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Final report

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1 Acknowledgments

The project team acknowledges the contribution of farmers and agricultural extension workers at the two case study sites. We were fortunate to have strong partnerships and hospitality from Benguet State University and Mindoro State College of Agriculture and Technology.

We were challenged by a critical and rigorous Mid-Term Review and a less critical but thorough Final Review. The project team acknowledges the time from reviewers and their suggestions which improved the project.

We deeply appreciated the ongoing encouragement and guidance from the Canberra and Manila office of ACIAR through both difficult and good times.

2 Executive summary

Smallholder farmers in the Philippines are exposed and sensitive to climate, the country is buffeted by over 20 tropical cyclones a year, is strongly influenced by the cycles of El Niño/La Niña and faces changes due to anthropogenic warming. There are many ways to improve the resilience of small-holder farmers including improved infrastructure, new crop varieties and practices and capacity building of farmers and farming communities. The focus of this project is climate information. Access to better climate information is a central plank of Climate Smart Farming. The Philippine government has provided extra resources to improve the capacity of the Philippine met service (PAGASA) to continue the improvement of their forecasts. This project addressed how the information can be incorporated into decision making that improves the livelihoods of smallholder farmers.

We focussed on agricultural extension officers who work with rice and corn farmers on the coastal plain of the island Mindoro and vegetable farmers in the highlands of the main island Luzon (Benguet) in Benguet. These case studies provided contrasting farming systems with specific risks. During the project, the case study site of Benguet was hit by Typhoon Mangkhut (known locally as Ompong) on September 2018, just prior to the mid-term review in October 2018 and Oriental Mindoro was hit in October 2020, a month before the Final Review. Other risks include dry spells, delayed onset of the Monsoon (Mindoro) and frost (Benguet).

The Philippine met service (PAGASA) was both a stakeholder and a co-researcher in this project. The social and economic research was conducted by the Philippine Institute of Development Studies (PIDS) and the University of Philippines Los Baños (UPLB). The fourth Philippine partner was the Agricultural Training Institute that led the development of a a training module for extension officers. Rather than using the international term “climate smart” ATI chosen the Tagalog words *KlimAgrikultura* to reinforce the Philippine context. The program works through the following questions

- What are your weather and climate risks? – use a Crop Climate Calendar to identify risks
- What PAGASA information is relevant to your weather and climate risks? – use a matching tool to link the risk to information
- How do you use the information for decision making? – use decision analysis tools.
- How can we build more climate resilient farming systems?

Information is only valuable if it is used. This project identified weather and climate risks for small-holder farmers and worked on improving decisions in current farming systems with what is available from climate science. This included working on how probabilistic seasonal climate forecasts can be communicated and used in decision making. This improves conversations between climate science PAGASA and agricultural development workers.

In addition to KlimAgrikultura, we have attempted to incorporate most of what we learnt from the project in a Special Issue of the Philippine Agricultural Scientist to be published in 2021.

3 Background

The case for increased investment in disaster risk reduction (DRR) and climate change adaptation (CCA) in the Philippines is compelling. According to the Global Climate Risk Index 2020, published by Germanwatch, in 2018 the Philippines ranked second in countries most affected by climate change based on direct losses and fatalities from extreme weather events, while it ranked fourth among the 10 countries most affected from 1999 to 2018 (annual averages) using the same index (Eckstein, Kunzel, Schafer & Winges, 2019).

Although the challenges are substantial, much is being done on DRR and CCA by the Philippine Government at a national and local scale in partnership with NGOs and donor countries. There is widespread support in the Philippines for the mandated approach of strengthening national agencies to equip Local Government Units (LGUs) and Community Based Organisations (CBOs) to deliver Disaster Risk Reduction and Climate Change Adaptation. In the past, DRR in the Philippines (and globally) has focused more on urban than rural communities. Now there is a growing interest in the Philippines, backed by donors and the FAO and WMO, on how agricultural development can include the lessons from the discipline of DRR to minimise the damage from extreme events and build more climate resilient farming systems.

Applying the urban based discipline of DRR to agricultural livelihoods in the Philippines requires recognition of three key differences.

- Agriculture has a broader interest in climate events: Urban DRR focuses on extreme wind, rain and associated flooding. Farming is sensitive to these events, but requires analysis of a wider spectrum of climate risks including drought and dry spells, heat events, untimely rain at harvest, and delays to onset of the wet season and even frost. Furthermore, resilient agriculture looks to opportunities from climate as well as minimising the risks.
- The response time and recovery stage can be much longer for agricultural production. This is especially the case if fields and fences are damaged along with crops and livestock.
- The unique role of the private sector. Many smallholder farmers in the Philippines are transitioning from subsistence to commercial enterprises. This change means that the risks and opportunities from climate need to be considered in a commercial context with economic analysis. The impact of an extreme climate event may also damage transport links for inputs or access to markets.

An emphasis on action-ready knowledge focuses climate science to identify how information will be used, who is taking action and with what effect. Actionable climate knowledge is required in all four steps of DRR for smallholder farmers. Prevention – developing more climate resilient farming systems. Preparedness – developing understanding and preparing management plans for the risks that can't be prevented. Responding to forecasts and warnings both seasonal (e.g. drought) and short term (e.g. cyclone or excess rainfall) and Rehabilitation and recovery, including the process of redesigning to minimise future damage.

A key term used by DRR is "risk knowledge" which is a hybrid knowledge developed between science and decision makers. This is consistent with the UN Hyogo framework on disaster risk reduction and resilience (UN 2005). In the Philippines, a review of DRR following typhoons Haiyan/Yolanda highlighted deficiencies in risk knowledge (Deutsche GIZ 2014). Similarly, the 2012 Mindanao declaration on DRR in response to typhoon Sendong (Mindanao Declaration 2012) lists 8 points; the first one is knowledge. Developing action ready climate knowledge is a genuine partnership between science and local knowledge. This knowledge is empowering and has significant social benefits. A review of scholarship on disaster risk and uncertainty assessment (Rougier Sparks & Hill 2013) identified three gaps: 1) assessments of risks that are transparent, defensible and credible 2) frameworks to compare actions and 3) implementation and review.

Adaptation to a variable and changing climate is a priority in ACIAR’s ten-year strategy and a high priority for ACIAR engagement with the Philippines. Much has been written about climate smart agriculture emphasising the vulnerability of smallholder farmers to climate and the need for new crops and varieties that fit new farming systems. In this discussion, information from climate science is called upon for evidence that extreme events are becoming more common and that future projections increase the urgency for adaptation. In our reading of material on climate change in the Philippines, there is often a reference to the use of climate information such as warnings and seasonal climate forecasts (Figure 3.1), but limited discussion on how the information can be applied to decision making by smallholder farmers. In this project we are not suggesting another decision support system, but we do see advantages in a closer examination of the decisions made by smallholder farmers.

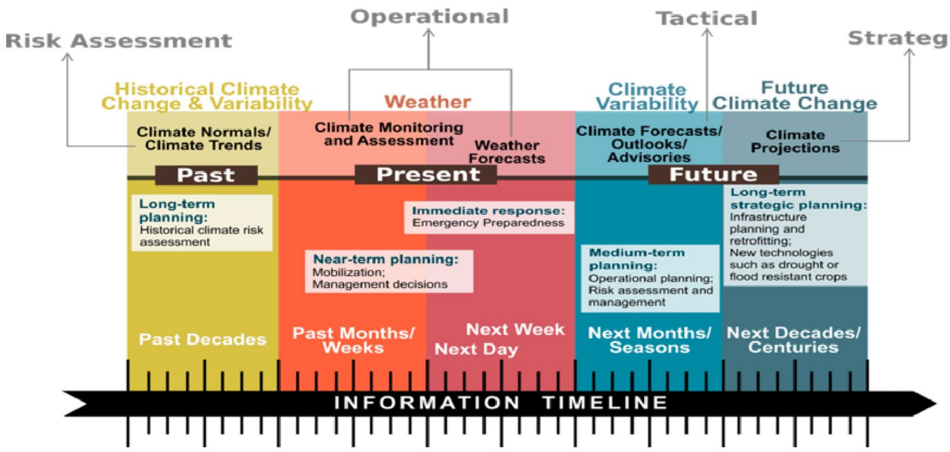

Figure 3.1 Timeline of information available from Hydrometeorological agency like PAGASA. Source World Meteorological Organisation

Types of weather and climate information can be usefully distinguished by time. PAGASA holds historical data for the Philippines, monitors current climate and issues warnings, short-term weather forecasts, seasonal climate forecasts and climate change projections. These different time frames can be used for risk assessment, daily operations (sowing, spraying, harvesting), tactical decisions such as input level that depend on seasonal outlooks and longer-term strategic planning using climate change projections.

Throughout the project we used the simple graphic of Figure 3.2 to identify the niche for the project. An important part of the clarity was to identify what the project wasn’t doing. First there was no intent to conduct applied R&D on the climate science used by PAGASA and second there was no attempt to promote new crops, livestock or farming systems. The focus was on how climate information was being used in decision making and how the flow of information from PAGASA to small farmers and from farmers to PAGASA could be improved.

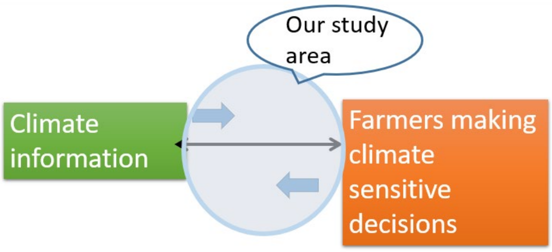

Figure 3.2 Simple graphic showing focus area for the project

To study the interaction between climate information and farmers making climate sensitive decisions we used applied economic research for development including risk matrices, Decision Analysis and simulation modelling. This was complemented by applied social research for development including surveys, focus groups, key informant interviews, social network analysis and cultural domain analysis.

4 Objectives

Aim: Improve the exchange of information between PAGASA and key decision makers involved in managing climate and weather risk of smallholder farmers

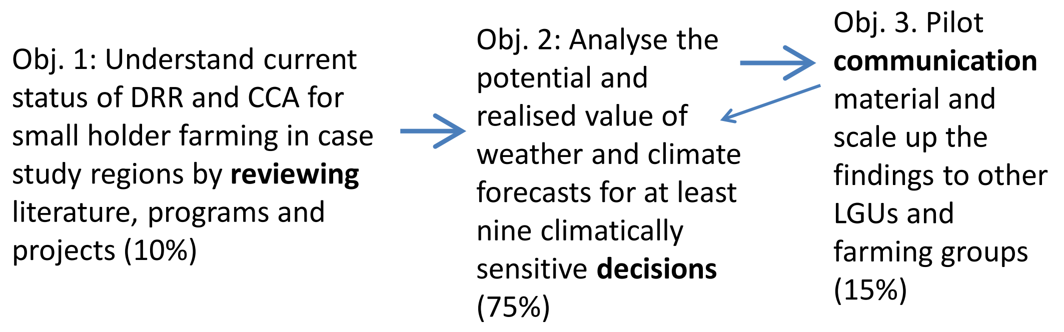

Figure 4.1: Flow of information between the three objectives

This project is focused on the exchange of information between the provider of climate and weather information (PAGASA) and decision makers. An over-riding goal is to discover how information is currently being used, identify barriers (awareness of forecast, skill/accuracy of forecast, communication and timing of forecast, choices and resources) and for each case study show how improvements can be made. The three objectives that support this goal (Figure 4.1) are designed to collate and investigate the current situation (Objectives 1) before using decision analysis and stochastic budgeting to value information in specific decision contexts (Objective 2) and developing pilot communication material (Objective 3). The arrows show the flow of information. The smaller arrow from 3 back to 2 reflects the fact that we planned to develop pilot communication material early and learn from the project. The percentages are a guide to the relative level of resources of time and money allocated.

Objective 1: To understand current status of DRR and CCA for smallholder farming in case study regions by reviewing literature, programs and projects. (10% of resources)

Activity 1.1 Identify case study farming groups and LGUs

Activity 1.2 Work with Bureau of Agriculture to compile past and current RD&E material, programs and projects.

Objective 2: To analyse the potential and realised value of weather and climate forecasts for at least nine decision contexts (75% of resources).

Activity 2.1 Survey how information is currently being used by decision makers and identify barriers (awareness of forecast, skill/accuracy of forecast, communication and timing of forecast, choices and resources).

Activity 2.2 Identify at least one climate sensitive decision in each of the three case study regions. These will be selected from one of the three levels (farm, LGU and value chain). We will assess risks and use decision analysis in an economics framework to determine the potential value of the climate information.

Activity 2.3 Determine the solution that has the highest economic returns and observe the opportunities and barriers to the use of climate information in actual decision making.

Activities 2.4, 2.5, 2.6 & 2.7 Activities 2.4.and 2.5 will address further decisions and assessment of climate risk in an economic analysis in each of the three case study regions with analysis (2.4) and observation of how the analysis fits reality (2.5). Activity 2.6 and 2.7 will take further case studies leading to a total of nine case studies.

Activity 2.8 Summarise the existing survey, FGD, KII and decision analysis conducted by the project to identify a set of conclusions and refined research questions for the project.

Activity 2.9 Workshop on barriers and opportunities for climate information for smallholder farmers with key decision makers from the Department of Agriculture, including ATI, PAGASA and PCCAARD

Activity 2.10 Conduct baseline and end line KIIs and FGD with ATI and agricultural extension workers

Activity 2.11 Co-learning and co-development with extension staff on making climate information useful to smallholder farmers using Crop Climate Calendars and Rapid Climate Decision Analysis.

