs is that they should be able to improve the outcomes of decisions taken with the aid of forecasts, compared to outcomes of decisions taken without forecast information. This is the prime source of value of CIPs. However, the context of CIPs is relatively complex than many other economic commodities. As a result, the demand for CIPs could be affected by product-related characteristics, as well as a number of extraneous factors. Among the product related characteristics, quality and value of products are the most important.

Table 2

Adaptation Decisions and Types of Matching CIPs

Time Horizon of Decisions	Types of Adaptation Decisions	Types of Matching CIPs
Short term	Tactical	Daily, weekly, monthly forecasts.
Medium term	Strategic	Multi-year or multi-seasonal predictions
Long term	Structural	Long term climate/impact projections

Quality of CIPs

Both quality and value of forecast products have received wide attention. The quality of information is defined in relation to forecast performance i.e., how well forecasts predict the observations. Several quality parameters have been identified, representing the desired characteristics in terms of product performance. Among the most widely examined parameters are: lead time, accuracy, reliability, and forecast skill.

Lead time refers to the time lag between the prediction and the predicted event. The desired characteristic here is the length of the lead time, the longer the better. The lead time of different CIPs may vary from a few hours (e.g., short term routine weather forecasts), through a few months (seasonal forecasts), to several decades (long term climate projections). When the lead time increases, as a rule, tradeoffs have to be made in terms of other quality parameters such as accuracy, reliability, and forecast skill, that determine the level of confidence attached to the prediction.

Accuracy refers to the level of agreement between prediction and observations (data). It is measured in terms of the difference between the true value (observation) and the prediction. The difference is known as forecast error. In the same vein, reliability is defined as the average agreement between forecast values and observed values. From a decision-making perspective, it refers to how well forecasts will be able to improve outcomes of decisions. Finally, measures of forecast skill provide a statistical evaluation of the relative accuracy of a forecast over some reference forecast. The norms used for references are persistence (no change in condition) and climatology (typical conditions in a given month). The type of references used may vary according to the type of forecast: e.g., short term weather forecast (persistence); seasonal forecasts (climatology). Forecast skill is mainly concerned with the increase in accuracy due to smartness of the forecast system, rather than accuracy due to easiness of the prediction.

The improvement of quality parameters of CIPs needs employing best practices in forecast methodology. The forecast quality has to be measured through a process of validation and verification. Different verification systems can be used; the WMO standard verification system of long range forecasts is a widely used system.

Value of CIPs

The value of forecast information is assessed with reference to benefits accrued to users by decisions taken with the aid of an information product. The value of forecasts justifies the investment on CIPs. Assessing the value of forecast information involves several conceptual and analytical difficulties. The essence of the idea is how much value is added to decision outcomes achieved with the aid of forecast information, relative to decision outcomes achieved without the guide of forecasts.

A variety of approaches have been used to estimate the value of climate information (forecasts). One measure of value is the expected value of forecast information (EVFI) —defined as the difference between the expected value of the outcome from a forecast-assisted decision, and the expected value of the outcome of a decision taken without the guidance of a forecast.

As already mentioned, CIPs are public goods in nature, and therefore limited incentives are available for private providers to supply them through a market driven mechanism. Hence, state or non-profit agents are usually involved in the supply and delivery of CIPs. Assessing the value of CIPs becomes an important step in the value chain, since it provides the main source of justification for making investments on CIPs in the absence of market based pricing mechanism to exchange products.

Delivery of Climate Information Products: Communication

Among the other factors that affect the demand for CIPs, factors connected to the delivery of products are the most important. Delivery implies the communication of information between providers and users. The delivery of CIP involves a two-way communication between providers and users. The primary path of communication is conveying the forecast message to users. Nevertheless, given the public good nature of CIPs, reverse feedback communication from users to providers can also be considered as highly important. Otherwise, due to the absence of a product exchange based on a price mechanism, there is no way to signal the important messages about quality and value of products.

There are a number of important issues involved in the delivery (communication) of CIPs. Among them are the format and content of the forecast message; availability, access, and targeting of products; and media of dissemination.

In terms of the format and content of forecast message, forecast products are probabilistic in nature and always carry some level of uncertainty. Hence, their usefulness is determined by the level of confidence attached to them. Overestimating (overconfidence) as well as underestimating (poor confidence) the accuracy and reliability of information could lead to erratic decisions with significant losses. Therefore, effective communication needs a balanced coverage of the level of uncertainty and applicability/limitations of CIPs. This is a matter of format and content of CIPs.

In terms of availability, access and targeting, the effectiveness of CIPs is determined by the availability of products, and easy access to them by users. Otherwise, even the information generated with sophisticated methods of forecasting could be wasted without being used by target users. Finally, the media of dissemination is closely associated with the issue of availability and access. Quite often, the CIPs are delivered through public media such as TV, radio, newspapers, and Internet. Research suggests that the relative importance of different media vary with the type of CIP. It seems that electronic media such as TV, radio and Internet has captured the highest attention. Pilot schemes are also being tested on special-ized channels such as mobile phones (e.g., SMS messages), targeted at specific user cat- egories in some countries.

Users' Forecasts and Beliefs: Subtitutes or Complements?

Another important area is users' local forecasts and beliefs on the climate system as a guide to decision-making. Communities such as farmers and fishermen, have been facing climate uncertainty long before the current scientific knowledge about climate and forecasting methods more developed. Such communities were taking day-to-day decisions under the guidance of local forecasts, that helped them to form expectations regarding the climate events to come. These forecasts are based on indigenous systems of knowledge and methods of prediction about local climate, that have been shared by communities as local beliefs. These can be considered as farmers' models generalized and simplified versions of experienced patterns of climate over long periods of time (over generations) that give some predictability about local climatic variability, thereby helping to plan regular livelihood activities. Studies have found that such beliefs carry expectations about the beginning of rainfall (season), onset of rainfall, duration and distribution of rainfall events, dry spells, end of rains, and a knowledge of local indicators that help predict oncoming climate events. Some have called such beliefs as naïve forecasts, compared to climatological forecasts based on formal methods of analysis.

Studies on local beliefs suggest that they may contain many favourable characteristics that serve as a useful guide to decision- making. According to recent behavioural economic findings, the methods used by local communities appear to be based on heuristics — mental shortcuts or 'rules of thumb' commonly used to make probabilistic judgments by decision-makers. Heuristics have certain advantages, subject to limited information processing capacity of decision-makers. However, decisions based on heuristics are usually associated with cognitive biases, and local beliefs on climate are not an exception. Researchers have suggested such biases are analogous to cognitive 'illusions' errors being made without knowing about them.

Research on local climate beliefs and forecasts has raised a few important points that are relevant in the case of CIPs.

Such beliefs are founded on generations of experience about the local climate. Evidence from many developing countries indicates that farmers are still using them widely in their regular farming decisions.

Recent behavioural studies suggest that they serve as an alternative system of decision tools, based on subjective processing of individual and group experiences (experiential processing), compared with analytical processing of systematically gathered weather data upon which CIPs are based.

Local forecasts could serve either as complements or substitutes for CIPs. As complements, they can fulfil an important role by serving as prior subjective distributions to be updated by forecast information. This is an essential step in a heuristically-driven process of probabilistic decisions, usually practiced by non-expert decision-makers. On the other hand, in the case of CIPs which are not compatible with farmers' decision context, local forecasts may compete with formal forecasts and substitute them. They may be given preference over formal forecasts due to the appealing characteristics of local beliefs, in terms of compatibility with farmers' decision - making behaviour.

Climate Information in Sri Lanka

The Department of Meteorology (DM) is the nationally mandated CIP provider in Sri Lanka. It has a mandate for the provision of weather and climatological services for na- tional development, general public, and stakeholders in sectors such as agriculture, energy, fishery, shipping, aviation, and insurance. These services are concerned with offering CIPs routinely on a daily/weekly, monthly, and seasonal basis. In addition, the DM issues warnings and advisories on bad weather situations due to events such as cyclones, heavy rains, lightning, and high wind. Its mandate also covers undertaking studies on climatology and climate change that lead to offering specialized products, such as long term projections of climate change. The DM has a country-wide network of own meteorological stations. It also maintains a large number of agro-meteorological units with the collaboration of other agencies dealing with sectors such as agriculture, plantations and irrigation. It is the national representative for the WMO, and the focal point for the IPCC. In addition, it is repre- sented in a number of regional forums on climate, such as the Tropical Cyclone Panel for Bay of Bengal, SAARC Meteorological Research Centre, the Asia-Pacific Network for Global Change Research, and South Asia Seasonal Climate Outlook Forum (SASCOF). Overall, the DM can be considered as the primary source of all forms of CIPs originating in Sri Lanka. Hence, it is the primary source of supply in the value chain of CIPs in Sri Lanka.

The DM presently offers a limited portfolioof CIPs which are channelled via public media and through its own website. It routinely issues short term weather forecasts on a daily basis under three categories: public weather forecasts, sea-area forecasts, and city forecasts, which are updated regularly at intervals of a few hours. Public weather forecasts are concerned with short term prediction of likely events of showers, thundershowers, lightning, and wind, on a broad geographical coverage at province or district levels. Sea-area forecasts, targeting fishermen and naval operations in particular, cover likely events of showers/storms, with direction and speed of winds in selected areas in the coastal belt around the island and adjacent sea areas. City forecasts provide daily forecasts of minimum and maximum temperature, relative humidity and likely events of rainfall for major urban centres. Those forecast products are mainly based on information obtained from satellites, observations made at weather stations around the country, and model outputs of major global centres.

In addition, the DM has recently launched the 'Monsoon Forum' which is aimed at providing a seasonal outlook with a lead time of around 3-6 months in the two monsoons periods — south-west monsoon and northeast monsoon. The Monsoon Forum includes the participation of several state agencies, responsible for agriculture, plantation, irrigation/water management, disaster management, and defence. The major information products offered by the Monsoon Forum include: (i) overall forecast on total rainfall for a given monsoon season under three classes of climatological probabilities: below normal, normal and above normal; and (ii) experimental monthly rainfall forecasts (average rainfall in mm ± 10%) for all districts under the same three classes of climatological probabilities.

These predictions are based on multi-modelforecasts published by international climate agencies on reviewing observations on global climate conditions such as ENSO, MJO, IOD, and other relevant phenomena. The forecasts are initially conveyed to stakeholder agencies bi-annually in the Monsoon Forum and their feedback is obtained. Subsequently, forecasts are made available to the agencies for their decision-making purposes.

The recent upsurge in climate change research has generated a number of research outputs that can be considered as specialized CIPs. Accordingly, locally downscaled versions of long term climate change projections for rainfall and surface air temperature have been developed under selected scenarios. The projections are available for target years such as 2025, 2050, and 2100. In addition, several studies that analyzed emerging trends in weather patterns based on historical records of meteorological data have also appeared. Information generated by such projections and trend analyzes have limitations in terms of confidence levels and applicability for practical decisions. Nevertheless, they can be considered as essential forward looking steps towards developing a viable system of CIPs in the long run.for practical decisions. Nevertheless, they can be considered as essential forward looking steps towards developing a viable system of CIPs in the long run.

While the research findings on actual use of available CIPs are scarce, a survey conducted by the IPS in village tank farmers in Anuradhapura district has shown that 73 per cent of farmers regularly look for daily weather reports in the public media. However, the share of farmers who ranked media weather reports as the major source of information is only 2.8%, falling far short of the numbers that ranked personal judgment/observations (86.7 %), or interactions with fellow farmers (8.8%) as the major source (Table 3). The information given in Table 8.3 suggests that farmers mainly rely on climate expectations based on personal observations. They are further assisted by interactions with fellow farmers too. While many farmers look for weather information from media, their assessment of the role of media information in making actual decisions was low.

Table 3

Information for Climate Expectations in Farming Decisions of Village Tank Farmers

Source of information on climate for farming decisions	Ranking (%)		
	1	2	3
Expectations based on personal observations	86.7	10.5	-
Information acquired from interactions with fellow farmers	8.8	71.8	71.8
Weather information from media	2.8	12.2	70.2
Information from local officers	-	1.7	0.6

The above are the core products of climate information currently available in Sri Lanka. In addition, some complementary products that play a supportive role in decision-making on climate related issues also are available. One of them is the classification of agro-metrological zones published by the Department of Agriculture. Based on long term records of local rainfall and elevation classes, the country has been divided into a number of agro climatic zones. This has become a standard CIP used by agricultural and irrigation agencies for decision-making, such as recommendations of crops/agro- nomic practices, and irrigation management.

To some extent, the high rankings assigned to personal observations and interactions with fellow farmers indicate the importance of locally shared beliefs about climate in farmers' decisions. A study documenting some aspects of local beliefs on climate shared by village tank farmers suggest that many regular farming decisions are guided by local beliefs.[3] Accordingly, farmers' beliefs consisted of the following key components:

Beliefs about local seasons: A core component of farmers' beliefs on local climate is the seasonal agricultural calendar with two traditional farmer-defined seasons

[3] Senaratne, A. (2013), "Shared Beliefs, Expectations and Surprises: Adaptation Decisions of Village Tank Farmers in Sri Lanka", unpublished PhD thesis, Deakin University, Australia

known as Maha and Yala. Local farming system activities are primarily centred on the two seasons. Beliefs on seasonality are associated with normal expectations about the onset of seasonal rains, duration and intensity of rainfall, dry spells and the end of rains. Farming activities are usually organized according to the beliefs about the seasonality of rainfall.

Beliefs on intra-seasonal distribution of rainfall: Farmers' beliefs also cover intraseasonal events of rainfall and dry spells sequenced in order of calendar months (originally based on the local lunar calendar) connected to temporal milestones of religious and cultural events. Farmers had specific local terminology to describe the nature of events (i.e., intensity and time/duration).

Beliefs about local indicators that predict the oncoming climatic events: Farmers share a set of beliefs about local indicators on climate. It consists of observations on the local environment that are interpreted as signs of oncoming events of climate (rainfall). They constitute a local system of forecasting, with indicators having different lead times towards expected events. Such indicators include phenomena such as observations on wind, sky and clouds; local hydro- logical phenomena (e.g., spilling time of tanks); thermal changes in the environment; cosmological observations; resurgence of indicator species and observations on behaviour of animals and local fauna.

Interviews and discussions with farmers confirmed that they still use local beliefs in regular decision-making on farming and other aspects of daily life. However, a majority of farmers (89 per cent) expressed that established patterns of rainfall are changing, and the reliability of local forecasts could decline over the time.

Climate Information Gap

An assessment on the current situation helps to identify specific gaps in climate information in Sri Lanka. Gaps are identified and discussed using a value chain framework in the following sections.

Supply Gaps of CIPs

The current supply of CIPs in Sri Lanka can be considered as limited compared to demand available in various sectors where CIPs can be used to improve decision outcomes in a gainful manner. A few areas where the scarcity of climate information has been felt severely, are agriculture, water resources management, energy generation planning, and disaster risk management. The list is not exhaustive and decisions taken in several areas of economic activity could be expected to benefit from a rational use of CIPs. Overall, the gains in value expected from a sensible use of CIPs in various economic sectors appear to be significant, and compared to potential demand, the existing supply of CIPs can be considered to be strikingly low. The supply improvements can be expected in range, quality, and accessibility of products. The supply gaps originate mainly from constraints faced by providers of CIPs that include the DM, and other relevant stakeholder agencies. The provision of CIPs is an advanced technical process that requires state of-the-art technical facilities and a high level of expertise. To achieve the necessary levels of facilities and expertise, substantial investments are needed. As a result, establishing and maintaining reliable systems of forecasting is a challenge to many developing countries. Sri Lanka is not an exception. Even though the DM has made a conscious effort to upgrade its facilities and range of CIPs over the years, the limited availability of resources has constrained its capacity to meet the challenge. Overall, it is reasonable to assert that insufficient investment on facilities and skills development in the DM and other stakeholder agencies is a key reason for the current gaps in the supply of CIPs.

Credibility Gap of CIPs

The availability of CIPs alone is not sufficient to generate value from adaptation decisions. They need to be credible products, acceptable to users so that they can be effectively used for generating value. Two aspects that critically determine the credibility of CIPs are the compatibility and quality of products. Compatibility refers to the gap between coverage of existing forecasts and the information needs of users. Quality refers to the performance of forecasts in terms of the accuracy and reliability of predictions. Compatibility and quality issues jointly contribute to the credibility gap, which is concerned with how users assess the value of CIPs. If the credibility of products is high, expected value and demand for products increases, whereas the opposite applies for products with low credibility. The credibility gap, on one hand, is an issue which is closely related to supply constraints faced by providers.

Table 4
Farmers' Assessment of Issues/Problems
of Media Climate Information

Problem/Issue	% Farmers
Failure of forecasts	24.9
Not locally focussed	3.4
Low confidence	7.2

Source: Senaratne, A., (2011), "Survey on Farmers' Perceptions and Adaptation to Climatic Variability and Change in Village Tank Systems in Dry Zone of Sri Lanka", unpublished survey, IPS

Table 4 presents a summary feedback from village tank farmers regarding the CIPs currently available from the public media.[4] A few factors that contribute to low credibility on weather forecasts can be identified according to their responses. Farmers have observed failures in forecasts and have low confidence in them. A few farmers stated that lack of local geographical focus makes them less useful. This issue was particularly stressed in FGDs held with farmers. According to them, the media usually covers the province or district as a whole,

[4] Only about 35 per cent of farmers offered responses to the relevant questions

but wide variations in rainfall could exist even within the province/district. As a result, weather forecasts in the media cannot be fully relied on for making regular farming decisions.

The discussions further revealed that farmers usually give relatively high attention to the media when events such as extreme rainfall events, floods, cyclones, and tropical storms take place. Such events normally cover wider geographical areas and often lead to hazardous consequences. They often occur as surprise shocks against normal expectations about climate, and farmers find that information from local observations/fellow farmers alone is not sufficient to face such incidents. Hence, farmers give a higher weightage for information from the media on such occasions.

Overall, it seems farmers use CIPs available from the media selectively, depending on the type of events they face, and the nature of decisions involved. They find routine weather information currently available from the media to be less reliable for usage in regular farm decisions. Nonetheless, they appear to rely more on information from the media when they face climate shocks.

Gaps in Communication (Delivery) of CIPs

Another gap in climate information can occur in communicating CIPs to target users. The communication gap refers to issues concerned with: (i) format and content—i.e., whether or/and how users understand the probabilistic nature of climate forecasts; (ii) availability, access and targeting—i.e., whether a given product is communicated to target users; and (iii) media of dissemination i.e., how effectively products are communicated to target users.

Format and content is closely associated with the problems of compatibility and, therefore, connected to the credibility gap also. Communicating probabilistic forecasts has become an important research area and several studies have been conducted regarding formats and content suitable for specific user groups. Some of these studies have been focussed on users with low education and literacy levels in Less Developed Countries (LDCs), thereby demanding extra care in designing CIPs for illiterate users. The situation in Sri Lanka can be considered some what favourable in this regard, due to a high level of literacy and formal education facilities available even in remote locations.

A second and third set of issues with regard to the communication gap are closely connected to the effective channelling of CIPs to users. Studies in certain countries have shown that electronic media has a major role to play in communicating CIPs. Radio and TV are the most widely used channels of communication of CIPs. The Internet also is becoming popular, especially among urban user groups. A survey conducted by the Ministry of Environment on public perceptions of climate change in Sri Lanka, has reported that TV is the main source of information for both urban (96%) and rural (93%) population, followed by the radio [urban (61%), rural (79%)], and newspapers [urban (79%), rural (68%)].[5] In the survey of village tank farmers, 89 per cent and 97 per cent farmers in the sample had TV and radios respectively, in their houses.

The above suggests that in Sri Lanka, TV can be considered as the most appropriate media for communicating CIPs, followed by the radio. Several TV and radio channels in Sri Lanka offer daily weather reports at the end of regular news bulletins based on the DM forecasts. In addition, both radio and TV channels report weather information as prominent news items on special occasions, such as extreme events. No studies have been conducted to assess the effectiveness of reporting climate information by electronic media in Sri Lanka. An area that needs research attention is on the communication gaps that can occur due to inaccurate, sensationalized coverage of climatic events and trends in the public media.

Declining Reliability of Local Belief Systems

Another aspect relating to the climate information gap is a gradual decline in the reliability of local beliefs on climate. Nearly 89 per cent of respondents in the sample of village tank farmers, expressed that they perceive long term changes in the local rainfall patterns. According to them, rainfall patterns in the area have undergone significant changes, and have become less predictable. As a result, some of the beliefs about local weather patterns have become obsolete and less reliable. In the FGDs, this view was particularly stressed by farmers with long term experience in farming in the area. They suggest that local weather patterns have become more random, and surprise events are more frequent than earlier. In addition, due to the commercialization of local economies, and the spread of modern agricultural technologies, the local environment has changed significantly. Due to changes such as clearing of local forest patches, some traditional indicators have become rare observations that cannot be relied upon for regular farm decisions. Overall, a decline on the reliance of local beliefs on climate, creates a vacuum that widens the climate information gap further. This extra gap has to be filled with suitably designed CIPs.

Bridging the Climate Information Gap

Bridging the climate information gap is an essential step in facing the threat of climate change. To achieve this, certain management and policy measures are necessary. In this section, a brief overview of essential major steps towards bridging the information gap is presented.

[5]Ministry of Environment (2010), "Public Perceptions of Climate Change in Sri Lanka: Findings of a Country-wide Survey in Sri Lanka", ADB Technical Assistance Project 7326-SRI: Strengthening Capacity for Climate Change Adaptation, Climate Change Secretariat, Ministry of Environment, Colombo.

Overcoming the Supply Constraints of Providers

The primary step in bridging the climate information gap is overcoming the supply constraints faced by the providers of CIPs. The DM is the primary provider of CIPs in Sri Lanka. Therefore, building the technical capacity of the DM is an essential step to overcome the information gap. This requires investing funds for upgrading technical facilities of the DM, recruitment of additional staff, technical assistance for launching sophisticated forecast models, building skills of staff by training, networking with global/ regional/national agencies operationally, and building its research and development capacity. Given the advanced technological components involved in capacity building efforts, technical assistance of developed nations, and international agencies is essential here.

Improving the Quality and Value of CIPs

Overcoming the credibility gap of CIPs is an area that requires special attention. The CIPs are imperfect products that require constant improvement. Range and product qual- ity should be upgraded continuously. Hence, product development has to be linked with an effective validation and verification process. This cannot be achieved by improving the technical capacity for producing forecasts alone. It has a strong socio-economic component that covers areas such as assessment of user information needs, appraising users' feedback/acceptance, and estimation of the economic value of products. Several pilot projects and action research programmes have been conducted in developing countries and feedback from such studies are being used to improve the CIPs. This is a continuous process that has to be supported by an efficient research and development programme.

Developing Effective Communication Channels

Capacity building of information providers and product quality improvement should be complemented by developing effective communication channels. As far as the public media is concerned, widespread access to TV and radio even in rural areas is a definite advantage. Another advantage is the high level of literacy of users. These advantages should be exploited to communicate a credible range of products to end-users in an efficient and timely manner. The communication of forecast products has been a wellresearched area. The necessity of norms and best practices of communicating probabilistic CIPs have been identified, and are being continuously developed. The communication of CIPs should be based on such norms and best practices, and also be supported by effective feedback mechanisms. Current research is also exploring the feasibility of communication channels that are targeting specific user groups. Connectivity through mobile phones is one potential way for channelling user specific information. The recent spread of mobile networks, and a rapid increase in phone users even in remote areas, provide a fertile ground for the growth of such experimental channels of communication.

Integrating Formal and Local Systems for Enhanced Performance

The strengths of forecast products should be integrated with local systems of user forecasts to achieve better outcomes from adaptation decisions. Despite the declining reliability of local belief systems due to changes in local weather patterns, such belief systems have developed in response to users' own experiences about the actual information needs of day-to-day decisions. Given that the information is developed based on the needs of actual decisions and personal experience, such beliefs may contain many desired characteristics as decision-support tools, in spite of certain biases that may be associated with them. On the other hand, CIPs based on climatological forecast systems are products of analytical processing of data by experts who are not the real users of the information. Therefore, some characteristics (e.g., format and content) of CIPs may not be behaviourally appealing to the actual users, as their own belief based forecasts. In essence, the CIPs based on scientific forecast systems and local forecasts based on shared beliefs have their strengths and weaknesses. If the strengths of both can be integrated by carefully studying them, a more effective system CIPs could be developed. Therefore, it is necessary to integrate formal and local forecast systems in ways that complement each other, so that better decision outcomes are achieved.

FARMERS' BELIEFS AND PERCEPTIONS OF CLIMATIC VARIABILITY AND CHANGE: IMPLICATIONS ON ADAPTATION DECISIONS

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ABSTRACT

Recent studies have shown that farmers' adaptive responses are shaped by their perceptions about variability and change in local climatic parameters. There is substantial evidence to suggest that farmers' perceptions on local climate are based on shared beliefs transmitted through local knowledge systems. This study examines the shared beliefs and perceptions held by village tank farmers in dry zone, Sri Lanka.

Study was guided by a conceptual framework that connects farmers' beliefs with dual type of rainfall expectations identified as normal rainfall expectations (NREs) and seasonal rainfall expectations (SREs). NREs are farmers' beliefs about local climatic variability which are updated seasonally to derive SREs with the aid of local climatic indicators, another set of beliefs. The study was carried out in nine villages under three cascade systems in Anuradhapura district. Primary data was gathered through conducting a household survey and focus group discussions. Descriptive statistical methods and qualitative tools were used to analyse the data. These NREs were elicited by analysing farmers' monthly rainfall expectations.

Results of the study outline the NREs of farmers based on their monthly expectations about rainfall amount, number of rainy days and level of rainfall fluctuation. Focus group discussions helped to identify farmers' beliefs that underline NREs. Farmers have beliefs about seasonal as well as intra-seasonal variability of rainfall. Beliefs about seasonality are founded on two farmer-defined seasons, Maha and Yala. Intra-seasonal variability of local rainfall is captured by beliefs about a sequence of rainfall events connected to temporal milestones. Beliefs about seasonal and intra-seasonal variability constitute a local model of rainfall variability that provides a template for updating with local climatic indicators. Results also describe the nature of local climatic indicators reported in discussions with farmers.

INTRODUCTION

Farmers in village tank systems in the dry zone of Sri Lanka depend on local rainfall for their livelihood. In the dry zone, conditions of water stress usually prevail throughout the year except for relatively short rainy period (Alles, 1971; Tennakoon, 1986; Panabokke and Punyawardena, 2010). Distribution of rainfall in many localities shows high annual variation, resulting in significant fluctuations (Yoshino eta/., 1983; Yoshino and Suppiah, 1983). Fluctuation of rainfall sometimes leads to extreme events giving rise to widespread livelihood damages. Consequently, village tank farmers carry out their livelihood activities under persistent risk of rainfall fluctuations.

Village tanks, a type of community owned rainwater-harvesting facilities; enhance their efforts to a certain extent by helping to store the surplus from the short rainy season to be used in the lengthy dry spell that follows. They collect and store water from direct rainfall and runoff flow of local precipitation. It has been estimated that over 18,000 village tanks are scattered in the dry zone areas of the country (Ratnatunge, 1979;Somasiri, 1980). In addition to village tanks, agro-wells-a recent innovation-enable a section of farmers to tap the groundwater storage based on shallow regolith aquifers confined to limited areas in the local landscape (Panabokke and Perera, 2005; Panabokke, 2007).

Despite the support from these facilities, basic conditions of rainfall risk faced by farmers remain unchanged.Village tanks as well asagro-wellsare dependent on local rainfall and an adverse fluctuation in rainfall, even in a single year, can lead to conditions that could affect the livelihood security of farmers in detrimental manner. Unforeseen effects of global climate change have the potential to complicate the situation further. Recent studies have indicated a significant decline in mean annual rainfall in many areas of the dry zone over the past 140 years (Costa, 2008; Eriyagama t al., 2010). 1t has been projected that this decline may lead to increase in irrigation water requirement in paddy by 13-23% by 2050. Several dry zone districts including Anuradhapura,which has the highest area under village tanks. were identified as vulnerability hotspots by a recent study conducted by the International Water Management Institute (IWMI) (Eriyagama et al., 2010). In addition, studies suggest that intensity and frequency of extreme climate events have increased during the recent period (Eriyagama et al., 2010; Imbulana et al., 2006; Ratnayake and Herath, 2005). Overall evidence on climate change indicates that village tank farmers are likely to face more severe conditions ofwaterstress in the future.

Adaptation and farmers' beliefs

Adaptation has been the key strategy that helped farmers all over the world to face the climatic uncertainty and village tank farmers are not an exception to this. Adaptation is a continuous process of adjustment that helps to moderate, cope with or take advantage of the impacts of climatic variability and change (IPCC, 2001, 2007). Adaptation decisions are essentially risky choices that can give rise to diverse outcomes subject to variable events of climate (rainfall). Achieving the desired outcomes of adaptation depends on making adjustments to match with climate events to come. When making adaptation decisions, farmers have to make expectations about rainfall that ultimately determines the final outcomes of their choices. Therefore, farmers' rainfall (climate) expectations play a major role in their decisions on adaptation (Hansen et al., 2004; Marxeta, 2007; Weber, 1997).

There is significant evidence that indicates farmers' rainfall expectations are influenced by 'shared beliefs' about local rainfall (Roncoli et al., 2002; Orlove et al., 2007; Slegers, 2008). Farmers appear to place their trust upon locally shared beliefs formed over long-term collective memory as a guide for making rainfall expectations. Usually, such beliefs encompass a familiarity with local weather patterns and set of local signs that provide clues about oncoming climate (rainfall) events (Orlove et al., 2007; Slegers, 2008). Those signs appear in local environment and can be called as local climate indicators. Farmers get access to shared beliefs through a social process of knowledge transmission (Orlove et al., 2007, Roncoli et al., 2002).

There is evidence to suggest that such beliefs on local climate exist among village tankfarmers also (Punyawardena, 2009, Tennakoon, 1986). An unmistakable evidence for such beliefs is local agricultural calendar based on two farmer-defined seasons known as Maha and Yala. Punyawardena (2009) observed that certain local beliefs correspond closely with the general pattern of 'climatic year' in dry zone indicated by systematic analysis of weather data. Tennakoon (1986) provided an account on certain local beliefs held by village tank farmers on the conditions of droughts and dry spells. Tennakoon (1986) further documented local indicators used by farmers to predict a 'drought in offing'.lmportantclues about the existence of shared beliefs in village tank systems are provided also by collective decisions on practices such as 'bethma' (Aheeyar, 2001; Panabokke et al., 2002; de Jong, 1989). Such community-based adaptation practices would not have been possible unless facilitated by shared beliefs to form common expectations about rainfall.

The objective of this study was to examine village tank farmers' beliefs on local rainfall to understand how they influence farmers' adaptation decisions. It was guided by a conceptual framework that connects farmers' beliefs to local rainfall expectations. Empirical findings of the study were based on primary data collected in several village tank sites in Anuradhapura district.

Conceptual framework

The study was guided by the conceptual framework presented in this section. This framework presents a conceptual model on farmers' rainfall expectations. According to this model farmers' decisions on adaptation are based on dual types of rainfall expectations that can be identified as:

- Normal rainfall expectations (NREs) and
- Seasonal rainfall expectations (SREs)

Normal rainfall expectations (NREs)

Normal rainfall expectations (NREs) refer to farmers' shared beliefs about local rainfall distribution, a local model of rainfall variability. NREs capture continuous variability of rainfall in an annual cycle consisted of farmer defined seasons and intra-seasonal variability within them. It provides a standard rule regarding a 'normal' rainfall year thereby serving as a template for making expectations on rainfall at a given period of time of the year. It also offers a reference for detecting and observing changes from the normal pattern. A simplified representation of the farmers' model is given in Table 1, which is characterized by joint expectations about amount (magnitude) and fluctuations (variability) of rainfall. It does not cover intra seasonal variability. Seasonal rainfall expectations (SREs) Farmers have to form seasonal rainfall expectations (SREa) in every season for makingtheir adaptation decisions and they use NREs as a template to derive SREs. SREs are conditional expectations based on the prior beliefs (NREs). Farmers update NREs with the aid of local climate indicators. Local climate indicators are signs of rainfall observed in the local environment by farmers. Unlike NRE, which are shared beliefs, SREs are individual expectations. Fig.1 provides a schematic representation of this process.

This conceptual framework on belief-based rainfall expectations has important implications towards understanding farmers' decisions on adaptation responses. Adaptation refers to adjustments in behavior offarmers in response to changes in conditions resulting from actual or expected variability or change in climate in order to cope with harmful impacts or to take advantage of opportunities (I PCC, 2007).

According to that two fundamental conditions that motivate farmers to take adaptive actions are recognition of: (a) changes in conditions and. (b) likelihood of impacts (harmful impacts or opportunities) associated with those changes. Farmers use either NREs or SREs when making choices among alternative adjustments depending on the nature of adaptation choices involved (Fig.I).

NREs provide the benchmark against which the changes in conditions have to be recognized. NREs as a reference can accommodate a range of short-term fluctuations by updating with local indicators to be captured through seasonal rainfall expectations (SREs). Therefore, short-run adaptation decisions of farmers are motivated by changes indicated for NREs by local indicators. NREs being a part of farmers' long-held beliefs can be considered as relatively stable over short to medium-term. In the long run, circumstances that lead to modification of beliefs (NRE) could arise. Global climate change represents such a circumstance. Climate change is usually defined as the long-term shifts in the mean state and variability of climatic parameters (Smit et al., 2000). Since NREs can be considered as a psychological (subjective) parallel to the objective phenomenon of mean state and variability of rainfall, they have a major role to play in farmers' detection and perception of global climate change.

Table 1. A template of NREs

		Rainfall amount					
		Season 1			Season 2		
		Low	Medium	High	Low	Medium	High
Rainfall variability	Low						
	Medium						
	High						

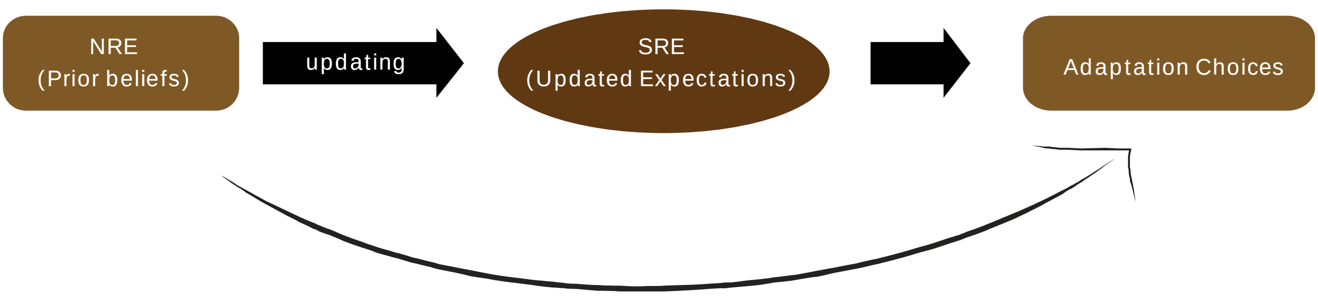

Fig. 1. Schematic representation of updating of rainfall expectations

METHODOLOGY

Study-site and data sources

The study was carried out in nine tank villages belonged to three cascades systems in Anuradhapura district, namely: Mahakanumulla, Tirappane and Periyakulama cascades. The list of selected tanks in three cascades is given in the Table 2.

Major sources of primary data a household survey in selected villages and three focus group discussions (FGD) conducted with farmers from each cascade. Household survey was conducted using a sample of 181 farm households. It was carried out using a structured interview schedule and heads of households were interviewed at their premises. In the survey. particular attention was directed to elicit farmers' NREs by asking farmers' expectations regarding following three parameters.

- *Amount of rainfall:* Farmers'expectations about rainfall amount for each calendar month of the year were elicited using a scale ofl-5 on increasing order of rainfall

- *Number of rainy days per month:* Farmers' expectations on number of rainy days per each month

Expected level of fluctuation

Farmers' chose whether expected fluctuation of rainfall for a given month was high or low.

FGD is a participatory method of data collection. Three focus group discussions (FGDs) were conducted with the participation of farmer groups of the size of 10-12 using a semi-structured focus guide. Discussion groups were:

Table 2. List of primary data gathering sites (villages)

Cascade system	Village tanks
Tirappane	-Tirappane tank -Meegassegama tank -Bulankulama/ Wendarankulama tanks
Mahakanumulla	-Mahakanumulla tank -Walagambahuwa tank -Paindikulama tank
Periyakulama	-Perlyakulama tank -Mawathawewa tank -Padiketuwewa tank

selected to represent different levels of experience/ knowledge ranging from younger generation farmers with few years of experience to mature age farmers with several years of experience. In the discussions, following aspects relating to farmers'adaptation decisionswere discussed.

- Local beliefs about rainfall variability
- Local climate indicatorsand farmers' use of them
- Farmers' past experience on adaptation Farmers' perceptions of long-term changes in rainfall

Data analysis

Two major types of descriptive analytical tools were used to analyse the household data from the survey, namely; (a) estimation of descriptive statistics and, (b) cross tabulation. Selected variables of cross-sectional data set was analysed by estimation of key statistics depending on the nature of variables as follows. Key variables covered in the survey were number of rainy days, expected amount of rainfall by month (scale of 1- s) and level of rainfall fluctuation cross tabulations were used to summarize data.

Information collected in FGDs was qualitative in nature. Examples are locally shared beliefs on rainfall and local climate indicators. They required lengthy discussions for exploring and collective brainstorming. Therefore, qualitative methods of analysis were used to analyze the data from FGDs. This has mainly been achieved through organization of information into tables and matrices.

RESULTS AND DISCUSSION

Profile of sample households

The sample of 181 included 86.7% male respondents and 13.3% female respondents. Average family size of the sample was 3.9. Age of the respondents varied in the range of 22-72 years with the average of 50 years. Age composition of the respondents included households headed by young respondents (< 35 years), households headed by middle-aged respondents (36-55 years) and households with elderly heads (> 55 years). The sample had 14%, 53% and 33% households under young, middle age and elderly categories respectively. A majority (76.2%) was educated beyond the primary education level and 53% had finished formal education after G.C.E (Ordinary Level) examination. One fourth of the sample had completed secondary education up to G.C.E

(Ordinary Level) examination. One fourth of the sample had completed secondary education up to G.C.E (Advanced Level) examination. Two respondents (1.2%) had tertiary level qualifications. Literacy rate of the sample was 100% given that all respondents had formal education up to a certain level.