Activity 2.12 Social network analysis (SNA) focussing on access to different types of weather and climate information.

Objective 3: To develop pilot communication material and scale-up the project findings to other LGUs and CBOs.

Activity 3.1 Develop and implement an external communication plan for the project

Activity 3.2 Policy briefs developed and delivered

Activity 3.3 Testing presentations for extension workers of more detailed climate information from PAGASA

Activity 3.4 Co Production of Crop Climate Calendars and Rapid Climate Decision Analysis guidelines with PAGASA

Activity 3.5 Pilot testing of KLIMAgrikultura with 30-40 extension workers in Benguet and 50 -60 in Mindoro

Activity 3.6 Partner with regional Universities to develop ATI training material that can be used past the life of the project in graduate diploma courses, on-line training and workshops

Activity 3.7 Workshop hosted by PAGASA with key agriculture stakeholders on next steps for communication of climate information for smallholder farmers

5 Methodology

The methodology section is organised by first describing the case study sites (5.1) and then providing details on applied economics (5.2), social science (5.3) applied climate science (5.4) and the development of communication packages including KlimAgrikultura (5.5). A linear approach to knowledge development might have organised for the social science and climate science to provide insights for the applied economics which would lead into the learning package. In this project these different disciplines benefited from interaction and some of the more detailed social science was undertaken in the final stages of the project.

The mid-term review held in October 2018 recommended tighter project management and improved rigour in social research, especially in the data collection. The review also recommended a focus on extension staff and the farm level rather than all parts of the value chain from farm supplies to traders of the end-product. The re-focusing that we did in response resulted in a much improved project.

5.1 Case study sites

Initial site selection included the following selection criteria:

- Significant level of smallholder agricultural activity present and representative farming systems
- Regions where agriculture is subject to weather and climate risk
- Willing provincial local governments
- Partnerships with local universities
- Climate data available from PAGASA and availability of agriculture and socio-economic data

We initially selected three case studies: High value horticulture in Benguet in central Luzon, corn and rice in Mindoro and corn, rice and vegetables in Leyte. Following the mid-term review we focussed on Benguet and Mindoro. These sites provided a contrast in farming system (intensive vegetable production compared to extensive rice and corn) and in geography/climate (highlands of central Luzon compared to coastal plains for rice and corn in the island of Mindoro). Strong partnerships were formed between PIDS and Benguet State University and UPLB worked closely with Mindoro State College of Agriculture and Technology.

Benguet is a mountainous area and the major vegetable production region due to the cooler climate compared with other Provinces. There are two seasons of roughly equal duration: the wet season from May to October, and the dry season from November through to April. Tropical cyclones occur most years during the wet season, with many reaching typhoon intensity.

Oriental Mindoro is a major rice and corn producing region. The climate is generally humid, with no pronounced maximum rain period and a dry season lasting only from one to three months around March. Tropical cyclones are most likely around November and December.

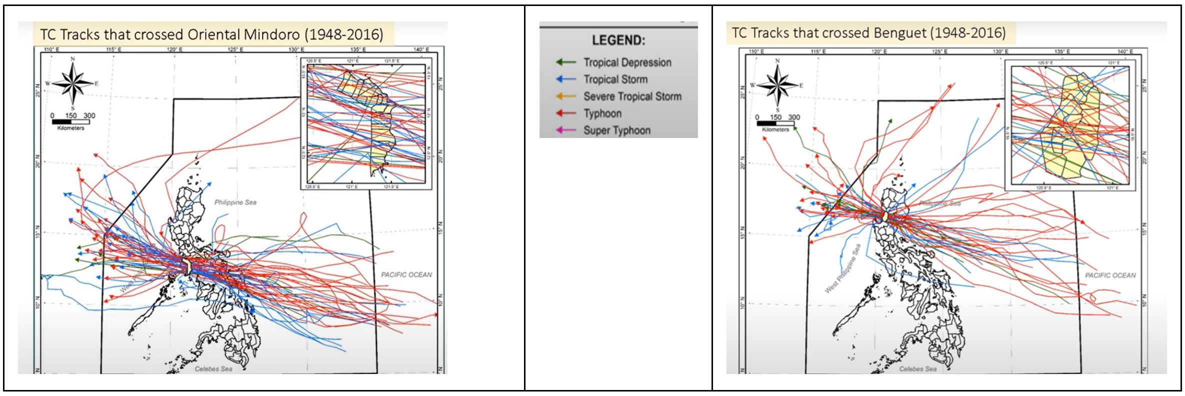

Figure 5.1 maps showing the tracks of tropical cyclone (TC) crossing Oriental Mindoro (left panel and Benguet (right panel).

As shown in Figure 5.1, both Mindoro and Benguet are highly exposed to tropical cyclones and the associated damage from wind and flooding. During the project, the case study site of Benguet was hit by Typhoon Mangkhut (known locally as Ompong) on September 2018, just prior to the mid-term review in October 2018 and Oriental Mindoro was hit in October 2020, a month before the Final Review. Other risks include dry spells, delayed onset of the Monsoon (Mindoro) and frost (Benguet).

5.2 Applied economics

Applied economics was the discipline that underpinned much of the activity of this project. We focussed on the field of Decision Analysis and the related subject of Value of Information. Different forms of Decision Analysis are regularly used in agricultural economic studies, including studies on climate risk. It is common for the results of this desktop analysis (value of the forecast is x peso per hectare) to be published in peer review literature and summarised in extension material. In some cases the output of the analysis is presented as a Decision Support System. It is rare in the Philippines or Australia for the method and concepts behind decision analysis to be transferred to intermediaries working on the interface between climate information and agricultural decision making. This was the challenge for the project to codify the logic and methods of Decision Analysis rather than the results of Decision Analysis.

It is important to distinguish our use of Decision Analysis from the production of Decision Support Systems as a tool for farmer decision making. We are not using Decision Analysis as a prescription of how people should make decisions, but as a tool to highlight areas of investigation where weather and climate information could be valuable to farm and LGU decision making. It is employed to examine the structure of farming decisions in the same manner that a microscope would be used by a scientific researcher to examine the structure of, say, a microbe. The purpose of this examination of the decision structure is to highlight the potential value of weather and climate forecasts. The three main steps to achieve this are to describe (a) the situation without the forecast information, (b) the situation with the forecast information, and (c) the differences between these two situations to indicate, among other things, the value of the forecast. In the description that follows, the important outcome is not whether the "right" answer has been obtained, but what the analysis tells us about the situation and its information needs.

Although most of the effort was with Verbal Decision Analysis and Rapid Climate Decision Analysis, the UPLB team also used Monte Carlo simulation (Diona et al. #11) and 30 years of local weather data from the Calapan case study site along with representative soil data to parameterize the Decision Support System for Agro-technology Transfer (DSSAT) for maize production. Monte Carlo simulation and 30 years of weather data used in the simulation model generates a series of cumulative distributions for different management options. Not only does the probability distribution provide information for further risk analysis, but relevant for extension workers there is also a rich set of information about on-farm risk management contained in the graph.

5.3 Social sciences

Decision analysis can over-emphasise a single decision maker. To overcome this problem we used social network theory and analysis of Agricultural Knowledge Information Systems (AKIS) to identify the networks of influence and information. Their methods examine key relationships between entities including farmers, their advisors, local government, the media and PAGASA. In doing so we describe the role played by traditional knowledge, farmer experience, media and agricultural advisers. We include climate change vulnerability and adaptation, but also focus on sources of information for short-term weather, disaster warning and seasonal climate information.

The social science methods of inquiry included surveys, key informant interview, focus groups, ethnographic surveys including cultural domain analysis and social network analysis.

5.3.1 Surveys, key informant interviews and focus groups

The earlier part of the project relied more heavily on surveys to understand behaviour and attitudes to climate risk and weather and climate information.

Methodology of sample selection

In Benguet, PIDS and BSU used the Registry System for Basic Sectors in Agriculture (RSBSA) lists of Atok and La Trinidad as an initial base. The list was verified with the barangays' list of farmers/farmworkers. PIDS selected municipalities and then narrowed further to major crops (Atok) and cutflower (La Trinidad). The Sample size was at 254 covering those registered as explicitly producing high value crops (cutflowers, carrot, potato, and cabbage), with a computed confidence level of 90% and a margin of error of 5%.The chance of being interviewed was calculated using a "rand" command in the excel-stratified sampling. The highest scores (e.g. 0.99; 0.98) were then culled-out from the list until the required sample was reached.

In Mindoro, five large Barangays were selected from the 34 Barangays based on their area, number of farmers and production. The number of farmers interviewed in each of the 5 Barangays was calculated as follows: (No. of rice farmers in the Barangay/Total No. of farmers) x Sample size. The G*power software (Faul et al. 2007) was used. UPLB added a further 25 to the 199 recommended by G*Power. Within each of the five Barangays, farmers were randomly selected from lists. Additional numbers/farmers were also drawn to serve as replacement in case of refusal of the original sample farmers selected.

Following the mid-term review we relied less on quantitative surveys and more heavily on focus groups and key informant interviews. The exceptions were surveys of the weather and climate needs of 200 smallholder corn farmers in Bulalacao, Mindoro (Losloso et al. #5) and an opportunistic survey of responses to warning and recovery from Typhoon Ompong which affected Benguet in September 2018 (Launio et al. #6). Table 5.1 lists the different social research engagements in the later part of the project.

Table 5.1 Social research engagements in the later part of the project.

July 2019 Calapan (Rice)	Cultural Domain Analysis CDA	Group workshop with 10 rice farmer leaders
July 2019 Gloria (Corn)	CDA	Group workshop with 6 corn farmer leaders
Sept 2019 Calapan (Rice)	Rapid Ethnographic Assessment	Participant observation, in-depth qualitative data gathering, cultural mapping, and narrative analysis in the study site with the farmer leader (1st part)
Oct 2019 Calapan (Rice)	CDA	CDA individual surveys with 20 respondents from Barangay Biga1.
Oct 2019 Calapan (Rice)	Rapid Ethnographic Assessment	Participant observation, in-depth qualitative data gathering, cultural mapping, and narrative analysis in the study site with the farmer leader (2nd part)
Sept – Nov 2019 Calapan & Gloria (Rice and corn)	Social Network Analysis	260 individuals Rice in Biga, Calapan and 156 individuals (83 corn farmers, 36 rice farmers, 35 vegetable farmers, 1 extension worker, and 1 government worker) from Narra, Gloria.
Oct – Dec 2019 Atok (Vegetable production)	Social Network Analysis	239 households from 3 communities in Atok (119 in Proper Paoay, 74 in Tulodan, and 46 households in Macbas)
Feb 2020 Gloria (Corn)	Rapid Ethnographic Assessment	Participant observation, in-depth qualitative data gathering, cultural mapping, and narrative analysis in the study site with the farmer leader
Feb 2020 Gloria (Corn)	CDA	CDA individual surveys with 20 respondents from Barangay Narra.
September 24, 2019 Benguet (Vegetable production)	Local Knowledge Supplementary data collection	FGD in Paoay, Atok for the local knowledge, and gender; KIIs and participant observation in La Trinidad for case study of Typhoon Ompong
October 4, 9-11, 18-19 Benguet (Vegetable production)	Local Knowledge/Gender supplementary data collection	Key informant interviews, follow-up interviews, and 2 FGDs in Cattubo for the supplementary data collection for gender, local knowledge; traditional indicators; KIIs for Case Study of Typhoon Ompong
Feb 16, 18, 2020 (Vegetable production)	Key informant interviews	Immediate aftermath of Typhoon Ompong OPAG,PDRRMC,NEDA,OCD

5.3.2 Cultural Domain Analysis

A cultural domain is a set of related items, themes, concepts, or statements on a single topic. Social scientists from UPLB conducted cultural domain analysis (CDA) to assess how rice and corn farmers in the selected study sites in Oriental Mindoro, Philippines interpret and organize the different types of *lagay ng panahon* (weather and climate conditions) that they experience and utilize for their agricultural management decisions. Although there are numerous PAGASA products available to farmers mainly through television or radio broadcasts, it would be problematic to assume that farmers organise their local knowledge about the weather and climate in a similar manner to that of PAGASA by reducing and classifying observable data into categories like advisories, forecasts, and warnings. The CDA was guided by the following research questions and corresponding objectives:

- How do rice and corn farmers understand and interpret the weather and climate conditions? - comprehensively document the terms related to weather and climate conditions in the farmers' vocabulary;
- Which information about the weather and the climate matters according to the farmers? - assess how farmers categorize and construct their knowledge on the weather and climate conditions, including its utilization for farm decisions; and
- Are there equivalent PAGASA products for these? - compare the farmers' knowledge system with that of the PAGASA categorization.

CDA workshops were conducted with 10 rice farmer leaders in Barangay Biga, Calapan City, and 6 corn farmer leaders in Barangay Narra, Gloria on July 4 and 5, 2019, respectively. At both locations, free listing was used to elicit all items under weather and climate and a taxonomic tree was produced through a pile sorting exercise. The importance of each item on the free list was then ranked. CDA individual surveys were conducted with 20 further farmers from Barangay Biga on October 4, 2019, using the free list from the initial workshop. Pile sorting and paired comparison were also conducted. Specific testing showed there was no clear evidence of subcultural variation, and an aggregate proximity matrix determined the similarity of the items with one another. Results from these individual surveys were compared with the results from the initial group survey. The third data collection activity was the Rapid Ethnographic Assessment done by UPLB anthropologist Clarissa Ruzol from 12-17 September 2019 and 1-6 October 2019 in Barangay Biga. Local knowledge about the weather and climate conditions and how it is related to the farming decisions were explored, and generated qualitative data about knowledge construction, collective action, motivations, and important factors in farm decisions through participant-observation, cultural mapping, and narrative analysis. These were also insightful in explaining the structures of information flow and social relations among farmers in the social network analysis study.

5.3.3 Social Network Analysis

The aim of this Social Network Analysis (SNA) is to assess how farmers in selected sites access and utilize the different types of weather and climate information and to understand the role of social networks in the delivery of W&C information between and among smallholder farmers and other non-farmer actors.

The SNA involved clear planning and productive discussion between PIDS and UPLB on their differences in approach of using full household census vs snowballing. The software package UCINET (Borgatti et al 2002) was used by both PIDS and UPLB to visualize the networks and generate network parameters such as degree centrality, betweenness centrality, and network density, to determine the potentially influential nodes.

The PIDS team conducted a full household enumeration across 3 sitios in Atok, Benguet. These were Proper Paoay in Barangay Paoay, and Tulodan and Macbas in Barangay Cattubo, which are considered major producers of cabbage, carrots and potatoes. Although a full enumeration was ideal, there were substantial difficulties during the field survey which prevented full enumeration. Based on the official list of households obtained from the local government, the total number of interviews expected was 315 households, but in the event, only 239 (119 in Proper Paoay, 74 in Tulodan, and 46 households in Macbas) were interviewed using a structured survey instrument administered through face-to-face interviews from October to December 2019.

UPLB targeted their SNA at the individual farmer level across two Barangays: Barangay Biga in Calapan (primary rice producing area) and Barangay Narra in Gloria (corn). Full enumeration of farmers only (not households as in the case with PIDS) was implemented using the lists provided by the Municipal Agricultural Office. A snowballing method was also implemented to capture any hidden population of farmers or those that were not included in the list. These may include farmers who do not reside within the area, or may have been missed on the official MAO list. With snowballing, respondents in the first stage, also known as the focal nodes of the network, determine who the respondents will be in the following stages, i.e. their sources and recipients of W&C information. Surveys were conducted from September to November 2019 (3 months). The snowballing method generated a total of 261 nodes in the Biga network and 160 nodes in the Narra network. Nodes in the network were multi-modal including farmers, extension workers, television, radio, and the moon calendar. The network population was derived from responses of 260 individuals (rice farmers) in Biga and 156 individuals (83 corn farmers, 36 rice farmers, 35 vegetable farmers, 1 extension worker, and 1 government worker) from Narra.

5.4 Climate Science

Although DOST PAGASA was the main partner in this project, this was not a climate science project. It was clear from pre-project discussion with partners that we would conduct R&D on how to apply the climate science from PAGASA rather than R&D on the climate science. This application of climate science can be summarised as meeting five broad needs that were highlighted from end user engagement throughout the project.

- Task 1 the need to produce simpler or 'laymanized' explanations of climate science.
- Task 2 extension workers and farmers were unaware of the range of PAGASA products that were currently available

These two tasks are described in the section 5.5 on KlimAgrikultura.

- Task 3 the need for more localised data for forecasts and climate change projections

Smallholder farmers and their advisers are aware of climate change, but not sure what it means for their location. Projections of future climate from global climate models is usually at a 150 km grid. This is problematic for the Philippines. Climate change projections for a 25km grid of daily rainfall and temperature for the case study sites were extracted for RCP 4.5 (moderate) and RCP 8.5 (high) emission scenarios.

The Regional Climate Models (RCMs) require bias correction using quantile mapping (Perez et.al. 2017) to offset the distributional and spatial biases in precipitation outputs (Cannon et al. 2015). RCM historical data were "trained" with the observed climate data to improve the accuracy of the estimate while maintaining the trend. To present the range of possible future changes, the multi-model median of the RCP 4.5 seven (7) and RCP 8.5 eleven (11) ensemble members were calculated, along with the 10th (lower bound) and

90th (upper bound) percentiles, and then presented using the Climate Information Risk Analysis Matrix (CLIRAM) tool (Daron et al. 2018).

- Task 4 Clarification of PAGASA categories for seasonal forecasts

The dominant method of communicating seasonal rainfall forecasts in PAGASA is by using rainfall categories. Categories are based on the percent of average rainfall and are split by PAGASA as follows: Way Below Normal (forecast rainfall is less than 40% of the average), Below Normal (40–80% of the average), Normal (80–120% of the average), Above Normal (120–160% of the average) and sometimes Way Above Normal (more than 160% of the average). The forecast is given as a map of the Philippines highlighted to show the most probable category in each region.

Although the percent of normal has the advantage of being vaguely understandable in that the forecast was for one of the above five categories, feedback from end user engagement showed that smallholder farmers and their advisers didn't understand exactly what the categories such as Below Normal meant. To assist in interpreting these categorical seasonal rainfall forecasts, a Microsoft Excel spreadsheet was created to allow users to enter monthly historical rainfall. This gives a historical perspective on the distribution across categories (climatology).

A further limitation in using a categorical system is that an end-user can't identify how the forecast shifts the probability from climatology. For example, a forecast of 60% chance of rainfall being in the Below Normal category might be a statement of the climatological odds or there may be information from the forecast. Through engagement with end-users in Calapan, Mindoro it was found that many expressed difficulties in interpreting the forecasts.

The spreadsheet was set up to work with any site, but we started with Baguio and Calapan, both of which span from 1951–2019. These relatively long-term datasets allow for a reliable analysis of historical values and provide a baseline for seasonal climate forecasts. Any missing rainfall values were filled using an APHRODITE gridded dataset (Yatagai etal. 2018). We focussed on the 30-year period 1981-2010 as this is the base period used by PAGASA when calculating the rainfall categories.

- Task 5 The need for probabilistic forecasts

The demand for probabilities from PAGASA was generated by PIDS and UPLB working with Decision Analysis. Hydrometeorological services like PAGASA don't generate a single forecast, rather they use a range of models and ensemble runs to produce many possible future climates. The range of future rainfall amounts for the coming months might have a general swing to wetter or drier or be evenly distributed between wetter and drier. There is valuable information in the spread of the future climates with a narrow spread indicating higher confidence. There are good reasons to express seasonal climate forecasts as probabilities. Not only does a probability distribution provide the most complete and honest version of the forecast, but the use of probabilities also acknowledges uncertainty and encourages risk management by end users.

Although climate scientists understand forecasts as shifts in probability distributions, many have found that it is easier to communicate deterministic forecasts (it will be wet) and let users apply their own experience in determining how much confidence to place in the forecast. Decision Analysis provides a framework to decide whether to use the forecast based on solving a climate risky decision with, and without, a forecast. This comparison requires a probability distribution for climatology and a revised probability distribution for the forecast.

5.5 KlimAgrikultura and communication

The third objective of the project was to develop pilot communication material and scale-up the project findings to other LGUs and CBOs extension activity. Outputs from the project include Crop Climate Calendars along with frameworks and spreadsheets to link uncertain climate information to risky, on-farm decisions.

Hadrian Aguilar (ATI) suggested the name of “KlimAgrikultura” for the project training material that links information from PAGASA to smallholder farmers through the pathway of Agricultural Extension Workers (AEWs). KlimAgrikultura are Tagalog words understandable in English but providing a strong message that this is a Philippine take on climate smart agriculture. KlimAgrikultura works through four questions.

- What are your weather and climate risks? We use a Crop Climate Calendar as one means of identifying risks, but there are other forms of enquiry investigated by social scientists from UPLB such as cultural domain analysis which offers insights into how farmers and extension workers categorise weather and climate.
- What PAGASA information is relevant to your weather and climate risks? – In some cases farmers and extension workers already know the information, but workshops and surveys show that this is uneven across regions and across types of information. For example there is a much higher awareness of warnings than there is of seasonal climate forecasts. We developed a simple matching tool to link the risk to information from PAGASA.
- How do you use the PAGASA information for decision making? In some cases the decision choice is clear based on the forecast. It is more difficult to use a forecast that is expressed as a shift in probabilities. In these cases we have found that decision analysis is useful.
- How can we build more climate resilient farming systems? This is an important final question and fits into programs that ATI are promoting. Our argument is that building up to this higher level question benefits from a detailed look at risks, the information available and decision making.

Pilot exercises with KlimAgrikultura indicated a strong demand for simplified scientific climate knowledge from PAGASA. Smallholder farmers and their advisers have an interest in weather and climate science, but the interest is primarily practical. This is expressed not just wanting to know what the weather will be (forecast of event), but also interest in what the weather will do (impacts and hazards) and what can be done to manage the risk. A framework used by PAGASA is the domino or cascading effect framework that distinguishes between hydrometeorological events such as a tropical-cyclones, primary hazards such as heavy rainfall and wind and secondary hazards such as flooding. The further steps of identifying the crop risks and actions taken to manage these risks is empowering for smallholder farmers, but it is also valuable information for PAGASA. In this way KlimAgrikultura has the potential to encourage co-learning between the providers and the users of climate information.

An important contribution has been to organise the DOST-PAGASA information into a format that could be matched to risks and decisions. This is the exercise of cataloguing the information by time frames (warnings, short-term weather, seasonal climate and climate change) and parameters (rain, wind, temperature etc). See Appendix 1 for the PAGASA document on forecast information.

6 Achievements against activities and outputs/milestones

Objective 1: To understand current status of DRR and CCA for smallholder farming in case study regions by reviewing literature, programs and projects. (10% of resources)

no.	activity	outputs/ milestones	completion date	comments
1.1	Identify case study farming groups and LGUs	Report identifying the selection of case studies including criteria for selection.	Dec 2016	Report providing criteria for case studies submitted in 2017. We initially selected three case studies: High value horticulture in Benguet in central Luzon, corn and rice in Mindoro and corn, rice and vegetables in Leyte. Following the mid-term review we focussed on Benguet and Mindoro.
1.2	Work with Bureau of Agriculture to compile past and current RD&E material, programs and projects.	Annotated bibliography of past and current RD&E on climate and weather impacts on Philippine Agriculture with special emphasis on case study farming systems. This will include a review of agroclimatic indices used in literature. Journal publication.	June 2017	Report submitted with 2017 annual report. PIDS led the review of Climate change adaptation and disaster risk reduction. A project officer working from Charles Sturt University used an applied economics lens to review the literature (published and unpublished) along with current and recently completed projects. UPLB team provided information on SARAI which is the DOST funded project on climate risk and PAGASA covered agroclimatic indices. We did not proceed to journal publication but some of the review was used in the final special issue.

PC = partner country, A = Australia

Objective 2: To analyse the potential and realised value of weather and climate forecasts for at least nine decision contexts (75% of resources)

no.	activity	outputs/ milestones	completion date	comments
2.1	Survey how information is currently being used by decision makers and identify barriers (awareness of forecast, skill/accuracy of forecast, communication and timing of forecast, choices and resources).	Report on the current use of information and sources of information and a ranking of enabling factors and barriers to the effective use of information	June 2017	Report submitted with 2017 annual report and included input from key informants on: 1) perceived changes to climate, 2) impacts of climate and weather on agricultural production, 3) decisions that are made to manage risks and adapt to changes, and 4) sources of information on weather and climate including barriers to the use of this information in decision making. Use of climate information is addressed in the special issue. For the Mindoro case study see Ruzol et al. (#3),Losloso et al. (#5) and Gata et al. (#8). For the Benguet case study see Tabuga et al. (#4), Launio (#6) and Launio et al. (#7).

no.	activity	outputs/ milestones	completion date	comments
2.2	Identify at least one climate sensitive decision in each of the three case study regions. These will be selected from one of the three levels (farm, LGU and value chain). We will assess risks and use decision analysis in an economics framework to determine the potential value of the climate information.	Report providing decision context, decision trees and Excel spreadsheet with solved decision. Journal publication.	Dec 2017	Activities 2.2 to 2.7 indicated that we would address at least nine decisions from three case studies and three levels (farm, LGU and value chain). We were encouraged by the mid-term review in October 2018 to focus on farm-level decisions for two case study regions. As shown as part of Table 7.1, we identified 19 climate sensitive decisions. Fifteen of these decisions are at the farm level and 10 have been analysed and submitted in the 2018 and 2019 annual reports. Papers in the special issue provide analysis of decisions for vegetable production in Benguet (see Domingo et al. #9) and rice and corn in Mindoro using RCDA (Diona et al. #10) and Monte Carlo simulation (see Diona et al #11). Following the mid-term review we emphasised transferring ways of thinking about uncertainty through Verbal Decision Analysis and Rapid Climate Decision Analysis.
2.3	Determine the solution that has the highest economic returns and observe the opportunities and barriers to the use of climate information in actual decision making.	Report of the observations & reflections that show the limits to application of climate information. Refined decision tree. Journal publication.	Dec 2018	This objective was amended in accordance with the mid-term review. Please see note in Activity 2.2
2.4, 2.5, 2.6 & 2.7	Activities 2.4 and 2.5 will address further decisions and assessment of climate risk in an economic analysis in each of the three case study regions with analysis (2.4) and observation of how the analysis fits reality (2.5). At each case study region, the decision will be at different levels (farm, LGU or value chain) than Activities 2.2 and 2.3. Activity 2.6 and 2.7 will take further case studies leading to a total of nine case studies. As shown in Gantt chart, Activity 2.4 will be completed by June 2018 and 2.5 June 2019. Activity 2.6 to be completed Dec 2018 and 2.7 December 2019. It is anticipated that there would be further journal publications associated with each of these three activities.			Please see note in Activity 2.2

no.	activity	outputs/ milestones	completion date	comments
2.8	Summarise the existing survey, FGD, KII and decision analysis conducted by the project	Short report outlining conclusions of previous work in Benguet and Mindoro. Prepared by SARDI and agreed by rest of team.	April 2019	As requested from the mid-term review we submitted a summary of the survey, focus group discussion and key informant interviews that had been conducted up to that point. This was included in the 2019 annual report. A handout on engagement activities supplied during the Final Review provided an update since the mid-term review (Oct 2018). This included the social research.
2.9	Workshop on barriers and opportunities for climate information for smallholder farmers	Half-day workshop held. Report covering the main conclusions from the workshop with follow up issues identified. Hosted by PAGASA with contribution from all partners	May 2019	Workshop held with key stakeholders at PAGASA in Quezon City, Wed May 29 2019. Report submitted as part of the July 2019 annual report. 22 stakeholders attended and contributed to what they saw as the main pathways and obstacles for information flow of warnings, short-term weather forecasts, seasonal climate outlooks and climate change projections. All attendees were invited to the final stakeholder meeting on 18 November 2020.
2.10	Conduct baseline KIIs and FGD with agricultural extension workers	Report on the baseline of extension workers knowledge on climate information, their perspectives on the barriers and opportunities for use of the information and identification of opportunities for co-production. Led by: PIDS (Benguet) and UPLB (Mindoro).	May 2019	Participant surveys held and reported as part of the KlimAgrikultura presentation on 18th November 2020 and in the Special Issue (see Cinco et al. #2). Following the advice of the mid-term review we placed more emphasis on capturing the attitudes and perspectives of the extension workers. PIDS held KII with extension workers in Benguet April 15-16 2019. UPLB met with local extension officers working on climate risk in rice Calapan, Mindoro (June 25 2019) and climate risk in corn at Gloria, Mindoro (June 27 2019).