A majority of respondents (77.9%) were full time farmers. The rest (22.1%) were engaged in some other occupation while also involving in farming on part-time basis. Farming experience of respondents varied in the range of 1-55 years.

Normal rain fall expectations (NREs)

Table 3 presents farmers' normal expectations on monthly rainfall amounts, average number of rainy days per month and level of rainfall fluctuation in each month. Nine respondents failed to offer satisfactory responses and percentages given in the table refers to total number of valid responses (172). Over 95% respondents ranked their rainfall expectations for November and December at the level 4 or above. This is followed by january and April at which over 77% farmers ranked their expectations at the level 3 or above. The lowest rainfall expectations were reported for june, July and August, which have been ranked at leveil by around 95% respondents. A majority of farmers expected February (75%) and May (72%) rainfall at the level 1. More scattered responses have been reported for months of March, September and October October having roughly equal number of respondents at the levels of 2, 3 and 4 (altogether 81.4%) with a significant number (16.3%) at the levels as well.

Table 3 also presents average number of rainy days farmers expected in respective months. Their expectations about number of rainy days seem to be corresponding with expectations about rainfall amountforeach month. Accordingly, months with low expected rainfall amount, namely, June, July, August, and March were expected to have low number of rainy days (0-5) by over 90% of respondents. On the other hand, November and December months with high expectations about rainfall amount were expected to have high number of rainy days (>20) by over 75% respondents. For January, April and October months with middle level expectations about rainfall expected number of rainy days varied in the range if 7-10 days.

As far as farmers' perceptions about rainfall fluctuation in respective months are concerned, over 90% assessed that level of fluctuation of rainfall in February, May. June, July and August as 'low rainfall months' in terms of expected rainfall amount and number of rainy days is generally low. Similarly, over 85% assessed fluctuation in November and December 'high rainfall months' also as low. This implies high confidence on farmers' assessment for months with the lowest and highest expectations of rainfall. Number of respondents that expected high level of fluctuation increased progressively for September (21.1%), October (29.6%), March (31.7%), April (34.5%) and January (83.1%). Overall, a majority of farmers expected that fluctuation of rainfall to be low in general exceptfor January.

NREs and farmers' beliefs

Numbers given in the Table 3 provided a numerical outline about farmers' NREs. However, interactions with in FGDs suggested that farmers usually hold their beliefs in vivid mental images of events connected to various temporal milestones. Discussions suggest that farmers have beliefs covering seasonal as well as intra-seasonal variability of rainfall. Farmers' beliefs about seasonality of rainfall are encoded in the local agricultural calendar with two farmer-defined cultivation seasons, Maha and Yala. Maha is a period of high rainfall expectations extended from mid-September to mid-March. Yala season is relatively a dry period with a short rainy period in March-April. Belief on two seasons helps farmers to organize their activities with rainfall expectationson a seasonal basis.

Table 3. Famers' normal rainfall expectations about amount of rainfall by month

Month	Amount of rainfall: 1-5 scale (% farmers)					Average no. rainy days	Level of fluctuations (% farmers)	
	1	2	3	4	5		Low	High
January	0.6	22.1	69.2	7.6	0.6	10.13	16.9	83.1
February	75.0	20.9	2.9	1.2	-	1.05	90.1	9.9
March	36.0	41.9	9.3	9.9	2.9	2.49	68.3	31.7
April	1.7	20.9	50.0	20.3	7.0	7.48	65.5	34.5
May	72.7	23.8	3.5	-	-	1.18	93.7	6.3
June	94.8	5.2	-	-	-	0.18	94.4	5.6
July	98.8	0.6	0.6	-	-	0.09	99.3	0.7
August	97.7	1.7	0.6	-	-	0.13	95.8	4.2
September	56.4	27.9	8.7	4.7	2.3	2.06	78.9	21.1
October	2.3	23.8	29.1	28.5	16.3	7.91	70.4	29.6
November	-	0.6	2.9	10.5	86.0	24.27	85.2	14.8
December	-	0.6	1.7	13.4	84.3	25.32	85.2	14.8

FGDs also helped to identify farmers' beliefs on rainfall events that constitute intra-seasonal distribution of rainfall. They are summarized in theTable 4.

These beliefs carry information on two major dimensions of events-usual time and intensity/nature of events that help to form expectations about intra-seasonal variability of rainfall.

Farmers' beliefs on cultivation seasons and intra seasonal events described here can be considered as a local modelof rainfall variability. Through this model farmers attempt to capture the complex pattern of local rainfallvariability and form rainfall expectations.

Farmers' belief-based model on seasonal and intra-seasonal variability basically represents normal

Table 4. Beliefs associated with intra-seasonal distribution of rainfall

Month	Local Name for Rainfall Event	Time of Rainfall Event	Nature of Rainfall Event
January (Duruthu)	Duruthu wehihella (werahella)	Throughout the month	Low intense continuous rains
February (Navam)		Early period of month	Scarce occasional rains
March (Medin)	El eta pelawena wehi, Tala wehi	Late period of month	Evening rains with thunder and lightening
April (Bak)	Bak maha wehi, Tala wehi,	Rainy period can shift (early, mid or late)	Evening rains with thunder and lightening
May (Wesak)	Meemal mandarama, Wel mal mandarama		Dark cloudy sky
June (Poson)	Maluwa hedena wehi	After full moon	Scarce occasional rains
July (Esala)			Scarce occasional rains
August (Nikini)	Nikini palu wehi	After full moon	Scarce occasional rains
September (Binara)	Binara kaluwa Nikini palu wehi, Wehituna	A pre-rain period Rains after 20 September or early October or after full moon	A few intensive rains
October (Wap)	Wop idella Akwessa (Mul wehi)	Dry spell in the early month Rains around or after 15 October	Scattered, intensive rains
November (Il)	Il maha wehi,	Rains throughout the month	Continuous, intensive rains
December (Unvuwap)	Unduraluwa Nattal kunatu	Rains throughout the month. Rains during the early to mid-period (around 15 days) Stormy rains in the late month (around 20-30 December)	Continuous, intensive rains

Time of events

Events were connected to months in local lunar calendar (e.g. Duruthu wehihella, Bak maha wehi, Il maha wehi, Nikini palu wehi, Undu raluwa) or specific religious/social events in the area (e.g.Maluwa hedena wehi, Nattal kunatu).

Intensity/nature of events

Farmers also have a local terminology to describe the nature/intensity of rainfall events (e.g. wehihella, Mandarama, Kaluwa, Idella).

rainfall expectations (NREs) that dealwith deterministic component of rainfall variability. Even the subtle aspects covered by farmers' model cannot take stochastic fluctuations of rainfall into account in adequate manner. In this connection, farmers are assisted by another set of beliefs local climate indicators. They help farmers to update NREs so that to derive SREs. Tables provides a summary of information gathered on local climatic indicators in FGDs.

Predictions based on local indicators have different time lags that may extend from fewhours to few months. Discussions revealed that indicators based on wind/sky/clouds, local hydrological phenomena and thermal changes in the environment are still widely used by farmers to update their rainfall expectations. Comparatively, cosmological phenomena, indicator species and observations on animal/plant behaviour are less frequently observed by farmers now. Less knowledge about and changed attitudes of younger generation farmers is one reason for decline of the usage of certain signs/indicators. Moreover, changes taken place in local environment has made it difficult to observe certain phenomena. For instance, certain observations on animal/plant behaviour have become rare due to clearance of local forest patches. Therefore, such phenomena can no longer be relied upon to make regular decisions.

Discussions highlighted few important points about local indicators. Firstly. signs/indicators are closely connected to beliefs on rainfall events (given in Table 4). Accordingly. early. usual or delayed occurrence (or non-occurrence) of events with respect to expected milestones provides a basic rule forfarmers to update their expectations. Secondly, when several indicators support farmers' expectations, they gain more confidence on the likelihood of an event. On the other hand, discussions highlighted

Table 5. Summary of the local climate indicators

Signs, indicators & predictors	Nature of observations	Time lag of forecast	Remarks
Beliefs about rainfall events connected to milestones	Occurrence of expected events in relation to milestones (early, usual, late or non-occurrence)	Serve as predictors of immediate events as well as general projections about season to come	Appears to be the most important indicators for the seasonal updating of rainfall.
Observations on wind,sky and clouds	Direction,speed and nature of wind movement Specific cloud formations, cloudiness and colour of the sky Occurrence of fog, mirage etc.	Serve as short-term predictors of rainfall events to come. Time lag may be around 1-10 days	Commonly observed indicators along with the predictions based on events connected to milestones.
Local hydrological phenomena	Water level,spread area and spilling of tanks Water level of wells	General indicators of rainfall potential of the unfolding season	Essential observations taken into consideration when decisions on joint adaptation are taken. Farmers have identified 'indicator' tanks and wells.
Thermal changes in the environment	Sudden changes in temperature in notable manner (warm or cold) especially in morning and night times	Short-term predictors of weather events with a few days' time lag	There is a natural tendency among farmers to take such changes as signs of forthcoming weather events.
Cosmological phenomena	Visibility and brightness of stars Width and intensity of aura of moon	Short-term predictors of weather events with a few days' time lag	Generally held beliefs that can strengthen the confidence on other predictors when they coincide with them.
Resurgence of indicator species	Sudden rise in insect populations (mosquitoes,fire flies) Appearance of certain species of animals (e.g. birds)	Short-term predictors of rainfall events with a few days' time lag	Generally held beliefs that can strengthen the confidence on other predictors when they coincide with them.
Specific observations on animal behaviour and local fauna	Nesting behaviour of certain bird species Relative abundance of flowering and fruiting of local tree species	Predictors with relatively longer time lags that may vary from few weeks to few months ; usually of rainfall conditions of forthcoming season	Respected as local wisdom yet with limited current use. Limited experience and knowledge in young farmers. Changes in the local environment (e.g. clearing of forests) have made them obscure.

few important points about local indicators. Firstly. signs/indicators are closely connected to beliefs on rainfall events (given in Table 4). Accordingly. early. usual or delayed occurrence (or non-occurrence) of events with respect to expected milestones provides a when indicators contradict, farmers would be more cautious in their decisions.

CONCLUSIONS AND POLICY IMPLICATIONS

The results of this study support the conclusion that farmers' shared beliefs on local rainfall guide their adaptation decisions. Results also suggest that farmers' beliefs provide a basis for making rainfall expectations about seasonal and intraseasonal events of rainfall thereby enabling to make risky choices of adaptation. Farmers have to update normal expectations to cope with fluctuations and observations on local climate indicators help to update rainfall expectations accordingly. In every season, farmers adjust operational arrangements of activitiesto a certain extent in response to stochastic fluctuations of rainfall. They can be considered as fine-tuning adjustments.

The foremost policy implication of the study is highlighting the importance of farmers' beliefs on their adaptation choices. Findings are directly relevant in the case of ongoing debate over the usefulness of climate information products such as long-term climate projections, seasonal precipitation forecasts (SPF) and short-term weather forecasts (Gadgil et al., 2002; Gine et al., 2009; Hansen et al., 2011; Ingram et al., 2002; Luseno et al., 2003; Meza et al., 2008; Roncoli, 2006; Stone and Meinke, 2006; Ziervogel, 2004). According to some scholars climate information products can be competing with farmers' beliefs (Lybbert et al., 2007). Findings of this study support this idea. For instance, NREs can compete with SPF and local climate indicators can substitute short-term weather forecasts at least partially. This implies that current information products are knowingly or unknowingly aimed at substituting farmers' beliefs. Given the strong connection of farmers' beliefs to their adaptation decisions, it is logical to expect that assessing the influence of beliefs would help to improve the effectiveness of such interventions. The findings of the study strongly emphasize the importance of taking farmers' beliefs into consideration in designing, producing and communicating climate information products and interventions based on them.

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Sri Lankan Farmers' Traditional Knowledge and Climate Change Predictions

Dilani Hirimuthugodage

"If eagles and grey hornbills are flying above their normal height in the sky, it signals that rain is expected soon; if seagulls are flying close to the ground, it suggests that there will be heavy rainfall. However, these patterns have now changed because of the development activities in the Lunugamwehera Tank, Bundala Salt Corporation, etc." said Mr. Bandara, a 60 year old paddy farmer from Bundala, in the Hambantota District. He attended the Participatory Rural Appraisal (PRA) programme of a research study conducted by the Institute of Policy Studies of Sri Lanka (IPS), and other partner institutes.

Mr. Bandara possesses what is known as traditional or indigenous knowledge. Traditional knowledge is awareness among lay people and their understanding of the structure or the system, which is generally passed on from one generation to the other, usually by word of mouth, observations, and practices. This knowledge is specific to countries, areas, or communities, due to varying environmental and social conditions.

Like Mr. Bandara, most farmers in Sri Lanka use techniques inherited from their ancestors to identify seasonal variations and predict weather patterns. Yala (May-August) and Maha (September-March) seasons were established based on such knowledge and observations. They used to start their cultivation based on these recognized local patterns and predictions which have usually been accurate.

Farmers' Use of Traditional Knowledge on Climate

A survey carried out by the IPS in six districts in Sri Lanka (Anuradhapura, Batticaloa, Hambanthota, Kurunegala, Badulla and Rathnapura), interviewed nine hundred farmers, using a semi-structured questionnaire. Nearly 57% of the farmers said they use traditional weather forecasting methods or their traditional knowledge in making crop cultivation decisions, while 43% of them stated that they do not use traditional methods (Figure 1). Furthermore, 60% of the farmers who are using traditional methods claimed that their predictions are consistent with the formal weather report predictions (Figure 1).

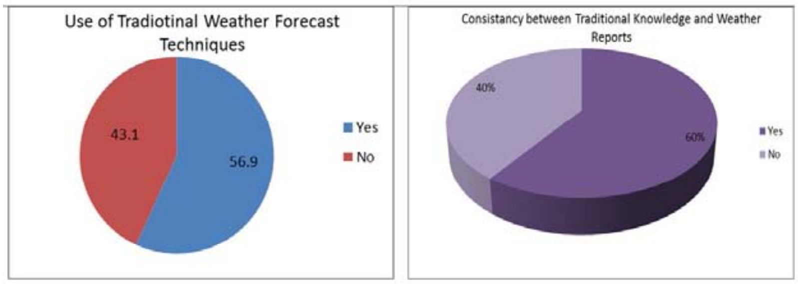
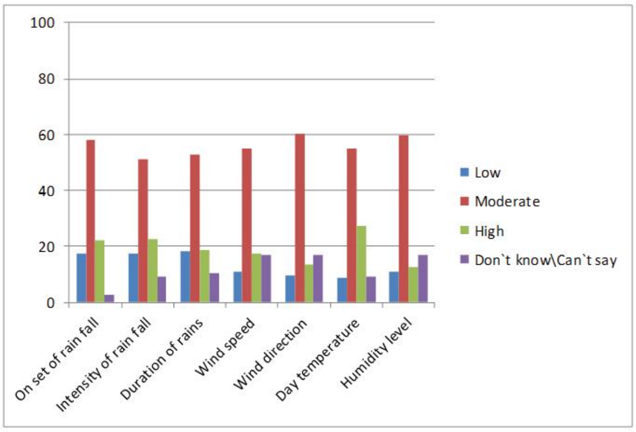


Figure 1 : Usage of Traditional Weather Forecasting

Source: Calculations based on survey data

Around 60% of farmers perceived that traditional weather forecasts are moderately consistent with formal weather predictions relating to parameters concerning the onset of rain fall, intensity of rain fall, duration of rains, wind speed, wind direction, day temperature, humidity level, etc. (Figure 2).

Figure 2: Farmers' Perceptions about Level of Consistency between Traditional and Formal Weather Predictions



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Traditional Knowledge and Weather Predictions: Some Observations

Participatory Rural Appraisal (PRA) sessions were conducted with farmers in six districts to explore the nature and use of traditional climate knowledge. Farmers who participated in PRA programmes informed that they use observations on the changes in local environment such as animal behaviour, blossoming of certain trees (mostly indigenous trees), appearance of various insects, and changes in cloud patterns and wind, etc. to take decisions regarding agricultural practices. Sometimes these practices vary from place to place within Sri Lanka. Box 1 highlights some of the local observations that constitute traditional climate knowledge as reported by farmers in PRA sessions.

Box 1: Local Observations Used for Prediction of Weather

Animal behaviour

Predictions are mainly based on the behaviour of birds. “If eagles fly high in the sky, if there are more than two young crows in a nest, if owls make noise at night, and if weavers build nests in neem trees, rain will fall very soon” claimed farmers from Kurunegala. Farmers in Ratnapura and Anuradhapura districts also mentioned the same behavioural pattern of birds when predicting rainfall. Meanwhile, Batticaloa district farmers forecast environmental changes if birds fly in the same direction in groups.

Blossoming of trees

Farmers in all six districts use observations on budding and flowering of trees, especially in indigenous trees such as Mora, Palu and Wood Apple for local weather predictions. “Palu trees covered with fruit indicate heavy rain fall. Normally, blossoming of Palu will happen in May. However, in 2017 there were ripe Palu even in December,” observed Hambantota district farmers. “If there are more than an average number of fruits in mango trees, it indicates that there will be good rainfall for agriculture and we can harvest in both Yala and Maha seasons” Kurunegala District farmers reported.

Cloud colour and cloud cover

Farmers in Sri Lanka also make climate predictions by observing patterns and colours of clouds. “Dark, clustered clouds in August indicate that heavy rainfalls will occur shortly” stated Kurunegala district farmers. “Dark clouds around the moon foresee raining and also appearance of a rainbow is an indicator of future rain” said Batticaloa district farmers. “Dark cloud cover in the months of July and August in the eastern side of sky predicts heavy rain in future. “When the east sky is dominated by red colour, it predicts heavy rains and it is a good start for a Maha season” mentioned the Anuradhapura district farmers.

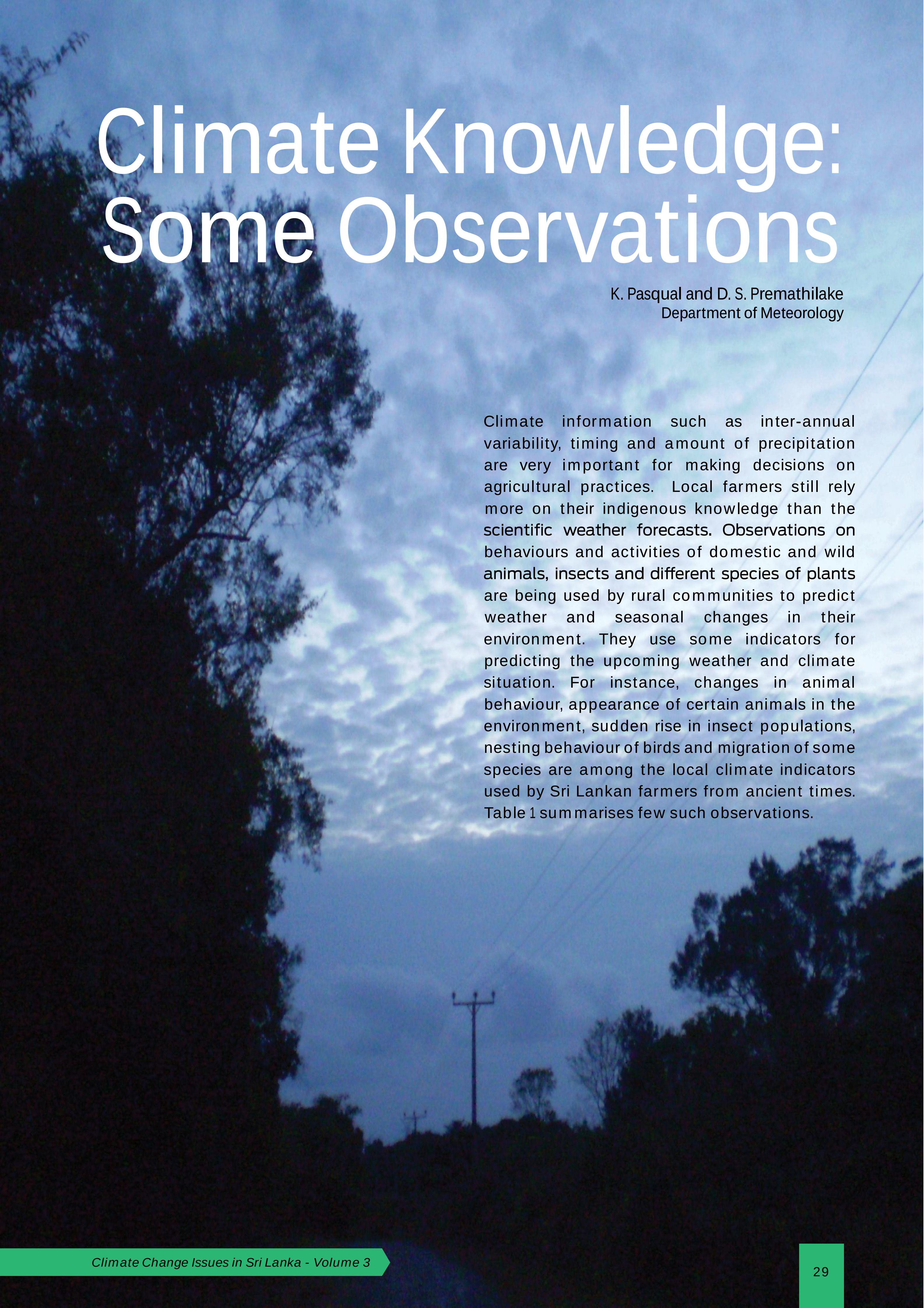
Appearance of insects

Appearance of certain insects helps farmers predict weather changes. “Meru flies appearing in November predicts the start of the rains for Maha season. If termites appear in rubber trees, it foretells rains” informed Ratnapura district farmers. There are some specific observations to identify seasonal variations. In the Kurunegala district, farmers believe that if rain comes between October 10th-15th (called Akk Wessa), they could cultivate both Yala and Maha seasons successfully. The Ratnapura district farmers too are concerned about wind speed and wind direction when predicting rainy seasons.

Declining Reliability of Traditional Climate Knowledge and the Role of Scientific Weather Forecasts

Farmers also observed that with the recent changes in global climate and local environments, their local predictions have become less reliable. They reported that, in the past, their predictions based on traditional knowledge have been accurate to a great extent. However, the situation has changed recently. Farmers in all districts complained that familiar patterns of local climate have changed significantly. Some farmers directly linked it to 'global climate change' of which they became aware from various sources such as the media. Their accounts confirm that climate change is already taking place in local areas. Moreover, it is evident that with the process of development, several environmental changes have also occurred. Infrastructural projects and construction of physical structures which are designed to make human life easier have changed the natural environment in local areas. Farmers explained that in some areas, traditional signs and indicator species of plants and animals that used to predict changes in climate are not easily visible due to local environmental changes. As a result, present day farmers find it difficult to predict climatic events using their traditional knowledge. In spite of this situation, a significant number of farmers still continue to use local knowledge to a certain extent even though they find it increasingly less reliable.

Therefore, it is evident that farmers may not be able to rely only on their traditional knowledge as local climate patterns and environmental conditions have changed, and some of the traditional indicators that they used in the past are not available at present. The best solution to overcome this challenge would be strengthening farmers' decision making capacity by providing them with science–based climatic weather forecasts to complement their traditional knowledge in predicting climate changes. This will help to produce reliable results by harmonizing farmers' local climate and environmental observations with scientific climatic predictions. Presently, the Department of Meteorology is providing science based weather forecasts to selected farmer groups in six selected districts as a pilot study. The research emphasizes the importance of providing weather forecasts focused at local levels rather than at district levels for higher accuracy, and also the importance of optimizing the use of farmer's traditional knowledge.



Climate Knowledge: Some Observations

K. Pasqual and D. S. Premathilake
Department of Meteorology

Climate information such as inter-annual variability, timing and amount of precipitation are very important for making decisions on agricultural practices. Local farmers still rely more on their indigenous knowledge than the scientific weather forecasts. Observations on behaviours and activities of domestic and wild animals, insects and different species of plants are being used by rural communities to predict weather and seasonal changes in their environment. They use some indicators for predicting the upcoming weather and climate situation. For instance, changes in animal behaviour, appearance of certain animals in the environment, sudden rise in insect populations, nesting behaviour of birds and migration of some species are among the local climate indicators used by Sri Lankan farmers from ancient times. Table 1 summarises few such observations.

Table 1: Some indigenous indicators used by Sri Lankan farmers

Observation	Indicator	Weather forecast interpretation
Weaver bird's nest	Nest height from the ground	If the height is higher it indicates good rainy season and vice versa
Birds	Birds seeking shelter during the day	Cloudy and humid conditions
"Meru" (winged Ants)	Sudden rise of "Meru"	Rains to come very soon
Frogs	Produce sounds	Rains are about to start
Swallow	Swallows flying at low altitude	Rains to come very soon
Ants	Ants sealing off holes into ant mound	Rains to come very soon
Elephant	Moving to another area	Upcoming thundershowers
Wind direction	Change in normal wind direction	Less rainfall
Colour of sky	Red	Showers to come very soon

Such practices are not limited to Sri Lanka. For instance, in Tanzania, the occurrence of large flocks of swallows and swans, roaming from the South to the North during the months of September to November, is an indication of onset of rains in short. Researchers have tried to identify scientific reasons that can explain indigenous climate indicators. Orlove et al. (2002) explained that there is a strong scientific basis in Andean potato farmers' predictions regarding forthcoming weather in connection to the observations on certain stars in the sky. Similarly, we can recognise some scientific common sense behind indigenous climate indicators used by Sri Lankan farmers as well.

Flying behaviour of birds: Birds fly high up in the sky when the sky is clear and it usually means that the weather will be dry. Stormy weather can be expected, if they fly at lower levels. Drop in pressure in the atmosphere due to upcoming storm makes the birds uncomfortable when flying high up in the sky.

Colour of sky: Farmers believe that when the sky colour is red in the late evening or night, it will rain sometimes later in the night (particularly during the inter-monsoon season in Sri Lanka). The red skies appear based on the reflection of light and how it bounces around in the atmosphere. Blue and indigo components of light are minimised during the reflection by water vapor and also its passage through the atmosphere. It is a sign of high humidity and it could lead showers to fall very soon.

Nesting behaviour of birds: Generally, weaver bird often build its nest closer to water bodies, mostly on tree branches that hangs over the edges of a river aiming to cool the inside of the nest to protect from the intense heat of the day and sometimes abrupt night-time temperatures. Farmers believe that, if upcoming rainy season is favourable they build their nests at a higher place from the ground and if the rainy season is unfavourable at a place close to the ground. This may be related to the atmospheric moisture content. If the rainy season will be good, the moisture level in higher atmosphere is also high and vice versa.

Migration of animals: Elephants are migratory animals and they move in herds, searching for food and water. Elephants have some strange migration patterns during the rainy season. Farmers observe sudden changes in direction of migration according to the direction of the rainfall. It is said that elephants are able to move towards storms that are still very far away.

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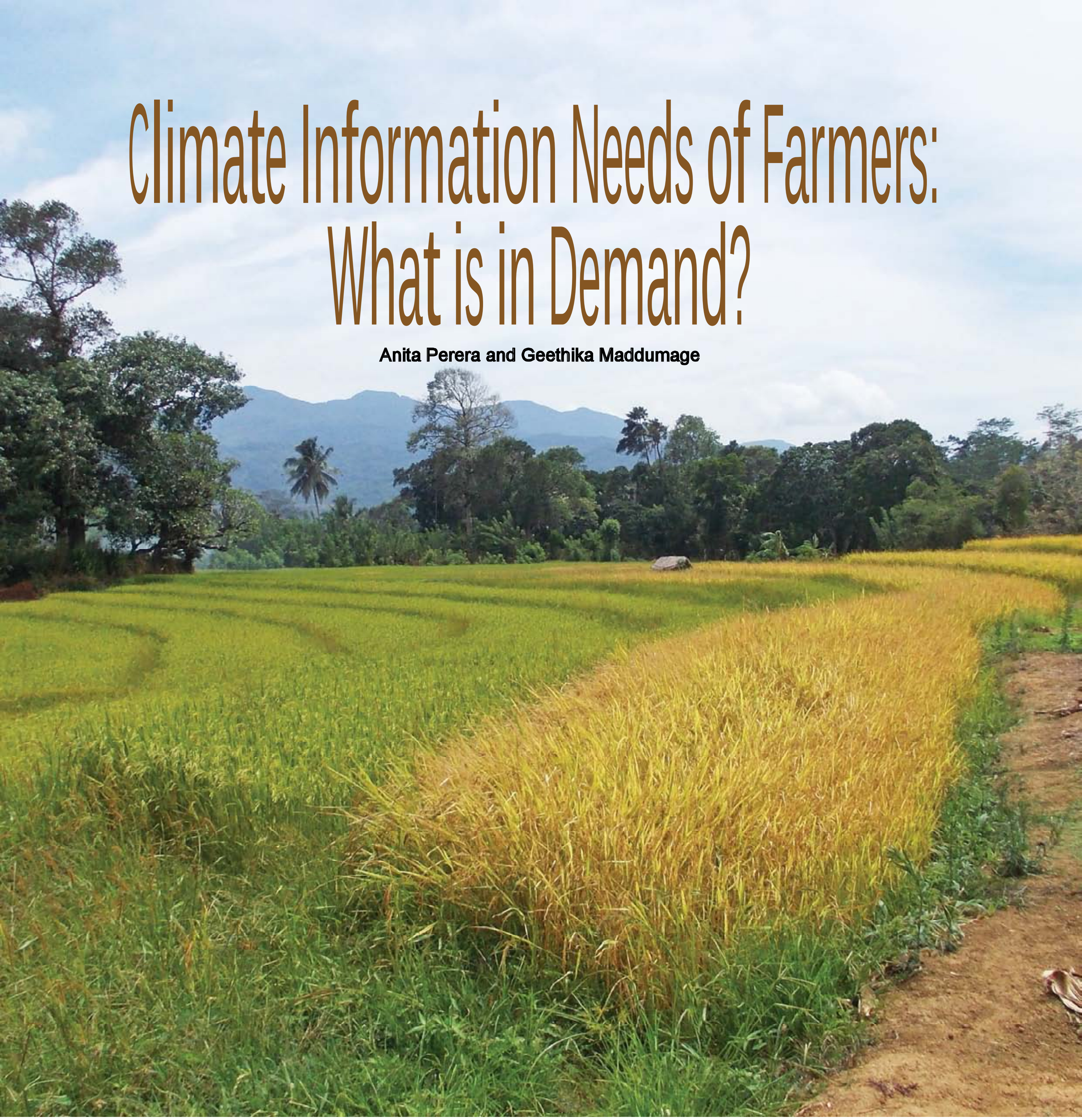
Climate Information Needs of Farmers: What is in Demand?

Anita Perera and Geethika Maddumage



As a developing country that still depends heavily on agriculture for rural livelihoods, Sri Lanka faces many challenges due to climatic changes. Without reliable climate-related information, farmers are unable to make accurate farming decisions. In the past, farmers were able to rely on their traditional knowledge to make precise weather predictions. They were well-versed on local weather patterns and the specific climatic requirements for crops, thanks to long-term experience and knowledge passed through generations.

A farmer from Kotawehera, Kurunegala district explains,

"we used to start cultivating after observing signs in the local environment and using them to predict the weather. We did not listen to weather forecasts on the radio or TV; most of the time it is not as trustworthy as our traditional weather forecasting."

However, with drastic changes in global climate patterns and local environments, familiar signs that provided clues about weather changes have become less reliable. Therefore, farmers find it difficult to adjust to agronomic practices, according to the rapidly changing climatic patterns.

"In the past, we could identify and predict weather changes in advance by observing animal behaviour and changes in our local environment, but now, some animals are hardly seen, and climate has become unpredictable," complains a farmer from Anda Ulpotha, Badulla district.

As such, farmers are gradually losing trust in their traditional climatic knowledge. Thus, it is important to identify farmers' climatic information needs correctly and fill the information gaps created due to declining reliability of traditional climate knowledge. As a solution, they should be provided with timely, scientific weather forecasts to better predict and prepare for imminent changes.

To address this climate information gap, the Institute of Policy Studies of Sri Lanka (IPS) teamed up with Department of Meteorology of Sri Lanka (DOM), and Janathakshan Gte. Ltd to pilot test an Integrated Climate Information Management System (ICIMS), with selected farmers from Padaviya (Anuradhapura district), Wakare (Batticaloa district), Anda Ulpotha (Badulla district), Bundala (Hambanthota district).

Climatic Information Needs of Farmers

Climate information plays a significant role in daily management decisions, as well as in the long-term development of climate-smart technologies. Providing timely information on weather trends helps farmers make accurate decisions in terms of planning seasons (Kanna salasuma) and other agronomic practices. An Irrigation Officer from Padaviya explains, "when planning a season we want a wide range of climatic information for the short term, medium term, and long term. In major irrigation schemes, we use the previous years' data and the environmental signals for the planning. Padaviya is an area covered by a major irrigation scheme. If we can get this information for the whole area, then we can apply it when making decisions."

Meanwhile, a farmer from Padaviya explains, "if we get information about the rain early, we can adjust practices accordingly. If it starts to rain in the harvesting and post harvesting time, it destroys our harvest."

"It is helpful to have information when applying fertiliser and starting to harvest," notes a farmer from Opanayaka.

Farmers also emphasised the importance of providing correct information in a timely manner. A farmer from Kotawehera says, "if we can get the information about rain before the season starts, then we can discuss in the farmer organisations and come to a decision."

A farmer from Opanayaka mentions that it would be ideal if they can get updates every five to ten days, highlighting the importance of continuous climatic information.

In critical climatic conditions, farmers make adjustments to farming activities and need continuous, seasonal forecasts to make their decisions. The President of the Farmer Organisation of Opanayake, elaborating, says, "Opanayaka-Dandeniya is a rain fed agricultural area. Because rain is scarce, only 25 farmers can farm during this season. We use the traditional variety of "Hatada vee" (a variety maturing in 60 days). As rain-fed farmers, continuous and seasonal climatic information is valuable for us."

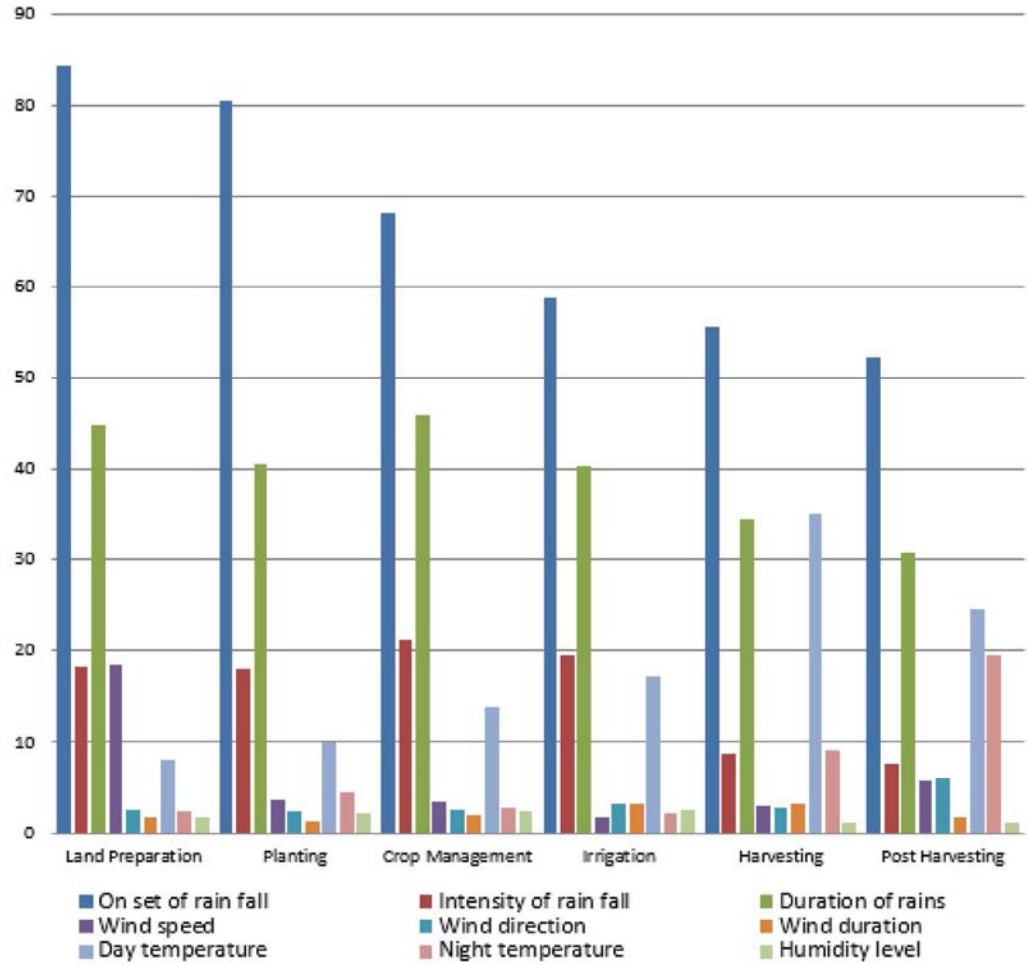
Even though farmers still depend on their traditional knowledge for climate predictions to a certain degree, they recognise the limitations of local predictions under changing climatic conditions and the need for bridging the resultant information gap through scientific climate information products. They highlight the limitations of currently available low-resolution forecasts, which cover entire districts, rather than specific local areas. Farmers' climate information needs are specific and time-bound. They need information to make decisions at specific stages in crop cultivation, and to make adjustments to practices according to prevailing and anticipated climate conditions.