no.	activity	outputs/ milestones	completion date	comments
2.11	Co-learning and co-development with extension staff on making climate information useful to smallholder farmers using Crop Climate Calendars and Rapid Climate Decision Analysis	A report with updates for the July 2019 annual report and final report in May 2020 The report will include end line KII and FGD with extension officers and cover the strengths and weaknesses of Rapid Climate Decision Analysis Led by: PIDS (Benguet) and UPLB (Mindoro)	Nov 2020	As shown in Appendix 3 and 4, there have been six co-learning exercises in Mindoro led by UPLB and four in Benguet led by PIDS. As part of these engagements we have revised Rapid Climate Decision Analysis to include Verbal Decision Analysis which uses words to describe the logic of the decision choice, the climate state and the outcome. The VDA is more likely to be used than the Rapid Climate Decision Analysis. Furthermore, we have developed KlimAgrikultura as an umbrella that includes components including information from Crop Climate Calendars and risk matching with PAGASA products. As reported in Cinco et al. (#2) and the Final Review presentation from Hadrian Aguilar from ATI, we have responses from participants of KlimAgrikultura.
2.12	Social network analysis (SNA) focussing on access to different types of weather and climate information	SNA mapped and report submitted Led by: PIDS (Benguet) and UPLB (Mindoro)	Preliminary report Dec 2019, final report Nov 2020	The social network analysis in Mindoro and the highland region of Benguet is described in the Special issue (see Ruzol et al. (#3) and Tabuga et al. (#4)) Details of the SNA in Benguet and Mindoro were presented at the final review on Tuesday 24 Nov and Wednesday 25 Nov respectively.

PC = partner country, A = Australia

Objective 3: To develop pilot communication material and scale-up the project findings to other LGUs and CBOs.

No.	Activity	Outputs/ Milestones	Completion date	Comments
3.1	Develop an external communication plan for the project	A communication plan that identifies the key audience and timetable for policy briefs (3.2), PAGASA information (3.3, 3.4) KLIMAgr(3.5) and module for university teaching (3.6). Led by ATI	June 2019	Plan developed and submitted to ACIAR as part of 2019 annual report.

No.	Activity	Outputs/ Milestones	Completion date	Comments
3.2	Policy briefs developed and delivered	Policy briefs with concise summaries of findings and implications written, reviewed and delivered.	Preliminary report Dec 2019, final report Nov 2020	Policy briefs developed, but not finalised and circulated. In this final report we have prepared a set of recommendations which we plan to combine as a policy brief.
3.3	Testing presentation of climate information from PAGASA	A report discussing the reasoning behind presenting uncertain but skilful climate information and different approaches tested with a range of PAGASA's clients with an emphasis on extension staff. Led by PAGASA	Preliminary report Dec 2019, final report Nov 2020	See spreadsheet developed by SARDI in cooperation with PAGASA, described in special issue (Cinco et al. #2). A discussion document on presenting uncertain forecasts and the importance of conveying the full spread of forecasts was included in 2019 annual report Attachment 12.
3.4	Co-Production of Crop Climate Calendars and Rapid Climate Decision Analysis guidelines with PAGASA	The production and testing of a codified approach to Crop Climate Calendars and Rapid Climate DA for PAGASA to use with their agricultural stakeholders Led by SARDI and CSU working closely with PAGASA, PIDS, UPLB and ATI	Preliminary report Dec2019, final report Nov 2020	PAGASA have been very involved in the development and pilot testing of KlimAgrikultura, including Crop Climate Calendars. PAGASA have developed the Payong PAGASA mobile app to include an additional module of seasonal probabilistic forecast to accommodate future use of Rapid Climate Decision Analysis.
3.5	Pilot testing of KLIMAgrikultura with 30 to 40 extension workers in Benguet and 50 to 60 in Mindoro	KLIMAgrikultura training module on access and use of PAGASA material and RCDA released and evaluated with 90 to 100 agricultural technicians Led by ATI	Dec 2019	Testing has been limited by Covid. However in addition to the co-development process, KlimAgrikultura has been pilot tested with 39 extension officers (10 Benguet 22 Mindoro and 7 Leyte) and 41 farmers (7 Benguet, 12 Mindoro and 22 Leyte.
3.6	Partner with regional Universities to develop training material that can be used past the life of the project in graduate diploma courses, on-line training and workshops	Training module tested and made live online. Available through ATI E-extension and partner universities in Benguet and Mindoro Led by SARDI and CSU with support from ATI	Nov 2020	Not achieved. We have focussed on getting the material together for activities 3.4 and 3.5. We have had preliminary discussion with ATI and hope to continue discussion.

No.	Activity	Outputs/ Milestones	Completion date	Comments
3.7	Workshop for key policy and decision makers on next steps for communication of climate information for smallholder farmers	Workshop proceedings that include the key findings and policy briefs from the project Participants to include Dept. of Agriculture, including senior ATI, PAGASA and PCCAARD.	Nov 2020	Workshop held online on 18^{th} November 2020.

7 Key results and discussion

This section on key results and discussion is set out to match the methodology sections on applied economics (5.2), social science (5.3) and applied climate science (5.4).

7.1 Applied Economics

As outlined in the methods section, we are more interested in the process of Decision Analysis (Figure 7.1) than the answer provided by Decision Analysis.

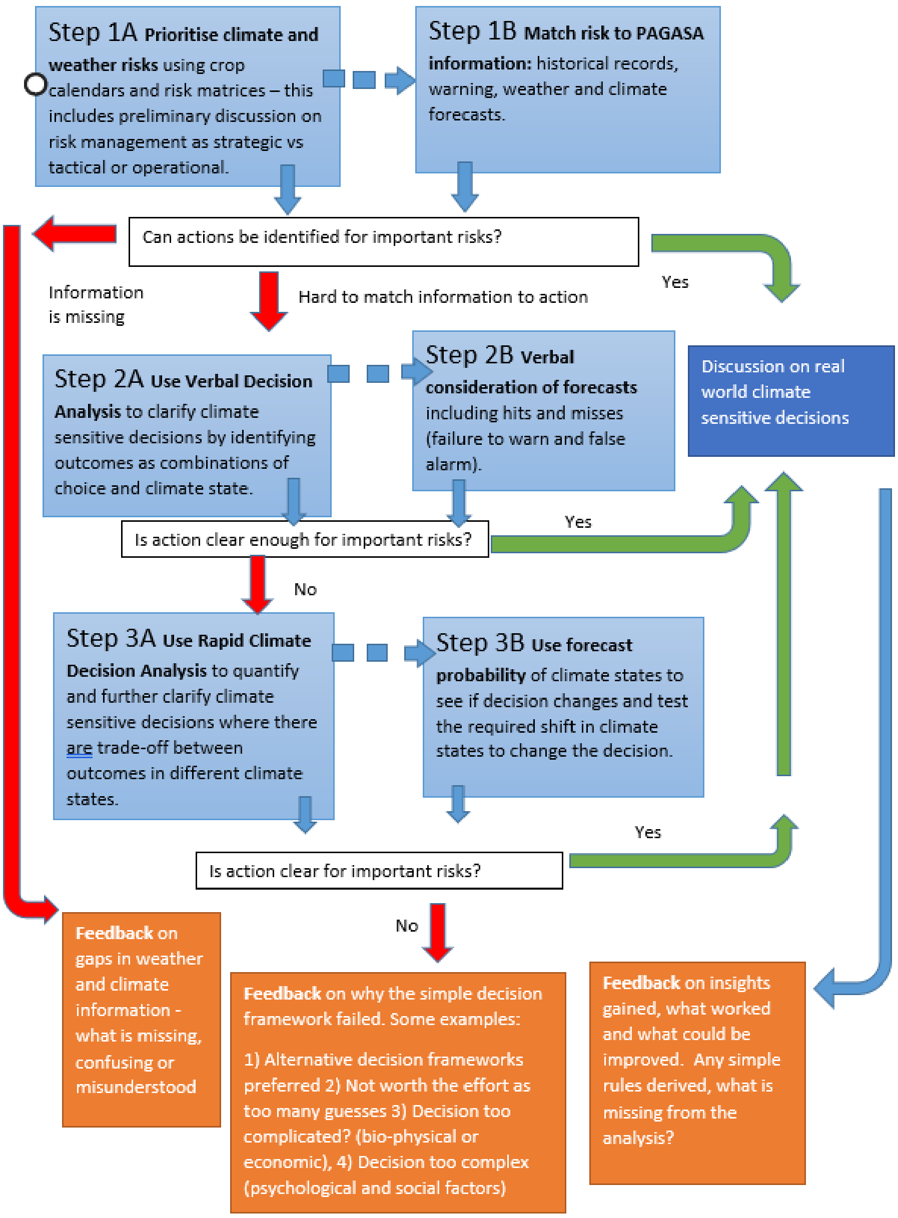

Figure 7.1 Flow diagram for the process of providing action ready climate information.

The key question is whether there is clarity on the next action. That is, can the required action be identified in terms of its important risks? – first without verbal decision analysis, if not, move to verbal decision analysis. Now can the required action be identified in terms of its important risks? If not, move to Rapid Climate Decision Analysis (RCDA). If the action still can't be identified using RCDA, then some component of the information feedback in the lower middle box of Figure 7.1 would be obtained. The purpose of engaging with end-users in this way is to generate discussion on real world climate sensitive decisions (dark blue box on right hand side). By climate sensitive decisions we are referring to alternative actions where the 1) outcome matters to the decision maker and 2) the best choice is only known in hindsight as it differs depending on the state of the climate. For example, in a cropping system limited by the amount of rainfall, the decision of fertiliser rate is a climate sensitive decision. The decision matters because of the cost of fertiliser. It is climate sensitive because the choice of high rates of fertiliser are preferred in an above normal season while lower rates are preferable in below normal seasons. Other examples of climate sensitive decisions are covered in Table 7.1

Discussion on real world climate sensitive decisions

The endpoint of the flow diagram is feedback (orange boxes). The aim is a conversation rather than advice. We are interested to know whether information is unavailable (left hand box), the simple framework failed (middle box) and what worked including what could be improved (right hand box).

Feedback on gaps in weather and climate information - what is missing, confusing or misunderstood	**Feedback** on why the simple decision framework failed. Some examples: 1) Alternative decision frameworks preferred 2) Not worth the effort as too many guesses 3) Decision too complicated? (bio-physical or economic), 4) Decision too complex (psychological and social factors)	**Feedback** on insights gained, what worked and what could be improved. Any simple rules derived, what is missing from the analysis?

Step 1A Prioritise climate and weather risks using crop calendars and risk matrices – this includes preliminary discussion on how the risks are managed.	**Step 1B Match risk to PAGASA information** historical records, warning, weather and climate forecasts.
Step 2A Use Verbal Decision Analysis to clarify climate sensitive decisions by identifying outcomes as combinations of choice and climate state.	**Step 2B Verbal consideration of forecasts** including hits and misses (failure to warn and false
Step 3A Use Rapid Climate Decision Analysis to quantify and further clarify climate sensitive decisions where there are trade-off between outcomes in different climate states.	**Step 3B Use forecast probability** of climate states to see if decision changes and test the required shift in climate states to change the decision.

The three main steps are to prioritise weather and climate risks (step 1) and, if necessary, clarify the decision using verbal decision analysis (step 2) and, where appropriate, to quantify the decision with Rapid Climate Decision Analysis (step 3). Steps 1A, 2A and 3A come from structuring the decision with the decision maker's information. Steps (1B, 2B and 3B) involve information from PAGASA. Although the focus on this project is how to use weather and climate information from PAGASA, it is useful to separate the process of structuring of the decision from the process of providing additional information from PAGASA. It is our contention that information will be more useful after the decision context has been examined.

7.1.1 Verbal Decision Analysis: Putting the Decision Context into Words First

Good decisions require an appropriate balance between optimism (taking the risks and enjoying the rewards) and caution (being prudent and avoiding risks). In some situations, being too optimistic and failing to take climate risks into account has major consequences. This is especially the case for smallholder farmers. Being too cautious or pessimistic and avoiding risks also comes at a cost. It is possible to allocate too many resources to crop protection 'just in case'. Cutting back on fertiliser can contribute to a poverty cycle.

- Plan for a favourable climate state and climate is favourable (the optimist's reward – opportunity realised)
- Plan for favourable climate state and climate is unfavourable (the optimist's cost – downside risk occurs)
- Plan for unfavourable climate state and climate is favourable (the pessimist's cost – opportunity missed)
- Plan for unfavourable climate state and climate is unfavourable (the pessimist's reward – risk avoided)

Farmers and advisers can readily point to risks and associated management options. Some key questions to ask that can clarify this are as follows:

1. What can be considered favourable and unfavourable climate events? At this initial stage it is useful to focus on simple climate events such as "drought", "frost" or "heavy rainfall".
2. What is the decision taken by an optimist who planned for favourable climate and a cautious approach to plan for an unfavourable climate?
3. Is the management objective to protect the crop – this is an insurance type problem where a cost is incurred to protect the crop and minimise the loss – OR is the management objective to maximise profit by adding the appropriate level of input such as fertiliser or choosing the right crop? This is a risk/reward problem with a choice between a higher reward and higher risk input level or crop and a lower reward, lower risk option.

Table 7.1 contains a summary of 13 climate-sensitive decisions that were identified earlier in the project. Associated with each is information available from PAGASA that could be used to assist in decision making (column 2) and comments on each decision (column 3) which are a useful intermediate step towards verbal decision analysis. The rows underneath each decision demonstrates how to move from the simple description of climate-sensitive decisions to a verbal decision analysis. For each decision it takes first an optimistic perspective and then a cautious or more pessimistic one. As an example, consider the first decision on the list about whether or not to harvest vegetables early in response to a warning about a typhoon. Let's initially view that decision from the optimist's perspective. The optimist plans for a favourable climate (no typhoon) and avoids the cost of protection by not harvesting early. If the typhoon misses the farm, this farmer receives the ***optimist's reward***. The farm is undamaged and the crop is undamaged and is still growing and available to be harvested at a later date.

However, if the typhoon hits the farm, the outcome for the optimist is the worst possible. Damage to the farm is made even worst by loss of the growing crop. This is the situation of the ***optimist's regret.***

Now let's return to the first decision about whether or not to harvest early, but this time taking the point of view of the pessimist. The pessimist plans for an unfavourable climate and is prepared to consider spending money on crop protection. Hence, in response to the typhoon warning, the pessimist harvests the vegetable crop. If the typhoon misses the farm, this farmer is relieved because there is no damage to the farm, but has incurred unnecessary costs and may have some difficulty in selling perishable vegetables. Such costs are the ***regret of caution*** from taking action that turns out, in the event, to be unnecessary.

On the other hand, if the typhoon hits the farm, there may be unavoidable damage to the farm, but the farmer has received the income from the sale of the vegetable crop. This is the ***reward of caution***.

Table 7.1 demonstrates how to express each of the 13 decisions as a verbal decision analysis. In each case the objective is to express in words that farmers and their advisors can understand the four possible outcomes of climate-sensitive decisions – the optimist's reward, the optimist's regret, the regret of caution and the reward of caution. Once this stage is reached for a particular decision, it should be possible to make a judgement about whether we have enough information to guide farmers and their advisors in the use of PAGASA information, or whether we need to make the additional step of moving to a more complete Rapid Climate Decision Analysis (RCDA).

Table 7.1: Climate-sensitive decision expressed as Verbal Decision Analysis

<table>
<tr><th>Benguet farm-level decisions</th><th>PAGASA information</th><th>Comment</th></tr>
<tr><td>1.Operational: To harvest early in response to warning of typhoon</td><td>Typhoon warning</td><td>Common advice is to harvest, but a false alarm means that farmers can be caught with perishable vegetables and low prices or closed roads.</td></tr>
<tr><td colspan="3">Being optimistic about human safety when there is a typhoon warning can be foolish optimism. This is a case where it is best to plan for the worst and hope for the best. Recent investments in PAGASA have meant that the typhoon warnings are earlier and more accurate. However, there is an inevitable cone of uncertainty.

This follows a cost/loss framing.</td></tr>
<tr><td rowspan="2">Don't harvest all vegetables (Optimistic– plan for favourable climate and avoid the cost of protection)</td><td>Typhoon misses farm

(climate is favourable)</td><td>Best outcome – farmer has options of when to harvest (Optimist's reward- no cost, no loss) ☺☺</td></tr>
<tr><td>Damaging typhoon hits farm

(climate unfavourable)</td><td>Worst outcome, damage from typhoon is made worse by the major loss of vegetables (Optimist's regret, loss occurred) ☹☹</td></tr>
<tr><td rowspan="2">Harvest all vegetables (Pessimistic – plan for unfavourable climate and spend money on protection)</td><td>Typhoon misses farm

(climate is favourable)</td><td>Farmer is relieved that typhoon missed farm, but may have difficulty dealing with perishable vegetables (regret of caution, unnecessary cost) ☹</td></tr>
<tr><td>Damaging typhoon hits farm

(climate unfavourable)</td><td>Farmer has to deal with the damage from typhoon but has harvested vegetables for income (reward of caution, cost incurred, but loss avoided) ☺</td></tr>
</table>

<table>
<tr><th>Benguet farm-level decisions</th><th>PAGASA information</th><th>Comment</th></tr>
<tr><td>2. Operational: To use sprinklers and covers in response to forecast of frost</td><td>Short-term frost warning</td><td>Major damage from failure to warn, but false alarms relatively low cost.</td></tr>
<tr><td colspan="3">This follows a cost/loss framing</td></tr>
<tr><td rowspan="2">Don’t use sprinklers covers (Optimistic– plan for favourable climate and avoid the cost of protection)</td><td>No damaging frost
(climate is favourable)</td><td>Best outcome – farmer avoids time and money of protecting for frost (Optimist’s reward- no cost, no loss) ☺☺</td></tr>
<tr><td>Damaging frost
(climate unfavourable)</td><td>Worst outcome, crop suffers frost damage (Optimist’s regret, loss occurred) ☹☹</td></tr>
<tr><td rowspan="2">Use sprinklers or covers (Pessimistic – plan for unfavourable climate and spend money on protection)</td><td>No damaging frost
(climate is favourable)</td><td>Farmer may be disappointed at spending time and money on unnecessary protection. (regret of caution, unnecessary cost) ☹</td></tr>
<tr><td>Damaging frost
(climate unfavourable)</td><td>Farmer is pleased that the action to minimise frost damage was worthwhile
(reward of caution, cost incurred, but loss avoided) ☺</td></tr>
</table>

<table>
<tr><th>Benguet farm-level decisions</th><th>PAGASA information</th><th>Comment</th></tr>
<tr><td>3. Tactical: To grow anthurium or roses</td><td>Seasonal rainfall</td><td>Anthurium higher return, but more susceptible to rain damage</td></tr>
<tr><td colspan="3">This follows a risk/reward trade- off framing</td></tr>
<tr><td rowspan="2">Grow higher return, higher risk option of anthurium flowers (Optimistic– plan for favourable climate with higher return, but higher risk option)</td><td>Normal or drier than normal (climate is favourable)</td><td>Best outcome, most profitable flower crop grown (Optimist’s reward - opportunity realised)</td></tr>
<tr><td>Wetter than average (climate unfavourable)</td><td>Bad outcome, losses from anthurium in wet years (Optimist’s regret- downside risk)</td></tr>
<tr><td rowspan="2">Grow lower return, lower risk option of roses (Pessimistic – plan for unfavourable climate with lower risk, but lower return option)</td><td>Normal or drier than normal (climate is favourable)</td><td>Bad outcome, less profitable roses when anthurium would have been superior (regret of caution - missed opportunity)</td></tr>
<tr><td>Wetter than average (climate unfavourable)</td><td>Good outcome, roses match the wetter season (reward of caution - risk avoided)</td></tr>
</table>

Benguet farm-level decisions	PAGASA information	Comment
4. To grow carrots, cabbages or potatoes	Seasonal rainfall	Carrots are most profitable in wetter than normal and normal years, potatoes the most drought tolerant
This follows a risk/reward trade- off framing		
Grow higher return higher risk option of carrots (Optimistic– plan for favourable climate with higher return, but higher risk option)	Normal or wetter than normal years (climate is favourable)	Best outcome, most profitable crop grown (Optimist's reward - opportunity realised)
	Well below average climate (climate unfavourable)	Bad outcome, losses from carrot in drought (Optimist's regret- downside risk)
Grow lower return, lower risk option of potatoes (Pessimistic – plan for unfavourable climate with lower risk, but lower return option)	Normal or wetter than normal years (climate is favourable)	Bad outcome, less profitable potato production when carrots would have been superior (regret of caution - missed opportunity)
	Well below average climate (climate unfavourable)	Good outcome, switch to potatoes in drought (reward of caution - risk avoided)
Benguet farm-level decisions	PAGASA information	Comment
5. Tactical: To use plastic tunnels to exclude heavy rain on cabbages	Seasonal rainfall	Cost incurred for relatively low value crop. Payoff in wet years
This follows a cost/loss framing		
Don't use temporary covers for cabbages (Optimistic– plan for favourable climate and avoid the cost of protection)	Rainfall is normal or below normal (climate is favourable)	Best outcome – farmer avoids time and money of protecting for rain damage (Optimist's reward- no cost, no loss)
	Rainfall is above normal (climate unfavourable)	Worst outcome, crop suffers damage from excess rainfall (Optimist's regret, loss suffered)
Use temporary covers for cabbages (Pessimistic – plan for unfavourable climate and spend money on protection)	Rainfall is normal or below normal (climate is favourable)	Farmer may be disappointed at spending time and money on unnecessary protection (regret of caution, unnecessary cost)
	Rainfall is above normal (climate unfavourable)	Farmer is pleased that the action to minimise rain damage was worthwhile (reward of caution, cost incurred, but loss avoided)

Benguet value chain decisions	PAGASA information	Comment
6. Operational: Truckers and traders - switch to vegetables from region that is not affected by typhoon to minimise postharvest losses.	Typhoon warning and weather forecast of rain following typhoon	Substantial cost of traders being caught with supply that they can't get to next buyers. Could exacerbate losses for farmers
This follows a cost/loss framing from the perspective of the trader		
Continue sourcing vegetables from normal regions (Optimistic– plan for favourable climate and avoid the cost of changing plans)	Typhoon misses region and roads clear (climate is favourable)	Best outcome – continue with normal plans (Optimist's reward- no cost, no loss)
	Damaging typhoon hits the region (climate unfavourable)	Worst outcome, damage from typhoon is made worse by the major loss from vegetables being unavailable (Optimist's regret, loss occurred)
Change and source from another region (Pessimistic – plan for unfavourable climate and spend money changing plans)	Typhoon misses region and roads clear (climate is favourable)	Traders and truckers have incurred costs when sourcing from another region (regret of caution, unnecessary cost).
	Damaging typhoon hits the region (climate unfavourable)	Traders and truckers are relieved that they have vegetables to sell even though the cost is increased and may not be able to be passed onto consumers (reward of caution, cost incurred, but loss avoided)
Benguet LGU level decision	PAGASA information	Comment
7. Tactical: Forecast of drought – distribute irrigation infrastructure and deliver water to drought areas	Seasonal Rainfall	Municipal officers responsible for assistance and advice. Possible to respond as event unfolds but any decision prior to the event will have opportunity cost of resources
This follows a cost/loss framing from the perspective of the LGU		
Continue with current plan of resources for LGU (Optimistic– plan for favourable climate and avoid the cost of changing plans)	Normal to above normal season (climate is favourable)	Best outcome – continue with normal plans (Optimist's reward- no cost, no loss)
	Well below normal or drought (climate unfavourable)	Worst outcome, damage from drought. Farmers worse off and LGU decision maker may lose their job (Optimist's regret, loss occurred)
Change plans and re-direct LGU resources to areas likely to suffer	Normal to above normal season	No drought and LGU officer may be asked why resources were re-

Benguet value chain decisions	PAGASA information	Comment
drought (Pessimistic – plan for unfavourable climate and spend money changing plans)	(climate is favourable)	allocated. (regret of caution, unnecessary cost)
	Well below normal or drought (climate unfavourable)	Drought damage is lessened by pre-emptive irrigation resources. LGU decision maker is promoted (reward of caution, cost incurred, but loss avoided)
Benguet LGU-level decision	**PAGASA information**	**Comment**
8. Tactical: Forecast of increased likelihood of flooding over the coming season. LGU send early SMS warnings to flood prone regions	Seasonal rainfall	Municipal officers responsible for assistance and advice. Possible to respond as event unfolds, but any decision prior to the event will have opportunity cost of resources
This follows a cost/loss framing from the perspective of the LGU		
Continue with normal plan of no pre-emptive SMS program (Optimistic– plan for favourable climate and avoid the cost of changing plans)	Normal to below normal season (climate is favourable)	Best outcome – continue with normal plans (Optimist's reward- no cost, no loss)
	Well above normal with floods (climate unfavourable)	Worst outcome, damage from floods and failure to warn. Farmers worse off and LGU decision maker may lose their job (Optimist's regret, loss occurred)
Change plans and start a pre-emptive SMS program (Pessimistic – plan for unfavourable climate and spend money changing plans)	Normal to below normal season (climate is favourable)	No flooding and LGU officer may be asked why resources were re-allocated. Farmers less likely to pay attention to future SMS programs (regret of caution, unnecessary cost)
	Well above normal with floods (climate unfavourable)	Flood damage is lessened by pre-emptive warning. Farmers save crops and LGU decision maker is promoted (reward of caution, cost incurred, but loss avoided)
Mindoro farm-level decisions	**PAGASA information**	**Comment**
9. Operational. Timing of fertiliser for rice	Weather forecast of heavy rain	Interesting case with benefits to farmer and the environment
This follows a risk/reward trade- off framing where we can assume that the unfavourable event is heavy rain		
Fertilise the rice (Optimistic– plan for favourable climate with higher return, but higher risk option)	Rainfall in coming week is not heavy (climate is favourable)	Best outcome, fertiliser is applied and losses are minimal (Optimist's reward - opportunity realised)