Demand for Climate Information

The demand for climate information originates from farmers' perceptions about climate risks. A survey to assess farmers' perceptions of climate risks and the demand for climate information, based on interviews with 900 farmers from six areas (150 each from a district), showed that, 558 (62 percent) rank climate change under the high risk category. Moreover, 481 (53 percent) of respondents recognise that water supply risk can hamper their farming activities in respective areas. Comparatively, fewer farmers rank pest and diseases, price shocks, and animal attacks under the high risk category. While respondents come from locations selected for high vulnerability to climate change and therefore these rankings cannot be generalised to all farmers in Sri Lanka, it suggests however, that the majority of vulnerable farmers recognise the threat of climate change and the associated risk of water supply as major risks.

The farmers were asked about their information requirements for three time horizons— short-term, medium-term, and long-term -- as well as climate information requirements with respect to different agronomic practices from land preparation to post harvesting stage.

Figure 1: Climate Information Needs by Agronomic Practies



For all time horizons, rainfall is the most critical climatic parameter, demanded by approximately persent of respondents. Onset of rainfall is the most important climatic information needed for almost all agronomic practices in all three time horizons, followed by the duration of rainfall. As the rainfall has a significant impact on planning seasons and other agronomic practices, the survey proves that the farmers' main concern is having accurate dates and the duration of rainfall, to prepare themselves effectively.

A significant share of respondents also indicate the importance of daily temperature readings for harvesting, post harvesting, and crop management. As they have correctly indicated, temperature-related information is important to reduce unwanted losses in post-harvest practices.

Conclusion

Farmers in vulnerable localities recognise climate change and the associated risk of water supply as the most critical risks among other threats. Declining trust over local climate predictions and the rising risk of climate change create a demand for scientific climate information products. To fulfill this demand, it is necessary to identify farmers' climate information needs correctly. Farmers' feedback gathered in Participatory Rural Appraisals (PRA) and a survey indicate that attention should be focused on three major dimensions; namely, time of information availability, weather parameters for which information is necessary, and agronomic practices for which information is necessary. Information needs in terms of different weather parameters are interconnected with different agronomic practices. Onsets of rain and rainfall duration are the parameters that are in highest demand by farmers when making decisions on all agronomic practices. When developing scientific climate information products to fill the emerging void created by declining reliability of local climate knowledge, due consideration should be given to address the above aspects of climate information needs.

The Climate Challenge: Bridging the Information Gap through Innovative Climatic Information Products (CIPs)

Athula Senaratne and Kapila Premarathne

Never in the recent history has Sri Lanka faced as many challenges due to disasters as the country did in the last decade. It experienced major floods in May 2016, a prolonged drought in 2016-17 Maha season and once again flash floods this May. Before that, flash floods disrupted the livelihoods of people in Anuradhapura in 2014. In 2013, fishermen lost lives and assets due to torrential rains and stormy conditions. Major floods in 2011 affected nearly all the districts. In just over 12 years, the country faced several other major disasters including, a tsunami, numerous landslides as well as the collapse of the largest waste dump yard, all of which claimed many lives, caused insurmountable damage to property and had long-lasting impacts on the economy. For instance, the prolonged droughts in 2016 affected food production and consumers were still experiencing higher retail prices in the markets when they were hit by floods in Southern and Sabaragamuwa provinces. Except for the 2004 tsunami and the Meethotamulla tragedy, which have geological and anthropogenic origins, the majority of other hazard events are climate driven. Consecutive climate-related disasters in recent years indicate the urgent need for disaster resilient coping mechanisms.

Climate Change and Disasters

There is significant evidence to indicate that climate change due to global warming is a factor responsible for the growing incidence of disasters. While sudden catastrophic disasters, with tremendous economic impacts, usually grab public attention more frequently, climate change is also likely to generate slow onset impacts such as the gradual rise of air temperature, alteration of established patterns of rainfall, rise in sea level and inundation of low-lying coastal areas. Due to the gradual long-term nature of such impacts, the losses and damage caused by them hardly capture public attention. However, scientists caution that in future, the magnitude of losses and damages due to such slow-onset impacts may even exceed the losses caused by the growing incidence of catastrophic disasters.

Making an informed effort to face this reality requires filling major gaps in the current system with respect to information, policy, institutions, technology and resource mobilization. While actions in all these areas are equally important, access to the right information is fundamental to succeed in all other areas. It is no secret that there is a huge gap in climate information. This gap needs to be bridged through appropriate types of climate information products (CIPs) and Sri Lanka has to take meaningful steps towards the development of reliable CIPs.

Climate Information Products (CIPs)

Information is an economic commodity with scarce supply relative to demand that possess an economic value, and CIPs are no exception. The value of climate information arises from its usefulness in avoiding losses and damages caused by climate disasters/impacts and its prospects for making use of favourable climate conditions to gain benefits. There are many types of CIPs, such as short- to long-range weather forecasts, monthly to seasonal outlooks, long-term climate projections, early warnings, information packs such as agro-climatic calendars, and customized weather information for shipping and aviation. Anomalies caused by rising turbulence in the climatic system all over the world have increased the demand for CIPs. As a result, various types of CIPs that operate at global, regional and national levels are being introduced by climate information providers.

The main purpose of any CIP is to predict the future state of climatic parameters with a specified period of lead time. Among many CIPs, short- to long-range weather forecasts are the most demanded products. In addition, many countries are now attempting to develop reliable seasonal outlooks that are especially useful for highly weather dependent economic sectors such as agriculture and primary industries. The World Meteorological Organization (WMO) has classified CIPs in the following manner.

Information products could be private or public and they involve supply chains that extend from producers (information providers) to consumers (information users). Since a majority of CIPs are considered as public information products, private producers have little incentives to supply CIPs. As a result, a majority of CIP providers are state, inter-governmental or international technical agencies. At the state level, the main providers of CIPs are national meteorological services (NMS) represented by national Meteorological Departments or Weather Bureaus (e.g., Department of Meteorology in Sri Lanka). Examples for inter-governmental bodies are WMO and the Intergovernmental Panel for Climate Change (IPCC). In addition, there are international technical agencies, sponsored by developed nations, such as the Commonwealth Scientific and Industrial Research Organization (CSIRO) and the International Research Institute for Climate and Society (IRI). Often, NMS in developing countries have to depend on products from international information providers for preparing national level CIPs due to their limited technical capacity.

With the spread of information technology, new business models for supplying information products have emerged. As a result, profit oriented private providers of CIPs that are based on innovative web-based platforms have materialized. These platforms combine various business models for multiple information products that range from subscribed customized private weather reports to free supply of public weather information. These privately run CIP networks appear to be getting more and more popular with the spread of smart phones and tablet PCs. With ongoing advancements in ICT in areas such as internet of things (IOT), big data, artificial intelligence and drones revolution, prospects for private providers of CIPs are expected to increase tremendously in the future.

Table 1: WMO Classification of Forecast Information Products

Lead time	Information product(s)	Remarks
0-2 hours	Nowcasting	Description of forecasted weather parameters
Up to 12 hours	Very short-range weather forecasting	
12-72 hours (half-3 days)	Short-range weather forecasting	
72-240 hours (3-10 days)	Medium-range weather forecasting	
10-30 days	Extended-range weather forecasting	
From 30 days up to 2 years	Long-range weather forecasting • Monthly outlooks • 90 day (quarterly) outlooks • Seasonal outlooks • Multi-seasonal outlooks	Description of average weather parameters expressed as a departure (deviation, variation, anomaly) from climate values of that period (e.g., month, season)
Beyond 2 years	Climate forecasting • Climate variability predication • Climate predication	Description of expected climate parameters associated with the variation of inter-annual, decadal and multi-decadal climate anomalies, including the effects of both natural and human influences

Source: World Metrological Organization (WMO)

Climate Information Gap in Sri Lanka

The dearth of reliable CIPs to cater to growing demands from various stakeholders is a challenge faced by many developing countries, including Sri Lanka. The Department of Meteorology (DOM) is the national climate information provider in Sri Lanka and is the national focal point for the WMO and IPCC. At present, the DOM offers a limited portfolio of CIPs to the general public as well as stakeholders from weather dependent economic sectors, such as agriculture, energy, fishery, shipping, aviation and insurance which are communicated through public media and its website. These CIPs include routine daily weather forecasts, monthly and seasonal outlooks, sea-area and city forecasts, forecasts for aviation and shipping, warnings and advisories on bad weather situations due to events such as cyclones, heavy rains, lightning and high wind. It has also started offering three day and 10 day model forecasts and making continuous attempts to develop long-term climate projections through downscaling of global models. Despite the efforts of the DOM to improve the availability of CIPs in the country, significant gaps persist. Broadly, they can be categorized into three major types, namely; supply gaps, credibility gaps and communication gaps.

With the gradual unfolding of climate change impacts, the demand for CIPs is rising. Compared with the growing demand, the current supply of CIPs is limited in Sri Lanka. This is particularly felt in more weather dependent sectors such as agriculture, fisheries, water resources management, energy planning, and disaster risk management. Even the available CIPs appear to have credibility gaps due to poor compatibility and quality. Poor compatibility implies a gap between coverage of the forecast and users' needs of information. The quality of forecasts is determined by accuracy and reliability of predictions. Low levels of compatibility and quality reduce the confidence of users about the CIPs, thereby resulting in a credibility gap. Finally, it seems that existing CIPs are not properly communicated. A communication gap occurs due to problems in format and content of messages, low access by users due to lack of targeting, and poor selection of media for dissemination. These gaps in climate information have led to frequent criticisms directed at the DOM, both by politicians and the general public.

Bridging Climate Information Gaps

Bridging climate information gaps in Sri Lanka is an essential precondition for facing the challenges caused by climate change. The limited supply of information products, low confidence of users on existing products, and poor communication contribute to climate information gaps in Sri Lanka. One major reason for information gaps is the capacity limitations of the DOM and other relevant stakeholder agencies. Developing quality CIPs requires state-of-the-art technical facilities and a high level of expertise and skills. The existing technical facilities and the limited professional DOM, as well as at other relevant agencies, are not adequate to meet the challenge. Hence, necessary policy and management measures should be taken to improve the situation. This involves making investment on upgrading technical facilities, recruitment of additional staff, building skills of staff through training, arranging technical assistance from international agencies for developing sophisticated forecast information products, networking operationally with global/regional/national agencies, and building research and development capacity. The range and quality of CIPs should be upgraded through continuous assessment of user information needs, validating and monitoring of products with the participation of users, and exploring effective communication channels for targeting specific user groups.

Besides improving the technical capacity of the DOM to produce reliable CIPs, awareness and capacity of other stakeholders in areas such as agriculture, fisheries, water, energy and disaster management should also be raised to facilitate the effective use and communication of information at times of need. The capacity of universities to offer courses on relevant technical areas have to be strengthened and the level of awareness among media on effective communication of climate information should be increased. All these interventions require significant foresight and determination for action from policy makers and continuous vigilance from the side of the general public. Overall, bridging the current climate information gap in the country, calls for a consolidated effort by all relevant stakeholders.

Uncertainties and Scientific and Technological Challenges in Weather and Climate Forecasting

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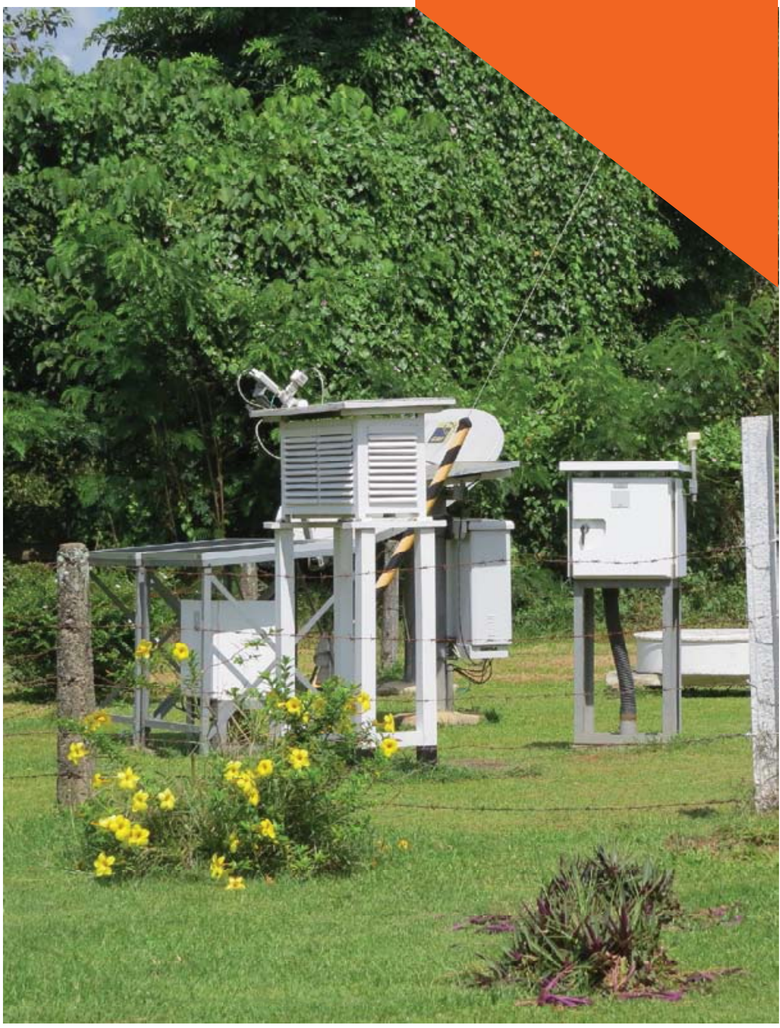
Over the last few decades, the frequency and intensity of extreme climate events have been increasing, especially due to global warming caused by human activities. According to a special report by the Intergovernmental Panel on Climate Change 2012, changes in the frequency, intensity, spatial extent, duration, and timing of weather and climate extremes can increase people's vulnerability to natural disasters and become a major threat to global economies. Weather forecasts, ranging from timescales of few hours to entire seasons, can reduce susceptibility to weather variations and climate-related disasters, improve food security and health outcomes, and enhance water resource management. However, a major challenge is predicting future weather patterns in a rapidly changing climate. The future is intrinsically uncertain. Further, dynamic physical processes of atmosphere and its interactions with surrounding systems (e.g. land, ocean, and ice surfaces) make forecasting even more difficult.



Forecasting Future Weather Patterns

Weather forecasts are prepared in a systematic way, which involves observation, process understanding, prediction, and dissemination. Each of these components has benefitted, and will continue to benefit from advances in science and technology. Over the past few decades, substantial leaps in science have resulted in improved and more efficient methods of making timely observations, using a wide variety of sources including radars and satellites. The use of such observation tools has dramatically increased the quality, value, and reliability of weather forecasts, assisting decision-making processes around the world. The impact of improved observational capability, increased scientific understanding of atmospheric processes, more sophisticated computer resources, skillful numerical models, and other forecasting tools have gradually changed the public's perception of the accuracy of weather forecasts. Two areas that achieved significant improvements in this regard are numerical weather forecasting and seasonal predictions.

Numerical Weather Prediction (NWP)

Numerical Weather Prediction (NWP) is a forecasting method that uses complex mathematical equations, based on well-established physical laws, to predict atmospheric behaviour. This is done by undertaking complex mathematical operations that model the current state of atmosphere, obtained from observations. High speed, high-performing computers are required to carry out the enormous number of calculations involved in this process. To get the current status of the atmosphere, routine and accurate measurements at ground and upper air stations, as well as remote sensing systems, are required.

Seasonal Predictions

Seasonal predictions are made in probabilistic terms, such as probability of receiving average/above average/below average level of rainfall/temperature over a season. Currently, seasonal predictions are made using both statistical schemes and dynamical models. The statistical approach seeks to find recurring patterns in climate, associated with a 'predictor field' such as sea surface temperature. Such models have demonstrated the ability to forecast El Niño and some of its global climate impacts. The basic tools for dynamic prediction include both atmospheric and oceanic models.

Challenges in Weather Forecasting

Whatever the successes, some level of uncertainty remains and there are challenges that act as barriers against further progress in weather forecasting.

Nonlinearity of atmospheric systems: Successful weather forecasts are possible if the processes are understood properly, and if the current state of the atmosphere is well-known. Even though, the scientific understanding of atmospheric and oceanic systems has made considerable progress through a variety of research activities, including field experiments, theoretical work, and numerical simulations, atmospheric processes are inherently non-linear. Furthermore, all physical processes cannot be understood or represented in NWP models. Continued research efforts, using computer technology and physical measurements, will improve these approximations. Even then, it will not be possible to represent all atmospheric motions and processes in NWPs, especially over tropical regions.

Limitations in observations: Despite recent advances, there are limitations in making observations, especially in desert areas and oceans. As a result, there is a need for improved observation systems and methods to assimilate these data into NWP models.

Predictability desert - sub-seasonal prediction: Substantial progress has been made in recent years in the development and application of short-range to medium-range weather forecasts and seasonal climate predictions. However, forecasting on the time scale beyond 14 days to season (sub-seasonal time scale) that lies between daily weather and seasonal climate has received much less attention because it is considered a 'predictability desert'. Sub-seasonal to seasonal prediction is a crucial planning window for the agricultural sector, water resource management, and other stakeholders, such as transport planners. There is a growing interest in the scientific community to develop forecasts that would fill the gap between medium-range weather forecasts and long-range or seasonal ones. This interest in sub-seasonal prediction was triggered, not only by a growing demand from potential users, but also from the progress in areas such as medium-range forecasting, as well as the predictive sources like Madden Julian Oscillation (MJO), over the past decades.

Weather Forecasting in Sri Lanka

Sri Lanka has major challenges in forecasting weather, due to its geographical location. Sri Lanka is close to the equator and is surrounded by the Indian Ocean, where observation density is sparse. Some atmospheric processes in the tropical region are not fully understood and impossible to resolve due to technology constraints. Data sparseness in the surrounding ocean, lack of scientific understanding of some weather systems inherent to the tropical region, and frequent, vigorous changes in the equatorial tropical atmosphere hinder the accuracy of weather forecasting in Sri Lanka. It is important to understand that, even with advancements in science, some meteorological phenomena associated with extreme weather events will remain inherently unpredictable.

However, the advances in computational technology, together with improvements in physical representation of the main atmospheric processes, have increased the accuracy of forecasts. It has prompted the use of short range NWP forecasts and seasonal forecasts in many activities dependent on weather and climate.

The Department of Meteorology (DOM) runs the Weather Research and Forecasting (WRF) model for operational purposes, as a tool in short range and medium range forecasting. The present system has 15x15 km2 horizontal resolutions for the outer domain, and 5x5 km2 for the inner domain covering Sri Lanka. The DOM's goal is to provide detailed, accurate, and reliable information for weather-dependent customers and stakeholders. Therefore, the use of a very high resolution limited area NWP model, with horizontal grid size of nearly 1 km, is well justified for countries like Sri Lanka, that have highly varying terrain from central highlands (containing many complex topographical features such as ridges, peaks, plateaus, basins, and valleys) to low laying plains. To achieve this goal, institutional strengthening, capacity building, strengthening and enhancement of the observation network, enhancement of research activities is important. In addition, improving computer resources, such as high end computer servers, is needed.

The DOM currently provides seasonal as well as monthly probabilistic rainfall and temperature forecasts, at district levels, using statistical downscaling of global models. Monthly and seasonal climate predictions are valuable in agricultural decision making, water resource management, and other climate sensitive activities. It is important to provide guidance on how to use probabilistic predictions to support these decisions. Some scientific research has identified that, provided with sufficient information about level of uncertainty, people would take better risk-based decisions. Understanding the limitations of weather and climate forecasts will result in the improved, rational use of forecasts and other weather information by decision makers.

Developing Climate Information Products (CIPs) for Farmers: Demand-side Challenges and Necessity for an Integrated Approach

Chandrika Kularathna and Lalith Rajapaksha
Janathakshan Ltd.

Agriculture is one of the key sectors that could benefit from well-designed climate information products (CIPs). Prior knowledge about variations of weather parameters can assist in planning and making operational decisions, reducing risks, and maximising returns, while facilitating the process of adapting to climate change. Therefore, CIPs can make a significant contribution to ensure the food security of Sri Lanka in the long run, under conditions of rising climatic uncertainty.

However, many developing countries, including Sri Lanka, still lag behind in producing and disseminating accurate and reliable CIPs for farmers. As a result, farmers still rely on their traditional knowledge when planning farming activities and making agronomic decisions. They make risky decisions, based on their own expectations about weather patterns such as rainfall. In this context, it is concerning that the reliability of farmers' traditional knowledge has declined due to unexpected changes in local climate patterns. Thus, farmers struggle to make accurate agronomic decisions. This points to the urgent need for developing and disseminating reliable and timely CIPs to farmers and integrating scientific climate information systems to their decision making processes.

Demand-side Challenges in CIPs

Despite the growing volume of available climate information across developing regions, there are substantial gaps between the information held by CIP providers, such as national meteorological agencies, and the information demanded by users, such as farmers. While scientific advances continue to improve the coverage and the quality of observational networks and the accuracy of forecasts across time scales, there are numerous scientific and practical barriers which impact the use of climate information by agricultural communities in these regions; limitations in relevance and accuracy of CIPs, inadequate institutional capacity for timely delivery and lack of access to climate information, technical formats that cannot be understood by farmers, and disconnect between the providers and users of CIPs to name a few.

Limited Local Relevance and Accuracy of CIPs

CIPs must be locally relevant if it is to be useful in guiding decisions at the community level. The locally focused, high resolution CIPs will foster confidence and trust among farmers about the reliability and accuracy of these information products. Moreover, if the users are highly vulnerable to climate risks, the marginal benefits of using CIPs are high; even the low resolution CIPs are useful in such cases.

Providing CIPs across multiple time scales is also important. Farmers demand different types of information at different time scales in the crop calendar. CIP providers should cater to this demand through short term, medium term and long term CIPs, to enhance the usefulness of CIPs. Despite the demand, many national meteorological agencies in developing countries, lack the skill and capacity to produce location-specific CIPs across multiple time scales, in high resolution.

Issues in Timely Delivery and Access

Even though communication technologies, such as the internet, email and mobile phones have become widely popular, the modes of disseminating CIPs still remain restricted. Many farmers live in remote areas, with limited connectivity and cannot afford communication channels. As a result, they do not have easy access to CIPs, even when locally-specific, high resolution CIPs are available. This calls for the development of innovative strategies to communicate CIPs to farmers in a timely manner.

Too Technical for Farmers

The format and the presentation of CIPs are vital to enhance their usefulness. Most CIPs, especially seasonal or medium and long-term CIPs, are in probabilistic terms. Users find these hard to comprehend and interpret. Furthermore, probabilistic weather forecasts do not contain key pieces of information, such as location of rainfall, timing and duration of rainfall, and the expected volume. Presenting CIPs in local languages used by farmers is another important consideration. On the plus side, recent interventions to guide and train famers to improve their understanding and the ability to interpret CIPs, have shown some positive results.

Disconnection between the Providers and Users of CIPs

In many developing regions, there is a wide disconnection between CIP providers and users. Certain factors such as poor connectivity, gaps in institutional capacities, and the lack of proactive mechanisms to engage with users are responsible for this. It invariably leads to a drop in the users' confidence and trust in available CIPs.

The local institutional structures such as farmer organizations, which govern the collective decision-making processes among farmer communities, play a critical role in making decisions based on probabilistic CIPs. Crop cultivation choices are highly dependent on collective agreements of local governing structures and are linked to sub-national and national level decisions.

All these demand-side challenges highlight the necessity for an integrated approach to develop and promote the use of scientific CIPs among farmers.

An Integrated Approach

A consortium of research partners, comprising of the Institute of Policy Studies of Sri Lanka (IPS), the Department of Meteorology (DOM) and Janathakshan Gte Ltd. has launched a pilot-scale action research study on 'Integrated Climate Information Management System (ICIMS)', with selected groups of vulnerable farming communities in Sri Lanka. In this project, location specific, high resolution forecasts were issued to farmers in six Grama Niladhari divisions in six districts. The resolution of these forecasts was considerably higher than the forecasts issued by the DOM on a regular basis. The forecasts are now being issued for every 10 days and updated every five days. Forecasts are presented in tailor made formats, after extensive consultations with farmers to identify their climate information needs.

The project took several steps to eliminate the disconnection between the DOM (CIP providers) and the farmers (CIP users). Farmers were trained and made aware on how to read and interpret CIPs, how weather parameters are observed and gathered, how the CIPs were developed, and challenges in issuing high resolution CIPs at the Regional Meteorological Stations. Community managed rainfall data collection stations were established in each project location. Farmers were also given the opportunity to visit the DOM to get an idea about its role and functions.

Bridging the communication gap was the key challenge faced during the ICIMS project. Almost all the farming communities lived in rural areas wehre there were no ready-made channels to disseminate the CIPs directly to farmers. Internet penetration in these locations was low, posing another hurdle. Telephone calls, faxes, and emails were the main channels used. Notice boards with CIPS were placed in the areas where community gathers together.

Such interventions have helped farmers understand and interpret weather forecasts and minimise the disconnection between the farmers and the DOM. Farmers are now aware about the process of issuing CIPs. Their ability to interpret forecast information and make systematic observations on rainfall has increased remarkably.

For Whom the Mobile Phones Ring?

Future of Climate Information Delivery in Sri Lanka

Nimesha Dissanayake and Manoj Thibbotuwawa

Most people use weather forecasts to plan their day to day activities. However, for those whose livelihoods depend on the variations in weather, this information becomes a lifeline. Farmers, as a community, are highly sensitive to weather forecasts, as their agronomic decisions revolve around daily temperatures, rainfall patterns, and wind speeds. Farmers used to be able to observe cloud patterns, behaviour of birds and animals, the direction of the wind, and other natural occurrences, to make accurate predictions about the weather. Before technology took over, farmers' wealth of experience in agronomy helped them make spot-on weather forecasts.

However, traditional farming experiences and centuries worth of accumulated knowledge on weather have now become obsolete, thanks to climate change. While the importance of weather-related information is felt today, more than ever before, the consequences of inaccurate and untimely information are grave, causing farmers to make incorrect decisions and eventually lose their livelihood.

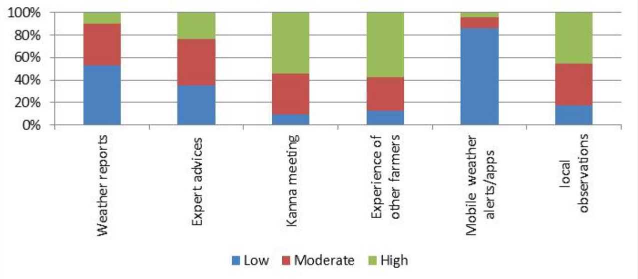
Thus, investing in climate information systems is a cost-effective way of making sure that farmers make the right agronomic decisions.

How Do Farmers Access Climate Information?

Farmers use both traditional and modern sources to get climate information, such as weather reports (TV/Radio/Newspapers), kanna meetings, expert advice (from Agriculture Instructors at the Department of Agriculture), experience of other farmers and local observations.

A survey carried out by the IPS in six districts (Anuradhapura, Batticaloa, Hambanthota, Kurunegala, Badulla and Rathnapura), showed that farmers most frequently use the experiences of other farmers, Kanna meetings, and local observations to get climate information (Figure 1). Before starting the cultivation season, kanna meetings inform farmers about the agronomic plans and practices they should implement to suit prevalent weather patterns. Farmers blend this information with their local knowledge and peers' experiences when making their own plans.

Figure 1: Sources of Weather Information Delivery



The moderate use of weather reports and the low usage of mobile weather alerts and applications indicate that farmers in Sri Lanka prefer conventional methods when it comes to receiving climate information.

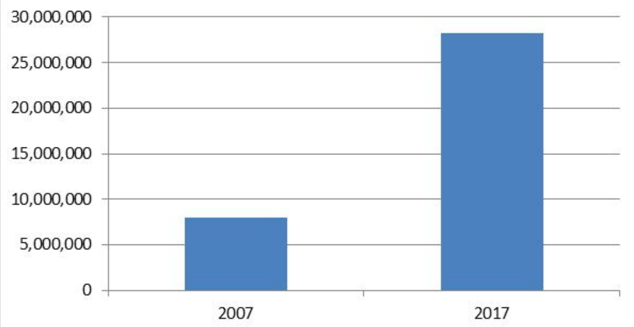
Role of ICT in Climate Information Dissemination

Long term (seasonal), medium term, and short term weather forecasts help farmers plan ways to maximise crop productivity. Most critical farming decisions are based on long term/seasonal forecasts, where farmers decide which mix of crops and seed varieties to plant, purchase seed and inputs, and prepare land accordingly. While kanna meetings could still be useful in providing long term forecasts, peer experiences and local observations have become unreliable, due to the frequent changes in the climate.

Medium term climate information and short term forecasts help determine the timings of various farming activities, such as sowing, weeding, spraying and harvesting. However, the three widely used information sources (peer experiences, kanna meetings, and local observations) are hardly useful in providing medium and short term information. Here, information communication technologies (ICT) can play a major role in bridging the gap in information delivery.

According to Professor Klaus Schwab, the Founder and Executive Chairman of the World Economic Forum, rapid evolution and uptake of digital technologies, hailed as the Fourth Industrial Revolution, have the potential to improve the quality of life for everyone, including those in the agriculture sector. Sri Lanka too is making use of these technologies; the total number of mobile phone connections in the country increased more than three-fold, from 0.8 million in 2007, to 2.8 million in 2017 (Figure 2). Thus, the ICT sector has the potential to be an important player in strengthening climate information systems. It can provide short, medium, and long term climate forecasts, as well as information on crop varieties and farming techniques that reduce the impacts of climatic variations and withstand extreme weather conditions.

Figure 2: Mobile Subscriptions

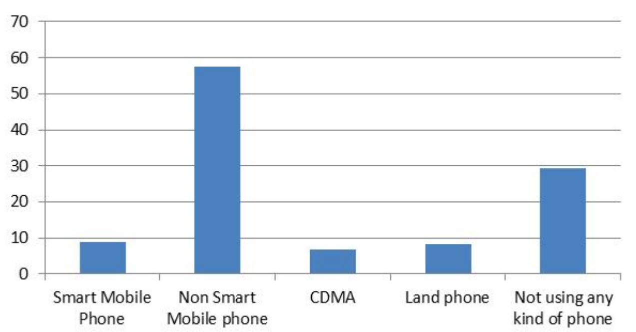


Radios and mobile phones are the most popular ICT tools used to disseminate climate information. While radios have wider coverage and high comprehensiveness than mobile phones, the former does not have a direct link with the user. Therefore, SMS is the most cost effective and simplest way to deliver information. Users with smart phones can have access to more advanced visual advices and more enhanced content. Moreover, mobile forecasts have the potential to target users geographically.

Challenges of Using Mobile Phones for Climate Information Delivery

The IPS survey indicates that, despite significantly high mobile phone usage and penetration in Sri Lanka, acclimatising farmers to use phones to access climate information remains a challenge. While more than half of the farmers have access to mobile phones, over 29% of farmers do not use any kind of phone. Moreover, only about 9% of farmers have access to a smart phone. This might be partly due to regional disparities in mobile penetration in Sri Lanka.

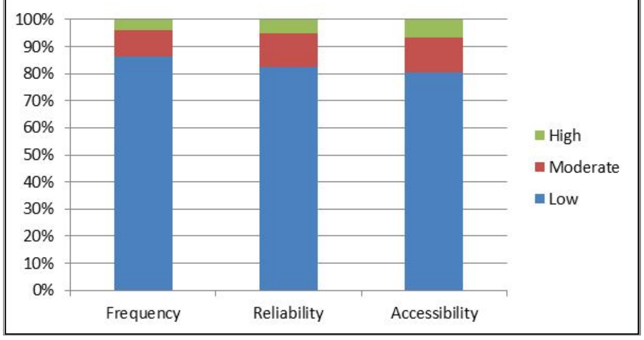
Figure 3: Mobile Phone Usage (%)



The IPS survey also found that farmers hardly use mobile weather alerts. This is due to the unreliability and inaccessibility of mobile weather alerts (Figure 4). Farmers' inability to understand highly technical climate information can also play a part in this regard.

systems. It can provide short, medium, and long term climate forecasts, as well as information on crop varieties and farming techniques that reduce the impacts of climatic variations and withstand extreme weather conditions.

Figure 4: Assessment of Mobile Weather Alerts



Way Forward

Despite various challenges, mobile phones have the potential to become a major component in climate and weather information systems. For best results, instead of providing weather information as a stand-alone service, it should bundled with other complementary information, such as customised crop guidance, market/price information, or even as a package with index insurance schemes. For example, in India, the Farm Need app provides information on agronomic management practices and weather related risks for selected crops.

Also, the information delivered through the mobile channels should be based on the needs of the users. The communication tools should be targeted to suit both the information and the users. It is also important to develop mobile platforms that facilitate two-way information flows, so that the collection of localised data and feedback from farmers can be done simultaneously. An example is Uganda's Mobile Weather Alert system.

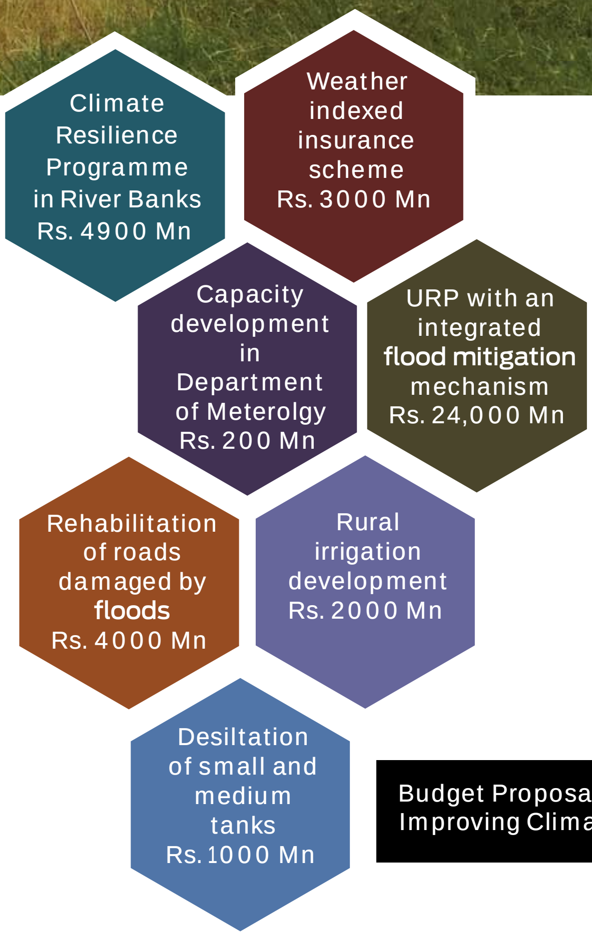
With increased mobile penetration and technical knowledge among rural farmers, mobile phones could be used as a potential solution for the existing challenges in climate information delivery.

Green Initiatives in the Blue-Green Budget: Can Sri Lanka become Climate Resilient?

Kanchana Wickramasinghe

Sri Lanka's Budget proposals for 2018 explicitly identify that changing weather patterns and the increased frequency and severity of natural disasters (droughts, floods, and landslides) had posed a substantial challenge to the country's economic performance in 2017. The cost of such disasters is calculated to be 1 per cent of GDP in 2017. The 2018 Budget proposals take a pioneering nature, as it pays due attention to enhancing climate resilience of the country through short, medium, and long term interventions.

The proposals mainly focus on increasing resilience in rural agricultural areas, mitigating urban floods, and bolstering the technical and human resource capacities of the Department of Meteorology(DOM). Among those, the proposal to design an index-based insurance scheme to enhance farmers' resilience towards weather shocks is a commendable step.



Budget Proposals Relevant to Improving Climate Resilience

Why is Index-based Insurance Important?

A weather indexed insurance scheme is proposed in the Budget, as a partially subsidized insurance, with a premium contribution from the farmers. The crop insurance programmes provided by the government in the past have been indemnity-based by nature. It requires farm level assessments of crop damages before making the pay-outs to the farmers. As such, there are many inefficiencies associated with indemnity-based insurance.

The need for an index-based insurance programme, and its technical feasibility, was assessed by an IPS study, with financial and technical support from the Global Development Network (GDN) through Japanese Award for Outstanding Research in Development 2014. The study findings, which were presented to major stakeholders in January 2017, mainly highlighted the necessity for improved data availability of the weather index – rainfall. At present, the number of raingauge stations in Sri Lanka are not adequate to carry out an index-based insurance programme. In the case of index-based insurance, the pay-outs to the farmers are calculated based on the rainfall levels. Therefore, the accuracy and the timely availability of rainfall data is a must for processing the pay-outs in an efficient manner. This also helps in maintaining the farmers' trust.

One of the major obstacles to popularizing insurance among vulnerable farmers is the lack of knowledge and understanding about crop insurance. Index-based insurance is a further novel concept for the majority of the farmer population in Sri Lanka – except in the case of a small number of farmers, who were targeted by the previous index-based insurance scheme, carried out by a private insurance company. Therefore, the proposed index-based insurance should certainly have a component to provide education and awareness programmes to all stakeholders involved, especially to the farmers.

Experience from other countries reveal that insurance should bring in tangible benefits to farmers to ensure the viability and popularity of such insurance schemes. It is vital to consult farmers to identify specific needs that should be covered through the insurance scheme. Further, studies in other countries' experience suggest that the insurance has to be integrated with other climate resilience programmes or developmental programmes. The close coordination with agencies providing rainfall data is also much important in this regard.

The Budget proposals for improving the technical and human resource capacities of the DOM is a significant step forward when it comes to achieving climate resilience. Improved climate information is an essential requirement for improved climate resilience of any country. It will undoubtedly help the successful implementation of the proposed index-based insurance, as the availability of data is likely to be enhanced, with the capacity development of the DOM. This will also boost the Met Department's ability to provide climate and weather forecasts with improved accuracy to all users, including the vulnerable communities. Improved climate data is also vital in other development planning activities.