Benguet value chain decisions	PAGASA information	Comment
	Rainfall in coming week is heavy (climate unfavourable)	Bad outcome, some or all of the fertiliser is lost (Optimist's regret- downside risk)
Do not fertilise the rice (Pessimistic – plan for unfavourable climate with lower risk, but lower return option)	Rainfall in coming week is not heavy (climate is favourable)	Bad outcome, fertiliser application is unnecessarily delayed (this may not be a major cost) (regret of caution - missed opportunity)
	Rainfall in coming week is heavy (climate unfavourable)	Good outcome, the loss of fertiliser has been avoided (reward of caution - risk avoided)
Mindoro farm-level decisions	**PAGASA information**	**Comment**
10. Tactical: Fertiliser rate for corn	Seasonal rainfall and chance of drought	The higher fertiliser rate on corn will have greater payoffs in good seasons than costs in poor seasons.
This follows a risk/reward trade- off framing where we can assume that the unfavourable event is drought		
Use the recommended rate of fertiliser (Optimistic– plan for favourable climate with higher return but higher risk option)	Normal to above normal season (climate is favourable)	Best outcome, fertiliser leads to higher yield and profit (Optimist's reward - opportunity realised)
	Well below normal or drought (climate unfavourable)	Bad outcome, expense of fertiliser but no extra yield (Optimist's regret- downside risk)
Use lower than the recommended rate of fertiliser (Pessimistic – plan for unfavourable climate with lower risk but lower return option)	Normal to above normal season (climate is favourable)	Bad outcome, yield of corn is limited by low fertiliser (regret of caution - missed opportunity)
	Well below normal or drought (climate unfavourable)	Good outcome, money not wasted on fertiliser (reward of caution - risk avoided)
Mindoro farm-level decisions	**PAGASA information**	**Comment**
11. Tactical: Hybrid rice vs traditional rice varieties	Seasonal rainfall and chance of drought	Hybrid rice will have greater payoffs in good seasons than costs in poor seasons.
This follows a risk/reward trade- off framing where we can assume that the unfavourable event is drought		

Benguet value chain decisions	PAGASA information	Comment
Plant hybrid rice (Optimistic– plan for favourable climate with higher return, but higher risk option)	Normal to above normal season (climate is favourable)	Best outcome, hybrid rice leads to higher yield and profit (Optimist's reward - opportunity realised)
	Well below normal or drought (climate unfavourable)	Bad outcome, expense of hybrid rice but no extra yield (Optimist's regret- downside risk)
Plant traditional rice variety (Pessimistic – plan for unfavourable climate with lower risk, but lower return option)	Normal to above normal season (climate is favourable)	Bad outcome, lower yields because of traditional rice variety (regret of caution - missed opportunity)
	Well below normal or drought (climate unfavourable)	Good outcome, money not wasted on hybrid rice (reward of caution - risk avoided)
Mindoro value chain decisions	PAGASA information	Comment
12. Operational: Solar or mechanical drying of rice by miller	Weather forecast of rain and cloud	Interesting value chain decision. Primarily a consideration of labour costs
This follows a risk/reward trade- off framing where we can assume that the unfavourable event is rain and cloudy weather		
Solar drying (Optimistic– plan for favourable climate with higher return, but higher risk option)	Clear weather in coming week (climate is favourable)	Best outcome, solar drying with lower costs (Optimist's reward - opportunity realised)
	Rain and cloud in coming week (climate unfavourable)	Worst outcome – solar drying failed and hence have to use mechanical drying (Optimist's regret- downside risk)
Mechanical drying (Pessimistic – plan for unfavourable climate with lower risk, but lower return option)	Clear weather in coming week (climate is favourable)	Not ideal outcome as mechanical drying is used when solar would be cheaper (regret of caution - missed opportunity)
	Rain and cloud in coming week (climate unfavourable)	Good outcome, mechanical drying was needed and used (reward of caution - risk avoided)

Leyte farm-level decisions		
13. Operational ploughing in corn farming	Weather forecast of heavy rain	Trade-off between cost of second ploughing operation and loss of timeliness and in some cases access to labour for transplanting.
This follows a risk/reward trade- off framing where we can assume that the unfavourable event is heavy rain		
Plough the field (Optimistic– plan for favourable climate with higher return, but higher risk option)	Rainfall in coming week is not heavy (climate is favourable)	Best outcome, field is ploughed (Optimist's reward - opportunity realised)
	Rainfall in coming week is heavy (climate unfavourable)	Worst outcome – cost of ploughing is wasted (Optimist's regret-downside risk)
Delay ploughing (Pessimistic – plan for unfavourable climate with lower risk, but lower return option)	Rainfall in coming week is not heavy (climate is favourable)	Not ideal outcome due to cost of the delay in ploughing (regret of caution - missed opportunity)
	Rainfall in coming week is heavy (climate unfavourable)	Good outcome, the delay in ploughing has saved time and money (reward of caution - risk avoided)

7.1.2 Rapid Climate Decision Analysis

As part of this ACIAR project and in partnership with projects in Australian grains and wine grape industries we have developed an Excel based tool which we are calling Rapid Climate Decision Analysis. It is important to restate the point that this is not intended as a Decision Support System or tool for farmers to use. The purpose is to consider a climate sensitive decision; that is one where the optimum decision is known only after the climate of that season has occurred. This might be growing a new crop or adopting a practice that is more profitable than the standard practice in wetter than average seasons, but leads to greater losses in drier years. If a practice is superior in all climate states for the coming season, information from PAGASA is unlikely to make any contribution to the decision.

Key concepts

Climate decision analysis –We are using Decision Analysis which is an established means of comparing choices by considering a range of possible outcomes depending on the season. This is simply a case of cost benefit analysis for different states of nature. Decision Analysis distinguishes between good decisions (best decision with information available) and lucky/unlucky decisions (the decision that hit or missed the unknown season).

Rapid – this exercise is based on the notion that farmers, advisers and researchers can make reasonable first estimates of the outcomes for different climate states. These numbers can be adjusted but there is an advantage of a guided process that rapidly gets a full set of estimates down and graphed. This contrasts with an exercise where farmers and advisers are questioned for background information and then the researchers go away and conduct the analysis which is presented weeks or months later.

Many people involved in developing countries will be familiar with rapid rural appraisal which has a number of strengths and weaknesses. A clear strength is that being rapid tends to maintain attention and engagement for all involved (Crawford 1997).

Fast graphs for slow thinking is a reference to the book Thinking Fast and Slow by Daniel Kahneman (winner of Nobel Prize for economics). Fast graphs - We are designing a spreadsheet to rapidly develop a profit-by-climate-states graph. These graphs summarise a vast amount of knowledge about the climate sensitivity of profit and risk. Slow thinking refers to idea that it is sometimes useful to slow down, be more deliberative, calculate the trade-offs in our decisions, ask what is missing from our analysis and consider other ways of solving the problem. The premise is that by getting quickly to the graphs there is more time for interpretation, testing of assumptions and discussion.

Step 1. Identify and isolate the decision

Consider a climate sensitive decision where there is a trade-off between an option with higher profit, but higher climate risk and a less profitable option that has lower climate risk. We need a decision where uncertainty about the coming season plays a significant (but not the only) role. Later in the process we will incorporate production risks that are not due to climate along with price risk. Consider this being applied to a particular field or farm, ideally one that is representative of the district.

At this stage in the process we are looking for a simple climate related decision. The process of extracting a simple decision from all the background context is difficult. It might be useful to note down some of the complicated and complex aspects of the decisions. We will come back to these other factors in Step 4.

Step 2. Plot yield by climate states or deciles of rainfall

For the field you have in mind, we need the expert opinion on the yields for the higher profit and risk option and the lower profit and risk option. In some cases it has been helpful to use the example of an agronomist as expert witness providing information to a court case that was deciding on how to recompense a grower for early season herbicide damage.

It is possible to just consider the yields for a good, average and poor season, but we also need some estimate of the lowest and highest on record. The key factor is considering the relative yield between the two options. The good thing about a spreadsheet is that we can change the answers and check the outcomes. The order doesn't matter, but we recommend to first ask the decile 9 season, when water is not a limit and then ask the other extreme of decile 1 followed by decile 5. This order can help to avoid "anchoring" on decile 5 and just adjusting answers up and down.

Suggested order		More profitable but higher climate risk	Less profitable but lower climate risk
4th	Driest on record		
3rd	Decile 1 season		
6th	Decile 3 season		
5th	Average season (D 5)		
7th	Decile 7 season		
Do this first	Decile 9 season		
2nd	Wettest		

How confident are you in the numbers? Are there some estimates that you are more confident with than others? Why?

Step 3. Convert yield by deciles to profit by deciles

Climate risk matters to farmers because of the impact on profit and loss. This requires information on prices and costs. In many cases these will not change across season type, but it is worth considering that wetter growing seasons may require higher costs of crop protection. (These numbers can be easily adjusted.)

	More profitable but higher climate risk		Less profitable but lower climate risk	
	Price	Growing cost	Price	Growing cost
Driest on record				
Decile 1 season				
Decile 3 season				
Average season				
Decile 7 season				
Decile 9 season				
Wettest on record				

Step 4. Check if graph makes sense

Some things to look for:

- Outcomes in the dry years - how bad are the worst outcomes?
- Outcomes in good to very good years
- What decile (or percentile) is the cross over between the two plans – how sensitive is this to price?
- What is the relative size of the upside opportunity wedge and the downside risk wedge?
- What is the shape of the downside risk wedge - is it biased towards the very dry seasons?
- What is the shape of the opportunity wedge - is it biased towards the wet seasons?
- How well does this simple version of the decision relate to the complications and complexity of farm decisions? What are we missing?
- From the perspective of a more conservative risk averse grower, are the main risks captured and/or the opportunities overstated?
- Does the graph make sense to a profit maximising grower?
- What can be done to manage the downside risks?

Applying the framework in the Philippines

In May 2017 at a meeting with PIDS, researchers from Benguet State University described their work on climate smart farming. This consists mostly of strategic decisions such as developing drought proof crops and building structures to cover crops or use as windbreaks. This is important work, but it requires very general information from climate change projections with no management changes at a seasonal time scale.

At a subsequent meeting with the same researchers from BSU in April 2018, when asked about dry or wet seasons they described what vegetable growers do in the low rainfall time of the year rather than a drier than average season and it took some time to communicate that we had in mind wetter than average wet seasons or drier than average wet seasons. When pressed, a tactical decision was the use of temporary plastic tunnel covers on cabbages. Because the market prefers small cabbages, they are planted at a high density and this makes them prone to disease when the season is wetter than normal.

The BSU expert was able to quickly identify the following information (within 10 minutes):

1) The sensible area to consider was 500 sq m.
2) The yield of saleable cabbages for this area would be 1200 kg/ha @ but with weather damage this could be reduced to 800 kg/ha
3) The growing costs for 500 square metres is 7000 pesos (180 AUD) and the cover is an extra 3000 pesos (including a small cost for labour)

This can be represented in the spreadsheet of Figure 7.2 which converts the above information into a graph. In this case the two graphs are identical because they are both set on climatological odds. The graph shows the following conclusions.

Under the assumptions used, spending the extra 3000 pesos for a low-cost cover eliminates climate risk and leads to a profit (before other costs are removed) of 14000 pesos in each year. If the season is drier than normal then the cover can be seen to be an unnecessary expense but if the season is wetter than normal the cover is a very good investment. The cross over is at the 44th percentile so the covers are superior just over half the time, but the accumulated avoided damage is greater than the unnecessary expense, but only by 7%. Some growers would want a higher payoff for the extra effort of dealing with the covers. Other growers are likely to see the elimination of losses in a risk of a much wetter than average season as justification. If the covers can be used for a second crop, the cost will be significantly reduced. The problem of disposing of the used plastic covers opens up discussion of externalities.

Some people in the discussion preferred the graphs and others preferred the decision tree shown in the lower section of Figure 7.2. The decision tree shows the same data but sets out the decision node (cover or no cover) and the chance node (coming season wetter, average or drier). The tree reinforces that while the probability weighted outcome is a useful summary statistic, it is only the average of individual years. Economists have found that anticipated regret can be a powerful part of human decision making. While there is modest regret for the grower who used the cover, but didn't need the cover, there is high regret for the grower who decided not to use the cover and suffered major loss.

The spreadsheet can be used to quickly show that if the price of cabbages falls to 15 pesos per kg, covering the crop becomes less viable, and if the price is 30 pesos, there is a stronger case to protect the crop. The loss and subsequent regret of not covering if a wetter season coincides with a higher price is a strong argument for covering. The regret associated with the extra expense of covering if the season is drier than normal and prices are low is an argument against covering.