The IPS' action research study, funded by the Think Tank Initiative (TTI) of the International Development Research Centre, which aims at overcoming the information and communication gaps in providing climate information to farmers, will make a useful contribution towards the budget proposal objectives. This project aims at assessing farmers' climate information needs and bridging the existing information communication gap with the support of the DOM, thereby ensuring improved availability of climate information, including short-medium term weather forecasts and seasonal climate outlooks. The index-based insurance programmes in Sri Lanka will undoubtedly benefit through this initiative. The proposed Budget also has allocations to scale up the existing climate resilience programme in the Kelani river basin, with the aim of mitigating urban floods, as well as extending such programmes to other important river basins. In addition, under the Urban Rehabilitation Project (URP), a specific component is included for an integrated flood mitigation mechanism within the Colombo city limits and its suburbs. This is expected to extend to other important cities in the country in the future. Allocations are proposed to rehabiliate the roads, which were affected by floods and landslides.

There are several other budget proposals which can address issues such as water scarcity in Sri Lanka. Support to develop rural irrigation, drip irrigation, and rainwater harvesting can help farmers find solutions for the increasing water scarcity in dry areas. The Budget proposals also aim at continuing the inititatve to desilt small and medium tanks in a systematic manner for rainwater harvesting.

It is commendable that climate resilience is given considerbale attention in several Budget proposals. However, climate resilience can only be achieved if the proposals are stategically translated into programmes and actions in a timely manner.

Index-based Insurance and Climate Information in Sri Lanka: Prospects for Community-based Rainfall Stations

Kanchana Wickramasinghe

Climate insurance for farmers has been a hot topic recently owing to recurring floods and droughts in agricultural districts in Sri Lanka. In these instances, interventions are necessary to help farmers adapt to weather and climate changes, using effective risk management strategies. Global experience has shown that insurance serves as an important risk management tool in this regard. However, an IPS study indicated that, in Sri Lanka, climate insurance is not yet considered a popular risk management strategy adopted by farmers due to issues in supply and demand.

Supply-side issues are related to the indemnity-based crop insurance products offered in Sri Lanka. The study proposed to shift to index-based insurance, to eliminate problems of traditional indemnity-based crop insurance. It further identified the lack of climate data as a main barrier in implementing index-based insurance in Sri Lanka.

Index-based Insurance and Climate Information

Once designed, the successful implementation of index-based insurance requires timely and accurate data, with precise geographical representation. This is especially important as insurance pay-outs in such schemes are purely based on data produced by the weather stations. An insurance payment is made only if the value of the index is above or below pre-determined threshold levels. However, a major challenge is to overcome the 'basis risk', the possible deviation between rainfall experienced by individual farmers and rainfall recorded at the stations. As a result, index measurements may not always tally with the actual losses incurred by individual farmers. Though basis risk cannot be completely eliminated, it should be minimised through data availability, to avoid possible issues in upscaling.

As insurance products are designed and implemented based on selected weather parameters, index-based insurance requires climate data. The weather parameter has to correlate closely with crop yield. Rainfall is the most suitable parameter for developing index-based insurance in Sri Lanka. As highlighted by previous studies, developing a rainfall index-based insurance product requires, at the very least, historical daily rainfall amounts at each rainfall station.

A private insurance company in Sri Lanka has already made a preliminary attempt to design and implement index-based insurance based on rainfall. Unfortunately, data availability was a main hindrance in replicating the said programme. In Sri Lanka, the Department of Meteorology (DOM), by its mandate, undertakes the measuring of rainfall at regional rainfall stations. In addition, there are a few other government agencies that collect rainfall data on a limited scale, such as the Department of Agriculture, the Irrigation Department, the Department of Agrarian Development, and the National Building Research Organisation. However, the current weather station facilities in Sri Lanka are not adequate to successfully implement a fully-fledged index-based insurance scheme.

Recent developments in Sri Lanka point towards improving the available climate information. The Budget Proposals for 2018 made a significant allocation to advance the technical capacity of the DOM. This can enhance the accuracy and the timeliness of the available data. Moreover, the budget has also proposed to introduce weather-based index-insurance products as a risk management tool for farmers.

An alternative to existing rainfall stations is to establish automated rainfall stations. A private insurance company is currently attempting to establish automated rainfall stations to remove data issues that are hindering the implementation of its own index-insurance products. Ideally, data collected through such initiatives should be shared among other users too.

Community-based Rainfall Stations: Way Forward

Basis risk can occur due to snags in product design or geographical factors. The latter is linked to data availability issues. Basis risk tends to be higher when microclimatic variations in a given geographical area are high, as these variations may not always be captured by weather data collected in a station. When the distance from the weather station to individual farmers is high, mismatches are more likely to occur between actual rainfall and recorded rainfall. When the distance is higher, it can also lead to mismatches between actual losses and losses indicated in the index. This can mean that affected famers do not receive insurance payments. However, high density weather stations can minimise this risk.

Community-based rainfall stations are an innovative way to address this problem, while overcoming resource constraints associated with government agencies in generating data. The pilot-scale action research study, being carried out by the Institute of Policy Studies of Sri Lanka (IPS), in collaboration with the DOM, and Janathakshan show that there is potential for a community-based approach in Sri Lanka. The project intends to bridge the climate information and communication gaps among the farming communities in Sri Lanka. An important element of the project is to focus on providing necessary equipment and training to farmers and getting them involved in measuring rainfall, using a standard approach. Farmers show a high level of enthusiasm in this regard. Daily rainfall data recorded by farmers is now shared with the DOM on a periodic basis. Even though the pilot study introduced community-based weather stations as a tool for enhancing farmers' adaptation decisions, it shows its potential to fill the current data gaps in index-based insurance schemes too.

Despite signs of improvement, however, further developments are necessary to generate and share climate data, before successfully implementing weather–based index insurance schemes in Sri Lanka. It is necessary to ensure the reliability and validity of the data generated through community-based stations. Data should be controlled for quality and reported based on standards. The aim should be to develop an effective system where data is collected and shared through an optimal data management system. If community-based weather stations are to lead to the development of successful index-based insurance products, the data generated by these stations should be acceptable to both public and private insurance providers. To this end, it is useful to develop public-private-community partnership models for managing community-based weather stations.

Climate Smart Agriculture: Key to Ensuring Food Security and Rural Livelihood in Sri Lanka

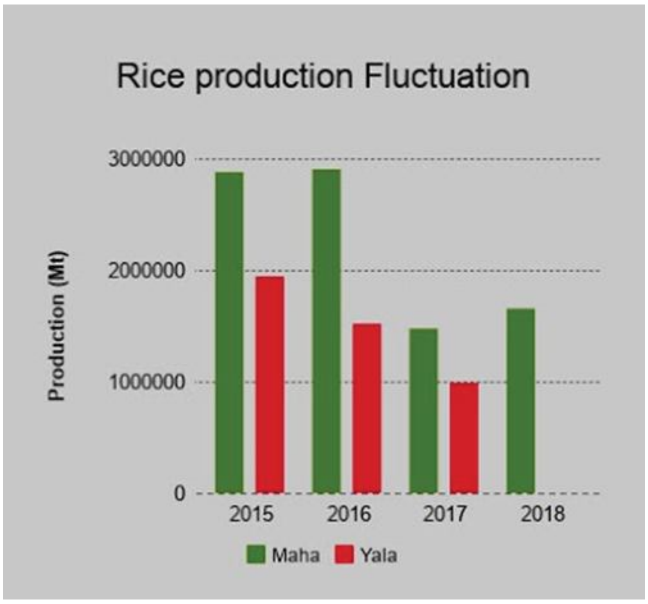
Manoj Thibbotuwawa

The Intergovernmental Panel on Climate Change (IPCC)'s report on "Climate Change 2014: Impacts, Adaptation and Vulnerability" says; "Climate change without adaptation could potentially affect the farm livelihood and all aspects of food security including food access, utilization, and price stability."

This is arguably the best way to summarize the impacts of recent climatic situation in Sri Lanka. Climate change threatens agricultural production, makes those who are dependent on agriculture more vulnerable and exacerbates the risks of food security. It is evident that long-term and gradual changes are taking place in Sri Lanka's climate, such as rising temperature and erratic rainfall patterns, and these negatively impact agricultural production and food security. However, in recent times, most of the attention focused on extreme climate conditions such as severe droughts and floods.

Climate Risks and Food Production Anomalies

Gradual changes in climatic conditions have already affected the production of domestic crops, including Sri Lanka's staple food rice, and extreme climate events threaten to worsen this. At the beginning of 2016, Sri Lanka faced the worst drought in 40 years, severely affecting the agricultural production in the country. Yala 2016 (May-September, 2016), the first cultivation season following the drought, recorded about a 20% drop in both production as well as the extent of cultivation of rice relative toYala 2015. The main harvest season Maha 2017 (December 2016-February 2017) achieved only a half of the rice production of Maha 2016. Yala 2017 production too showed a further drop in production. This situation was further exacerbated by severe floods in mid-2017 in South Western parts of Sri Lanka. The impact of continuing dry spells and severe floods was disastrous for farmers' livelihoods and food security.

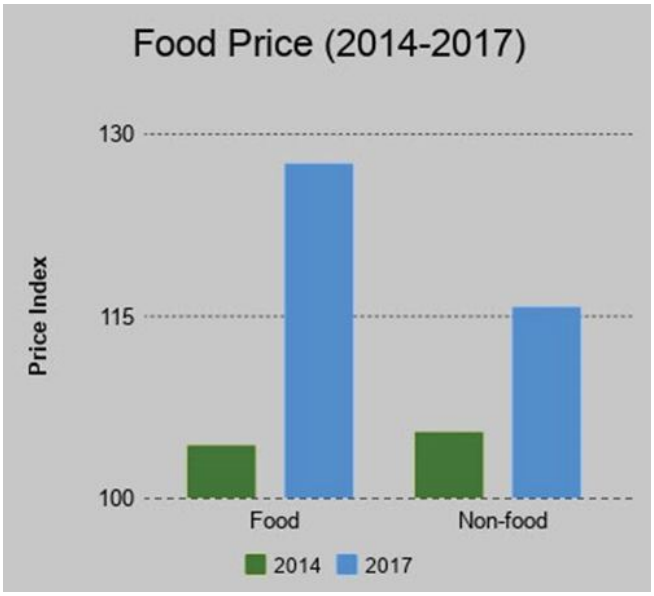


While the production of rice showed some improvementswith climate threats easing off towards the end of 2017, production forecast for Maha 2018 is nowhere close to the levels before the drought. Usually, over 85% of the total rice supply to the country is produced domestically. It has been estimated by the Department of Agriculture that, at the present annual consumption of 110kg per person, the population of Sri Lanka can only be fed for just seven months from the Maha 2018 harvest; this situation jeopardizes food security, rural livelihoods, and the economy of Sri Lanka. The production of other major agricultural products, including maize, potato, onions, grams, and vegetables, too have been similarly affected. Farmers have been continuously struggling to adapt to climate shocks, as they try to safeguard their livelihoods.

Soaring Food Prices and Livelihood Impacts

Climate change leads to low levels of agricultural output, resulting in diminished incomes for the farmers, and higher food prices for the consumers. Both of these consequences undeniably reduce the purchasing power of people, and thereby limit their access to food; the rural poor are especially vulnerable. Under these circumstances, the poorest people, who already use a larger proportion of their income on food, are forced to sacrifice other assets to meet their food requirements, pushing themselves further into depths of poverty. If not, they resort to poor coping strategies such as limiting their food consumption or shifting to less nutritious and unhealthy diets, which makes them insecure in terms of food and nutrition.

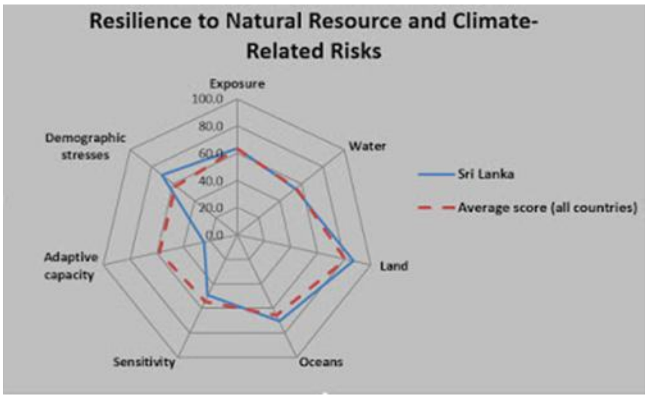
Food price index (FPI) relates the changes in cost and economic access to food by consumers. The FPI increased by a staggering 22% from 104.3 in 2014 to 127.5 in 2017, compared to a 10% increase of the non-food price index during the same period. Lack of access to sufficient nutritious food due to high cost is a key factor contributing to food insecurity and malnutrition in Sri Lanka. Also, there are regional and seasonal differences when it comes to the affordability of a nutritious diet. The minimum Cost of Diet (COD) estimate of the World Food Programme (WFP) finds that more than 50% of households in the Eastern Province could not afford an adequately nutritious diet in 2014, while this ranges from 39% and 48% (between the Yala/Maha cultivation and harvesting seasons) in the Uva Province. Even though the COD estimations are not readily available, access to food in 2017 is not expected to be better.



Increasing Food Insecurity

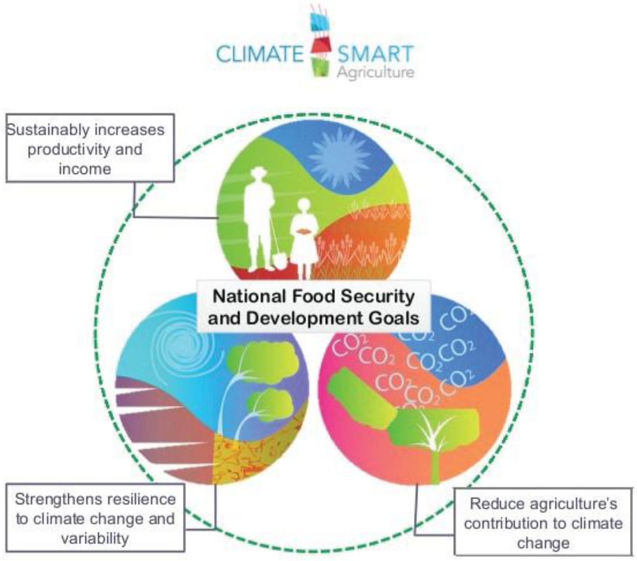
The impacts of climate risks, food production variability, and rising food prices are clearly visible in recent national and global food security indicators. Malnutrition is a good indicator to determine whether households are food secure. Average of 2014-2016 data indicates that nearly 4.6 million people, equivalent to 22% of the total population in Sri Lanka, are estimated to be undernourished. The Global Nutrition Report 2016 ranks Sri Lanka among the countries with the highest wasting (low weight for height) prevalence (21.4%). The FAO data indicate a comparatively higher level of underweight (26.3%) in Sri Lanka. Moreover, according to the National Strategic Review of Food Security and Nutrition, severe regional disparities exist in the prevalence of malnutrition, with highly vulnerable farming areas representing the highest levels of malnutrition. For example, Kilinochchi, Monaragala, Mullaitivu, Polonnaruwa and Trincomalee show the highest prevalence of wasting and underweight in Sri Lanka.

The Global Hunger Index (GHI) developed by the International Food Policy Research Institute (IFPRI), and the Global Food Security Index (GFSI) constructed by the Economic Intelligence Unit (EIU) of The Economist rank Sri Lanka at 84th and 66th positions respectively, showing a slight worsening of food security and hunger situations in 2017. The GFSI further shows that the resilience of Sri Lanka to natural resource and climate-related risks is at an average level, posing long term threats to food security in the country.



Climate Smart Agriculture as a Solution

While Sri Lanka is trying to move in the right direction to achieve Sustainable Development Goals (SDGs) by 2030, challenges posed by climate shocks have made it difficult to reach the goals pertaining to sustainable agriculture and food security. Since climate change is the current reality, agricultural systems must adapt accordingly, to avoid the harmful consequences of climate risks. Climate-smart agriculture (CSA) is an approach that transforms agricultural systems to effectively support farming livelihoods and ensure food security in the current context. CSA can prevent the worst impacts of climate change on farm livelihoods and help make people less vulnerable to food insecurity and poverty.



As studies CSA highlights that climate threats can be reduced by increasing the adaptive capacity of farmers, as well as by increasing resilience and efficiency of resource use in agricultural production systems. While reducing the agriculture sector's contribution to climate change is less of a priority for Sri Lanka, more importantly, farming communities need to adjust their livelihood patterns to sustainably increase their production and income. This demonstrates that the solutions for climate risks and food insecurity can be derived from making agriculture climate smart.

Sri Lanka is off to a good start when it comes to making agriculture climate smart. The government has developed a National Adaptation Plan to help adapt to climate change. The National Agriculture Policy, undertaken by the Ministry of Agriculture, includes climate change adaptation as a main priority. While different CSA strategies, including developing tolerant varieties, promoting water efficient farming methods, and adjusting cropping calendars according to climate forecasts, have been proposed, Sri Lanka is still lacking in terms of developing systems for timely issuing and communicating of climate information to farmers. Moreover, even though resilience is embedded in traditional knowledge, none of the policy responses to climate change support and enhance indigenous resilience.

Therefore, CSA practices should be tailored to the specific characteristics of the local farming systems and local socio-economic conditions and require a well-articulated information management system coupled with improved small holder access to finances, resources and markets.

PHOTO STORY

Regional Consultation Workshop for an Integrated Climate Information Management System (June 2016)







Initial farmer awareness programme (February – June 2017)





Participatory Rural Appraisal (PRA) Programme (June – August 2017)

Brainstorming session with the participation of project team and key experts (August 2017)

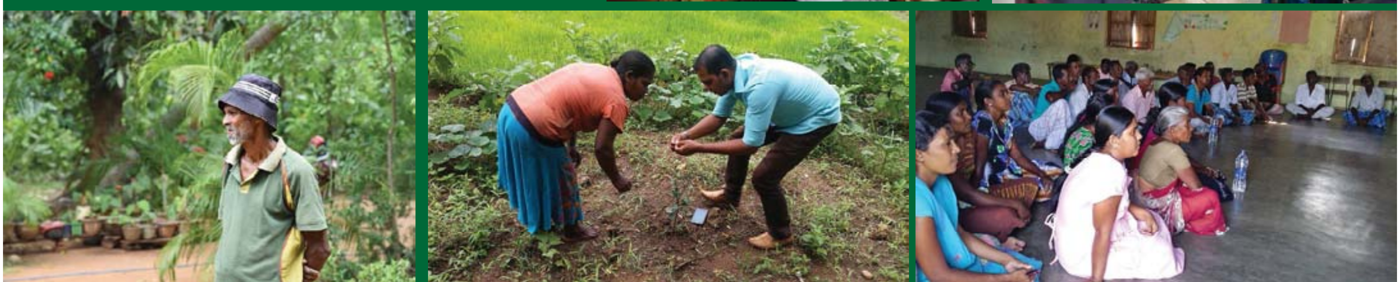



Basic farmer awareness programme on climate information and weather forecasting (September – October 2017)

Technical training for officers of the Department of Meteorology (November 2017)

Project stakeholder workshop and exposure visit to the Department of Meteorology (January 2018)

Farmer awareness programme on Climate Smart Agriculture (August 2018)



Regional Consultation Workshop for an Integrated Climate Information Management System

June 21 – 22, 2016
Galadari Hotel, Colombo

A Regional Consultation Workshop on "Bridging the Climate Information and Communication Gaps for Effective Adaptation Decisions: An Integrated Climate Information Management System" was held on 21st and 22nd June, 2016 at the Galadari Hotel, Colombo, Sri Lanka. The Workshop was organized by the IPS in partnership with the Department of Meteorology of Sri Lanka (DOM), Janathakshan, and South Asian Network for Development and Environmental Economics (SANDEE). The Workshop was a part of an action research programme to identify and pilot test replicable Integrated Climate Information Management System (ICIMS) for vulnerable farming communities in Sri Lanka with potential applications in other developing regions too. It was financially supported by the International Development Research Council (IDRC) of Canada. International and Local experts in the field shared their inputs during fruitful discussions.

Introduction to the Workshop
Athula Senaratne, Research Fellow, IPS

Keynote Address
W.L Sumathipala, Chairman, Advisory Committee on Climate Change Mitigation and Advisor to the Ministry of Mahaweli Development and Environment, Sri Lanka

Climate Change and Implications for South Asia
Heman Lohano, Senior Economist, SANDEE

Integrating Climate Risks in Agricultural Value Chains: Policy and Management
Enamul Haque, Professor, Department of Economics, East West University, Bangladesh

Weather and Climate Services for Small Farmers: Connecting Service Providers and Up-scaling Best Practices
Nambi Appadurai, Strategy Head (Climate Resilience Practice) World Resources Institute, India

Communicating Climate Information to Small Farmers: Innovative Approaches
Sheetal Sharma, Soil Scientist/ Nutrient Management Specialist- South Asia, IRRI, India

Integrating Farmers Local Climate Knowledge and Probabilistic Weather Forecasting
Alfred Opere, Head, Department of Meteorology, University of Nairobi

Participatory Decision Support Systems and Tools to Reduce Climate Risks for Small Farmers
Jacob Churi, Lecturer, Deputy Director, Center for Information and Communication Technology, Sokoine University of Agriculture, Tanzania

Innovating Climate Information Products (CIPs) in Sri Lanka: DOM's Efforts to Improve the Existing CIPs
Shiromani Jayawardena, Deputy Director, Department of Meteorology, Sri Lanka

Innovating Climate Information Products (CIPs) for Agricultural Adaptation: The Role of the Department of Agriculture
Aruni Abeysekera, Assistant Director of Agriculture Research, Department of Agriculture, Sri Lanka

Forecasting Techniques used for Preparing Outlooks of Seasonal Forecasts
Syed Mushtaq Ali Shah, Director, Regional Meteorological Centre, Pakistan Meteorological Department

Dynamical Seasonal Monsoon Forecasting at IITM
Hemant Kumar Chaudhari, Scientist, Indian Institute of Tropical Meteorology

Major Community Participation Events

	Event	Target Audience	Time Frame	Venue	Objective	No of Participants
1	Initial farmer awareness programme	All 06 project sites	Andaulpotha:06 February 2017 Kadiraweli: 21 March 2017 Abhayapura:03 April 2017 Dandeniya: 20 March 2017 Bundala: 05 June2017 Kumbukwewa: 05 February 2017	Andaulpotha: Community Hall Kadiraweli: Primary school building Abhayapura: Community Hall Dandeniya: Dandeniya School Bundala:Attale Rest In Kumbukwewa: Community Hall	To make the farmers in the respective farmer organization aware on the action research and identity their concerns	Andaulpotha:65 Kadiraweli: 72 Abhayapura:68 Dandeniya: 75 Bundala: 57 Kumbukwewa: 95
2	Participatory Rural Appraisal (PRA) Programme	All 06 project sites	Andaulpotha: 24 June 2017 Kadiraweli: 25 June 2017 Abhayapura: 26 June 2017 Dandeniya: 11 August 2017 Bundala: Kumbukwewa:	Andaulpotha: Community Hall Kadiraweli: Primary school building Abhayapura: Community Hall Dandeniya: Dandeniya School Bundala:Attale Rest In Kumbukwewa: Community Hall	• To capture the traditional knowledge related to agriculture and climate sector. • To identify 30 years major climate impacts related to agriculture • To identify the cropping pattern of selected farmer communities • To identify the relations and services related to agriculture • To understand climate impacts to the agriculture sector. • To identify the available climate information sources for agriculture sector. • To identify the dissemination channels of ICIMS	Andaulpotha:19 Kadiraweli: 18 Abhayapura:39 Dandeniya: 19 Bundala: 17 Kumbukwewa: 38
3	Basic farmer awareness programme on climate information and weather forecasting	Farmers in all 06 project sites	Andaulpotha: 26 September 2017 Kadiraweli: 27 September 2017 Abhayapura: 22 September 2017 Dandeniya:04 October 2017 Bundala: 03 October 2017 Kumbukwewa: 21 September 2017	Andaulpotha: Monaragala Agro Met Station Kadiraweli:Baticaloa Agro Met station Abhayapura:Wauniya Agro Met Station Dandeniya:Rathnapura Agro Met Station Bundala:Hambantota Agro Met Station Kumbukwewa: Kurunegala Agro Met. Station	The primary objective of this programme was to provide a basic understanding to farmer groups on the collection of weather data and forecasting of weather.	Andaulpotha:15 Kadiraweli:13 Abhayapura:12 Dandeniya: 15 Bundala:10 Kumbukwewa: 14

4	Project stakeholder workshop and exposure visit to the Department of Meteorology	Farmers in all 06 project officers Field level government officers (Agriculture Research and Production Assistant, Development Officer, Grama Niladhari, Agriculture Instructor, Agrarian Development Officer) Officials from the Department of Irrigations Officials from the Irrigation Management Division	04 January 2018	Auditorium, Department of Meteorology	• To get the feedback of farmer and other relevant stakeholders on the progress and the direction of the action research • To discuss about the future plans and next step of the project • To provide an introduction /overview to the Department of Meteorology and it's mandates to the participants	78
5	Farmer awareness programme on Climate Smart Agriculture (CSA)	Farmers in all 06 project sites Field level government officers (Agriculture Research and Production Assistant, Development Officer, Grama Niladhari, Agriculture Instructor)	Andaulpotha: 06 August 2018 Kadiraweli: 07 August 2018 Abhayapura: 11 August 2018 Dandeniya:16 August 2018 Bundala:17 August 2018 Kumbukwewa: 21 August 2018	Andaulpotha:Auditorium-Rideemaliyedda Provicial Council Kadiraweli: Primary School Building - Kathiraweli Abhayapura: Community Hall - Galkulama Dandeniya: Dandeniya Temple Bundala: Attale Rest In Kumbukwewa: Community Hall	• The primary objectives of this programme is to aware famers and field level officers about the climate smart adaptive agriculture practices and identify the possible adaptive agriculture interventions • Secondary objective of the programme is to get the famer feedback about the ICIMS project and capture the key outcomes, lesson and experiences of the project	Andaulpotha:35 Kadiraweli:38 Abhayapura:32 Dandeniya: 29 Bundala:22 Kumbukwewa:

RESEARCH PROFILE
Environment, Natural Resources and Agriculture

About IPS

The Institute of Policy Studies of Sri Lanka (IPS) was conceived in the mid-1980s as an autonomous institution designed to promote policy-oriented economic research and to strengthen the capacity for medium-term policy analysis in Sri Lanka. It was established by an Act of Parliament in December 1988 and was formally set up as a legal entity by gazette notification in April 1990 managed by a Board of Governors and the Executive Director.

Operational independence from financial and administrative regulations of the government were very much part of the rationale for setting up an independent IPS. Since its inception, the IPS has functioned under the key ministries involved in economic policy making and implementation in Sri Lanka while enjoying considerable autonomy in setting and implementing its research programme. Its institutional structure has allowed the IPS to acquire a unique position as an authoritative independent voice in economic policy analysis, working closely with the government, private sector, academia and civil society.

Since its establishment, there has been a substantial expansion of activities undertaken by the IPS. The number of areas on which it sustains on-going research has expanded significantly with the systematic strengthening of expertise of its research staff. The expanding research output has been reinforced by professional in-house support services in overall finance and administration management and in the provision of information and resources including the Institute's own library, publications, information technology, web development and database services.

With an in-house research capacity of 25 full time researchers – of which eight are with PhD's and most with over 10 years of post-doctoral level research experience – the IPS research programme aims to provide an integrated analysis of the medium to longer term development challenges facing Sri Lanka. The IPS has substantive expertise in carrying out studies with both quantitative and qualitative methodologies, and in managing the administrative and financial arrangements of large projects.

The principal thematic areas of research at present include:

- Policy Reforms and Competitiveness
- Environment, Natural Resources and Agriculture
- Human Resources for Sustained Development
- Poverty and Vulnerability
- Private Sector Development
- Migration and Urbanization

Theme: Environment, Natural resources and Agriculture

Sri Lanka is traversing a path of reform when the world is entering the era of Sustainable Development Goals (SDGs). A main objective of SDGs is ensuring judicious use of natural resources and ecosystem services for the sustained growth of economy. The Government's Vision 2025 aspires to make Sri Lanka a prosperous country, ensuring the opportunities for future generations also intact through a 'Blue-Green' initiative. Reforms in land and agriculture sectors and new policy directions in environment, clean energy, disaster resilience, waste management, public private partnerships and regional development assume high priority in the agenda of Vision 2025.

Sri Lanka's agriculture sector which is still a major subsector of the economy is comprised of export oriented plantation sector and agrarian food crop production sector. It employs a significant section of the labor force and impinges on critical areas of food security, use of natural resources, poverty and vulnerability. While the domestic agricultural sector is plagued with low productivity, inefficient resource use, food insecurity, poor market linkages and unsustainable agricultural practices, the plantation sector too is in crisis owing to the low productivity, volatile commodity prices and high production costs. Moreover, the looming threat of global climate change has imposed added conditions that growth should be low carbon and climate resilient. Sri Lanka's agenda for reform is compelled to take these concerns seriously; not as something optional but mandatory. The research theme 'Environment, Natural Resources and Agriculture' was initiated for finding solutions to these challenges arising from problematic policies adopted time-to-time as well as from emerging global threats such as climate change.

Research Focus

The IPS research theme 'Environment, Natural Resources and Agriculture' has been forward looking in anticipating the challenges for sustainable development in the country from the beginning and will continue to focus on finding solutions to those challenges in the emerging favourable policy climate. The key areas of interest under the theme 'Environment, Natural Resources and Agriculture' 2018-2020 will be: (1) Climate change; (2) Environment policies and green economy; (3) Natural resource policies and institutions; (4) Food security; (5) Agricultural productivity and (6) Agriculture value chains.

Climate change: Combatting climate change is a major challenge to be faced in years to come. Adaptation is the key strategy to face the challenge. The IPS has assisted the Climate Change Secretariat of the Ministry of Mahaweli Development and Environment to prepare the National Adaptation Plan for Climate Change impacts in Sri Lanka 2016-2025 and involved in number of other relevant initiatives with government organizations and donor agencies. Successful adaptation to climate threat requires formulating effective policies that can fill existing gaps in areas of information, technology, policy, institutions and resource mobilization. Overcoming these gaps is constrained by high level of risk and uncertainty associated with climate change impacts at all levels. As a way to overcoming this decision uncertainty necessity of adaptive management and policy making approach has been suggested. It is a strategy for making effective decisions under deep uncertainty of climate change by identifying and implementing robust, no-regret policies that would be resilient under a range of uncertain futures. The IPS research on climate change is based on adaptive policy making framework for overcoming the major gaps concerning information, technology, policy, institutions and resource mobilization gaps.

Environmental Policies and Green Economy: There has been an increased emphasis on "greening" the economies worldwide. The world leaders have adopted Sustainable Development Goals (SDGs) in 2015. The essence of SDGs is to transform the global economy towards a green economy. The IPS research on green economy focuses on policy innovations that can ensure sustained flow of ecosystem services from the natural capital of the country while capturing emerging global green economy opportunities.

Natural Resource Policies and Institutions: The objectives of natural resource policies and institutions are to increase the resource use efficiency and sustainable management of natural resources. Livelihoods of many Sri Lankans are dependent on natural resources such as land, water, fisheries and forests to a large extent. Institutions are essential to make sure that these natural resources will be used optimally, ensuring inter- and intra-generational equity. Therefore, IPS research on natural resources focuses on examining existing natural resource policies, existing regimes of property rights and institutions, their strengths/limitations, and ways to improve them.

Food Security: Despite having made significant progress on several of human development and health indicators, Sri Lanka continues to struggle with respect to food security and nutrition. In 2017, The Global Hunger Index (GHI) and Global Food Security Index (GFSI) rank Sri Lanka 85 out of 119 countries), and 66 out of 113 countries indicating moderate performance in food security and serious hunger situation respectively. Sri Lanka has one of the highest rates of acute moderate malnutrition in the world which is defined as the "critical" threshold level by WHO. The National Strategic Review for Food Security and Nutrition Leading to Zero Hunger in 2017 (NSRFSN) done by IPS and World Food Programme (WFP) clearly reveals that food and nutrition security in Sri Lanka, as targeted by SDG2, remains an unachieved social and economic goal in spite of numerous interventions by the government and development partners. Within this background, analyzing the food security situation of the country; evaluating the policy and programmatic responses aimed at improving food security; identifying the gaps in accelerating progress towards SDG2 and finally, examining the issues that hinders the progress towards a food secure nation are utmost priority. Thus, IPS will continue its Food Security Research in line with the government's Vision 2025 to make Sri Lanka.

Agriculture Value Chains: It is understood that the inclusive agribusiness is a powerful tool for raising rural incomes, creating jobs and helping communities adapt to climate change. IPS has been researching on how the rural poor can benefit more fully from integration into markets and trade during the last few years. On the basis of the experience and lessons learned, some of the important questions that have to be addressed include; how public-private-producer partnerships can be expanded; what are the opportunities for and challenges to enhancing access to input and output markets and improving infrastructure; what is the role governments and other partners need to play in creating an enabling policy and institutional environment to promote lasting rural transformation and growth. This complexity of the changing environment has created uncertainty around how to promote inclusive and sustainable approaches and public-private-producer partnerships to generate impact at scale. Thus IPS will continue its Value Chain research to analyze the key features of business models adopted in Sri Lanka and other developing countries in sustainably connecting small farmers with the global value chains.

Agricultural Productivity: Sri Lanka's agriculture sector suffers from low productivity and leads to food insecurity and poverty. The yield levels of domestically grown food crops, including rice, have stagnated during recent times. Yield levels are unimpressive even by developing country standards. This yield stagnation has restricted the potential of increasing domestic food supply in the country. Domestic food production has also been stagnant in recent years along with yield stagnation. The government's Vision 2025 identifies the importance of promoting new technologies to enhance productive, resilience, and diversification in order to align the products to take advantage of global market opportunities. Thus, agricultural productivity and related issues will be one of the main priority themes of IPS for the coming three years.

Research: Environment, Natural resources and Agriculture (2007-2018)

Year	Project
2018	Commercial Insurance for Farmers for Human Wildlife Conflict by Elephants, funded by the International Institute for Environment and Development (IIED)
2018	Economic Analysis of Land and Transport Sector Issues, funded by MCC
2018	Evaluation of Public-Private-Producer-Partnerships (4P) of National Agribusiness Development Programme (NADeP) under IFAD Country Programme Evaluation
2018	Measuring the Impact of New Food Processing Facilities on the Farmer Community in the Northern Region, funded by Avishkaar
2018	Sri Lanka Voluntary National Review (VNR) of the Sustainable Development Goals, funded by UNDP
2018	Inclusive and Sustainable Agribusiness Development through Public Private Producer Partnerships for NADeP/IFAD
2016-2018	Challenges for Adaptation to Climate Change: Bridging the Information and Communication Gap, funded by IDRC
2017	Mainstreaming and Integrating Climate Change Issues into Urban Related policies in Sri Lanka, funded by UN-Habitat
2017	Disaster Risk Reduction and Climate Adaptation in Agriculture Sector in Sri Lanka funded by UNDP
2017	Analysis of Cinnamon, Pepper and Cardamom Value Chains in Sri Lanka for JICA
2017	Export Promotion and Market Access for Agriculture and Food Products in Major Global Markets funded by SAARC Agriculture Centre (SAC)
2017	Climate Insurance for Dry Zone Farmers in Sri Lanka, funded by Global Development Network (GDN)
2014-2017	Value Chain Analysis on Dairy, Fisheries and Rice Sectors in Sri Lanka, funded by National Science Foundation (NSF)
2016	Demand for Micro-insurance in Sri Lanka, funded by IFC
2016	National Strategic Review of Food Security and Nutrition: towards Zero Hunger funded by WFP
2016	Living Wage Estimation for the Plantation Sector in Sri Lanka for Global Living Wage Coalition (GLWC), ISEAL Alliance, London,
2015	Food Standards and Governance in the Tea Industry in Sri Lanka: A Value Chain Analysis for IPS
2016	National Climate Change Adaptation Plan (NAP) for Sri Lanka for Ministry of Environment
2016	A Study on Agricultural Adaptation Practices in Sri Lanka, funded by South Asia Watch on Trade, Economics and Environment (SAWTEE)
2015	Public Investment in Agriculture in Sri Lanka funded by South Asia Watch on Trade, Economics and Environment (SAWTEE)
2014	Evaluation of Progress and Impacts of the Country Studies on the Technology Needs Assessment in Sri Lanka for Institute of Global Environmental Strategies (IGES) of the Ministry of Environment, Japan

Year	Project
2013	Regional Knowledge Networks for Natural Food Security Strategies funded by UNESCAP
2012	Intellectual Property Rights in Protecting Plant Varieties and Farmers Traditional Knowledge in Sri Lanka funded by National Science Foundation (NSF)
2012	Agricultural Pricing and Procurement Policy in South Asia for Global Development Network (GDN)
2011	Role of ICTs in Early Warning of Climate related Disasters: A Sri Lankan Case study
2011	Impact of Migration & Remittances on Agriculture and Food Security: Case of Sri Lanka for IPS
2011	Value Chain Development for Fostering Regional Cooperation in South Asia: Case of Tea Sector in Sri Lanka funded by Research and Information System funded by Developing Countries (RIS)
2010	Trade Poverty Nexus in the Sri Lankan Fisheries Sector funded by UNIDO
2010	Articulating and Mainstreaming Appropriate Agricultural Trade Policies in Sri Lanka funded by Food and Agricultural Organization (FAO)
2009	Mainstreaming Climate Change for Sustainable Development in Sri Lanka, funded by UNESCO
2009	Food Security Situation in Sri Lanka, for Indian Council for Research on International Economic Relations (ICRIER), New Delhi, India
2007	Value Chain Development in Conflict-Affected Environments: Analysis of the Fisheries Sector in Sri Lanka funded by USAID
2007	Innovative Practice in Integrating Small Farmers into Dynamic Supply Chains: A Case of Spice Value Chain funded by International Institute for Environment and Development (IIED), London
2007	Poverty and Social Impact Analysis (PSIA) of Sri Lanka's Land Policy Reforms funded by World Bank
2007	Mapping and Analysis of South Asian Agricultural Trade Liberalization Effort for Asia-Pacific Research and Training Network on Trade (ARTNeT)

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