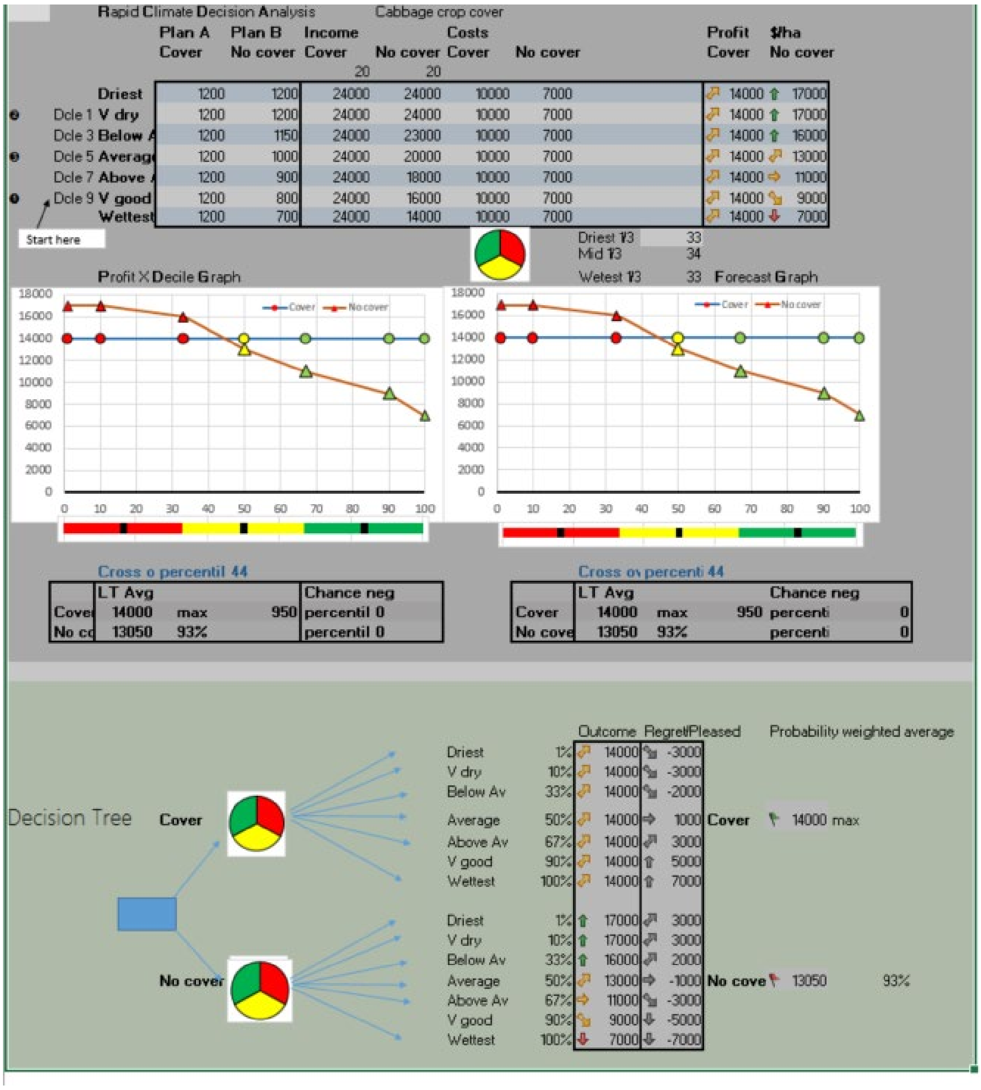

Figure 7.2: Example RCDA for comparing the decision to cover or not cover the cabbage crop, under climatology (no forecast information).

The spreadsheet is designed to then explore how the conclusions change if there is a change in the likelihood of drier or wetter than normal seasons. A key point is that the risk and returns are discussed prior to introducing the forecast from PAGASA.

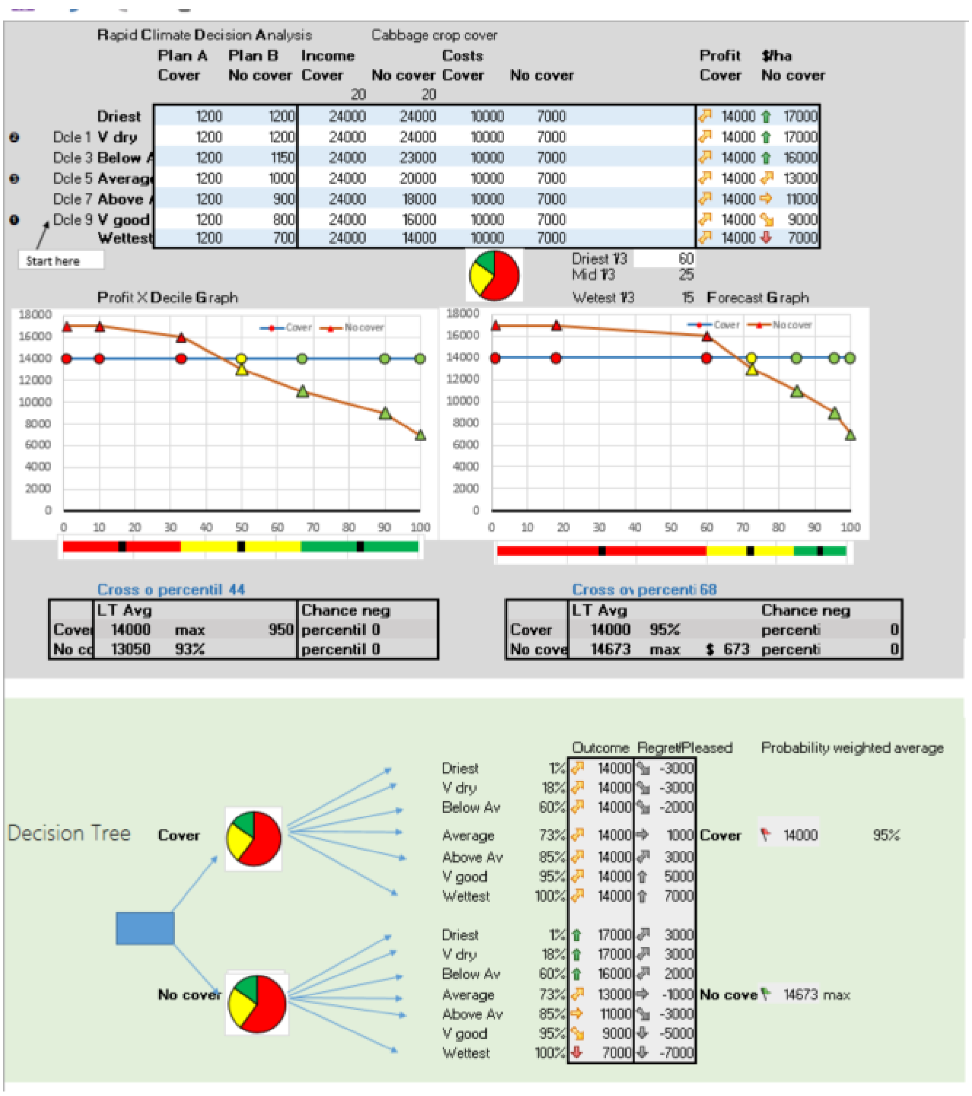

Figure 7.3: Example RCDA for comparing the decision to cover or not cover the cabbage crop, with a forecast of increased chance of being dry.

With a PAGASA forecast in which the odds are strongly revised for a drier than normal season, the cross over moves to close 68th percentile (see Figure 7.3). In other words a cover will only be superior in about 3 years out of 10. The long-term average profit is higher when not using a cover, but only by 5%. Importantly the chance of a wet season (and the consequent loss and regret) is reduced but not eliminated. A grower who had decided to use a cover may need an even stronger forecast to abandon the idea.

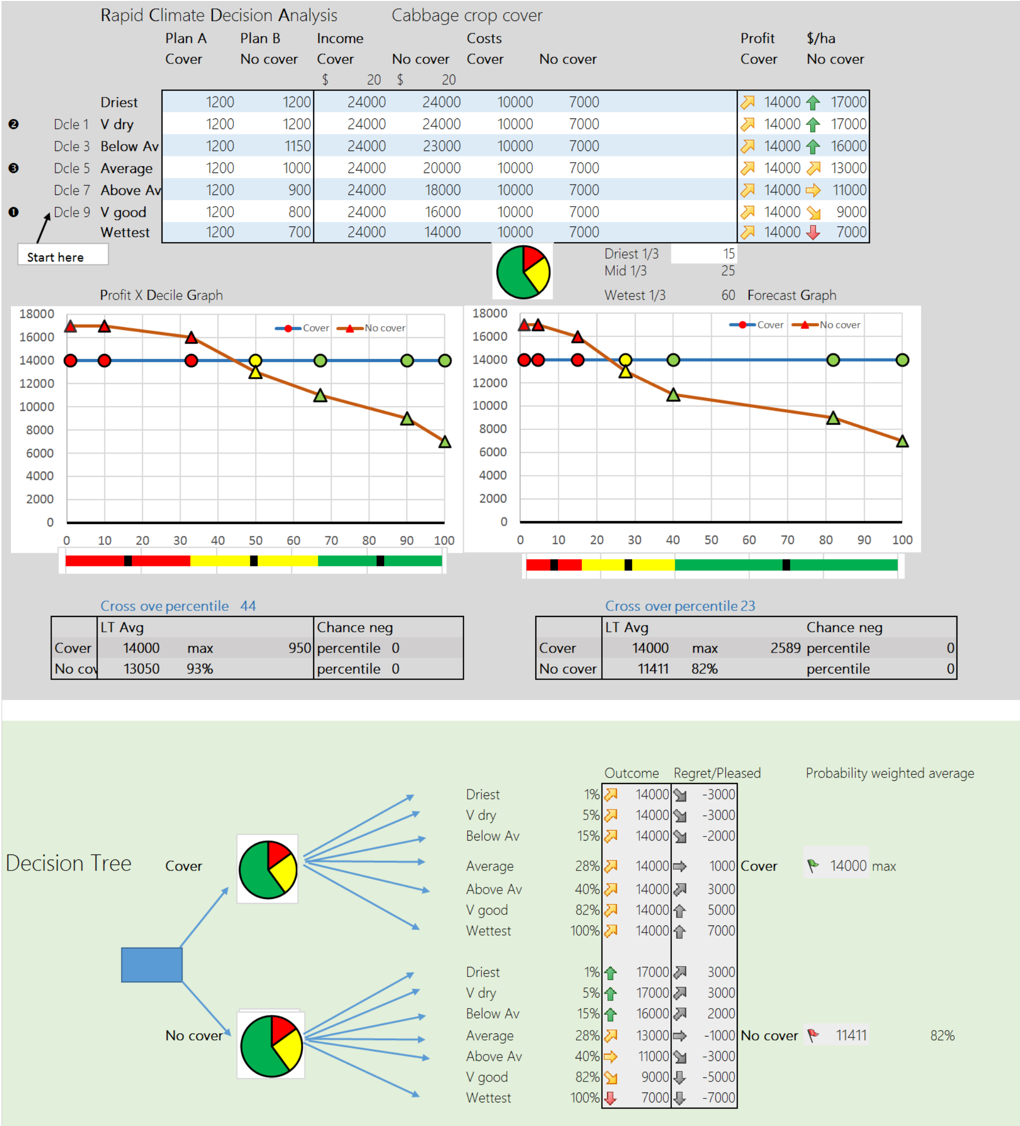

Figure 7.4: Example RCDA for comparing the decision to cover or not cover the cabbage crop, with a forecast of increased chance of being wet.

A forecast for above average conditions greatly favours the use of the covers (see Figure 7.4). In one sense this forecast has no value because climatology favoured the use of covers, but this leads to the covers being beneficial about more than 3 out of 4 seasons and reduces the amount of regret of unnecessary protection.

This application of Rapid Climate Decision Analysis is not intended as a decision support tool for vegetable growers, but rather as a means to create discussion around a climate sensitive decision.

7.2 Social science: surveys, key informant interviews and focus groups

During the course of the project a range of surveys, key informant interviews and focus groups were conducted to better understand attitudes and behaviour in response to information designed to manage climate risk. In this results section we focus on four studies published in the special issue, two from Benguet and two from Mindoro.

1. Weather and climate risks cool highlands of Benguet

Launio (#7) and colleagues from Benguet State University used surveys and key informant interviews to study local knowledge on climate hazards and the use of weather and climate information in the cool highlands region of Benguet. Smallholders in the highlands are prone to typhoons and flooding like much of tropical agriculture, but are also exposed to frost, hailstorms and landslides. Most of the respondents and informants were members of the indigenous peoples Benguet Kankana-ey and Ibaloi. These local farmers have maintained a rich local knowledge of climate-related risks. They also have traditional weather and climate indicators for all seasons of the year.

Seasonal calendars were used to identify climate risks and perceived changes in the timing of the rainy season, typhoons, thunderstorms and frost. The study recommends more research and development on frost management and the promotion of the 10-day rainfall forecast and monthly climate forecasts. The seasonal calendar was also used to catalogue traditional indictors including atmospheric phenomenon (eg bluish clouds for drought) and biological indicators (insects or migratory birds) were catalogued. The authors suggested that future research should study this local knowledge and compare it with long-term records and PAGASA forecasts.

2. Recovery from Typhoon Ompong

On September 15, 2018, Super Typhoon Mangkhut (known locally as Typhoon Ompong) hit the Philippines with sustained wind speeds of more than 205 km/h and gusts of 255 km/h. The typhoon was preceded by almost month-long, non-stop monsoon rains that had already affected Benguet Province. Participants in the study by Launio (#6) were asked how they heard that Super Typhoon Mangkhut was going to hit the province and what changes or actions they implemented as a response.

Most of the farm households heeded the early warning of the typhoon occurrence by securing their farm and house, storing food, and harvesting harvestable standing crops or transporting harvested crops to the local trading area before the event. After the event, re-planting and marketing the remaining crop were the only options. Community cooperation was found to be automatic in terms of the cleaning and repair of roads and water sources. Most farmers recovered their losses within six to eight months, but the average was 13 months from the typhoon occurrence. The study recommends to PAGASA, Local Government Units and Agricultural extension services the need to strengthen forecasts and forecast dissemination of continuous heavy rainfall, increased local R&D on erosion and road landslide forecasting, ensuring the availability of ready-to-plant seeds and seedlings after extreme weather events, and capitalizing on the traditional *"adduyon"* where farmers provide free labour to the most affected areas for disaster management.

3. Weather and climate use by corn farmers in Mindoro

Losloslo and colleagues (#5) from UPLB surveyed 200 smallholder maize farmers in Oriental Mindoro. The study found relatively high use of weather and climate information for operational and tactical decisions. An interesting observation was that a relatively small proportion of maize farmers still relied on traditional forecasting methods, but even among them there was some questioning about the continuing reliability of these forecasts. An explanation offered by participants was that increased climate variability has led to a decline in the perceived accuracy of indigenous and local knowledge of forecasting. The authors recommend that beneficial information from traditional knowledge should not be ignored, but incorporated into farm decision making.

Other factors that influenced the uptake of climate and weather information were the nature of the cropping system and the ownership status. Regression analysis indicated that intercropping was associated with increased use of weather and climate information. A possible explanation is that bananas are used as a perimeter crop and, like maize, are highly prone to damage brought by torrential rain, strong winds, and typhoons. The uptake of weather and climate information was also higher where respondents were landowners or working on land owned by relatives. The authors make the important point that information was not always the limiting factor, as access to farm inputs could limit decisions.

4. Weather, climate and gender in rice and corn production

Gata et al. (#8) examined the question of gender in weather and climate risk. The authors provide a useful overview of the expanding literature on gender and climate in agriculture. A common finding is that it is the women who suffer the most due to limited access to and control of agricultural assets and restrictive social and cultural norms on gender roles. In the Philippines, women own few agricultural assets and are less likely to own agricultural lands than men.

The study used focus group discussions and a survey of 337 farmers. Apart from female-headed households, agricultural activities in rice and corn production in the Philippines remain male-dominated. Women's roles seem to be more visible in rice production than corn production, but the operational (weather dependent) and tactical (seasonal climate dependent) decisions are still male dominated. Longer-term strategic decisions about household livelihoods and adaptation to climate change are more evenly shared between genders. Studies such as this provide essential information for policy and development programs, not only to achieve equity but also for effectiveness. Furthermore, gender roles in agriculture are not static in time or place and hence updates will be required.

7.3 Social research: SNA

The first paper in this section, from Ruzol and colleagues from UPLB (#3), used social network analysis to investigate the weather and climate information networks of rice and corn farmers in Oriental Mindoro. An underlying premise for this work is that decisions are seldom made in isolation but come from interaction with neighbours, outside experts and past experience. It follows that mapping flows of ideas and information through social networks provides both an understanding of current flows of information and guides more strategic and effective communication plans or programs in the future.

A Rapid Ethnographic Assessment was conducted to gauge the type of weather and climate information accessed by smallholder farmers. The assessment included a cultural domain analysis to investigate how farmers think and talk about weather and climate. This highlighted distinctions between information about warnings of disasters such as typhoons and everyday weather and climate forecasting. The social network analysis was preceded by an initial site visit to visualize the landscape, interview key informants, and determine the network boundary. An important finding from this process was a "hidden farmer population" of laborers and tenants who did not appear on the master list of the Municipal Agriculture Office (MAO) because their residence was different from where they farmed. Given the incompleteness of the census, snowball sampling (using participants to recommend further participants) was an effective way to find these isolated nodes or hidden actors in the barangay.

The second social science paper came from Tabuga and colleagues from the Philippine Institute of Development Studies (#4). Using a census approach to social networks in three upland farm communities in the province of Benguet, the researchers set out to find insights about how information and education campaigns may be designed to more effectively reach farmers located in these remote and mountainous areas. Regression analysis showed that in this mountainous environment, social interaction depended on geographic location such as living near a village, government hall, church or market. Unsurprisingly, belonging to a large family clan increases interaction. The most affluent families were not necessarily the most central actors; the authors speculate that these families may have less need for or interest in social interaction.

A significant contribution of this study is the use of social network mapping to examine the role of agricultural extension workers in communicating weather and climate information. The authors note that there will never be enough resources for extension workers to have direct contact with all the smallholders. Identifying central actors is important for both the efficiency and effectiveness of information dissemination and education campaigns. The challenge is how to identify and encourage these central actors to become disseminators of weather and climate information within their networks. At the same time, it is important to identify actors who are not well-integrated into the social systems and find ways to ensure that they are not left behind.

7.4 Climate science

Task 1 simplified and useful climate knowledge and Task 2 cataloguing the PAGASA forecasts and information are covered in section 5.5 on KlimAgrikultura.

Task 3: Localised climate data

The median projection of bias-corrected, downscaled model projections for Calapan is for warmer temperatures in all months, but wetter conditions from December to May and a drying from June to November (Cinco et al. #2). All eleven climate models analysed projected warming, whereas for all seasons some climate models project drying and some wetting. Table 7.2 presents the projected seasonal changes of rainfall (in mm and percentage) and temperature (°C and deviation) between the observed historical and the bias-corrected future ensemble climate data.

The worst-case scenario (upper bound) warming approaches 1.8°C under low emissions (RCP4.5) and 2.2°C under high emissions (RCP8.5). With a potential increase of temperature from 0.9 to 2.2°C, crop yields are expected to decrease by approximately 10-20% (Bouman et al. 2001). There may not be practical and efficient methods currently available for the adaptation of smallholder rice farms to the projected temperature increases in the mid-21st century. Nonetheless, crop breeding technologies are focused on developing heat-resistant crop varieties (Asian Development Bank. 2009).

The climate change projections indicate that farmers should plan for more drought during the second half of the year and a consistent 1°C increase in temperature year-round. Adjustment of the cropping calendar to a more suitable season for farming may be required. During El Niño, farmers may opt to plant more rice varieties that are resistant to drought (Borines, Gravoso & Predo. 2008). Planning water conservation and storage strategies, especially in rainfed areas (Ewbank, 2016) for irrigation management, will help avoid crop stress during drought or dry spell occurrences. There may be opportunities for farmers to incorporate agroforestry (Lasco et al. 2014), as it is less dependent on onset and seasonality of rainfall and poses many benefits such as providing an alternative livelihood, food sources and erosion control.

Table 7.2. Bias-corrected projected changes in seasonal rainfall and temperature for Calapan centered at mid-21st century (2036–2065) against the baseline period (1971–2000) for emission scenarios RCP4.5 (7 models) and 8.5 (11 models). The intermodal spread is indicated by the median (50th percentile), lower (10th percentile) and upper (90th percentile).

Season; Baseline values (mean temperature, rainfall)	Scenario	Range	Projected Temperature Change		Projected Rainfall Change	
			Change (°C)	Projected Seasonal Mean Temperature (°C)	Percent (%)	Projected Seasonal Rainfall Amount (mm)
December-January-February (DJF)	Moderate Emission (RCP4.5)	Lower bound	0.9	26.8	-8.4	329.9
		Median	1.1	27.0	10.9	399.5
		Upper bound	1.5	27.3	25.3	451.4
Observed baseline = 25.8°C, 360 mm	High Emission (RCP8.5)	Lower bound	1.1	26.9	-8.7	328.8
		Median	1.4	27.3	0.2	360.8
		Upper bound	1.9	27.8	11.6	401.9
March-April-May (MAM)	Moderate Emission (RCP4.5)	Lower bound	0.9	28.7	-11.3	303.0
		Median	1.1	29.0	1.8	347.6
		Upper bound	1.5	29.3	27.7	436.3
Observed baseline = 27.8°C, 342 mm	High Emission (RCP8.5)	Lower bound	1.2	29.1	-6.0	321.2
		Median	1.6	29.5	4.9	358.5
		Upper bound	2.2	30.0	15.6	394.9
June-July-August (JJA)	Moderate Emission (RCP4.5)	Lower bound	0.2	28.0	-19.0	521.3
		Median	0.8	28.5	-7.3	596.5
		Upper bound	1.6	29.4	5.0	676.2
Observed baseline = 27.8°C, 644 mm	High Emission (RCP8.5)	Lower bound	1.3	29.1	-4.6	614.0
		Median	1.6	29.3	5.1	676.4
		Upper bound	2.2	30.0	16.0	746.5
September-October-November (SON)	Moderate Emission (RCP4.5)	Lower bound	0.9	28.2	-22.7	609.7
		Median	1.1	28.4	-1.7	775.6
		Upper bound	1.8	29.1	18.9	938.2
Observed baseline = 27.3°C, 789 mm	High Emission (RCP8.5)	Lower bound	1.3	28.6	-7.6	729.3
		Median	1.5	28.8	-1.5	777.2
		Upper bound	2.2	29.5	10.5	871.6

Task 4 Clarification of PAGASA categories

An Excel spreadsheet using historical monthly rainfall data was created to interpret the percent of average rainfall categories used by PAGASA for seasonal outlooks (Cinco et al. #2). The historical perspective on the distribution across categories (climatology) can be compared with a forecast to see whether the forecast offers any new information.

Figure 7.5 shows that the proportion of years that fall into the five rainfall categories at Calapan varies considerably by month. For the 30 years between 1981–2010, during May there have been roughly equal (six out of 30) cases of rainfall being in any of the five categories of deviation from the long-term average. However, for the same 30 years, March rainfall has been in the Way Below Normal category more than 40% of the time. As a consequence of this skewed distribution, Way Below Normal (rather than Near Normal) is the most likely category for that month. If the forecast for March is Way Below Normal, it may be perceived to be a signal from the forecast system of a drier than expected outlook. However, the long-term climatology shows this to be the most likely category.

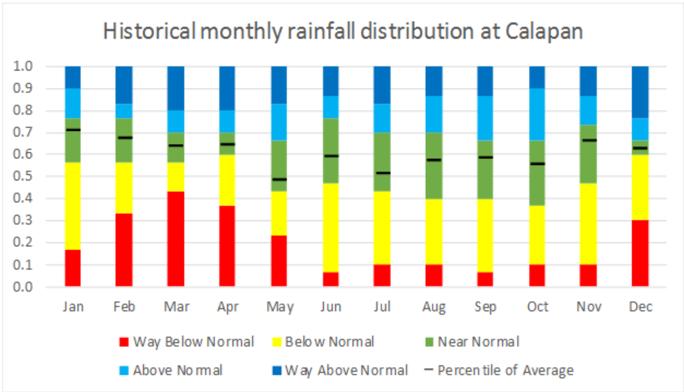

Figure 7.5. Monthly stacked bar charts showing the portion (between 0-1 on the y-axis) of years that fall into each rainfall category for all months between 1981–2010.

Task 5 The need for probabilistic information

PAGASA, like the Australian Bureau of Meteorology issues alerts and declarations for El Niño and La Niña events. In both countries these alerts and declarations receive a high level of media attention and in both countries there is a tendency for the media and general public to interpret El Niño as a drought outlook and La Niña as a flood outlook. The spreadsheet output shown for all years can be adjusted to show El Nino or La Nina years (Figure 7.6). During El Niño, there are increased chances that rain will be in the lower two categories (Way Below Normal and Below Normal), and decreased chances that rain will be in the higher categories (Way Above Normal and Above Normal). This is in line with general observations of increased chances of reduced rainfall during El Niño years in many regions of the Philippines, including Mindoro (Hilario et al. 2009). During La Niña, there are increased chances of higher rainfall categories, particularly around March and April, and correspondingly decreased chances of lower rainfall categories. Hence, these seasonal forecasts are not forecasts of wet or dry conditions, but forecasts of increased chances of wet or dry conditions.

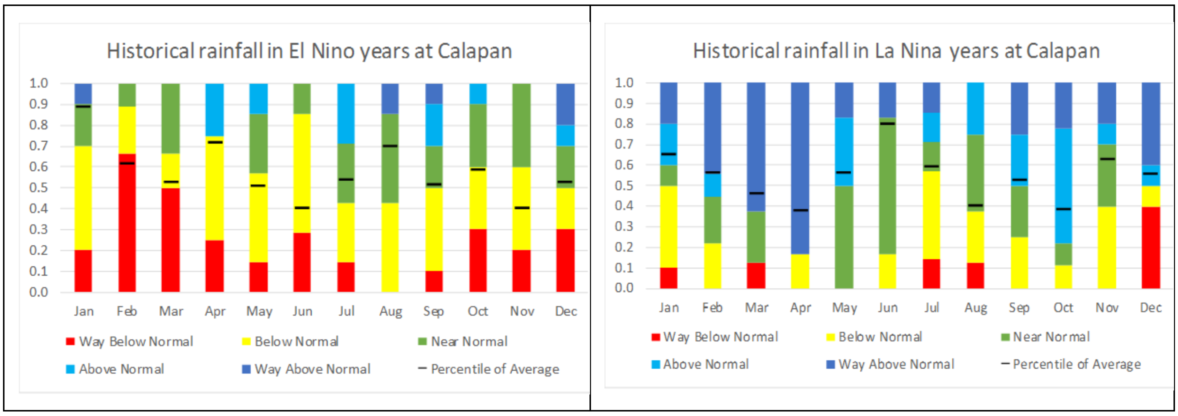

Figure 7.6 shows significant changes to monthly rainfall climatology depending on the ENSO category.

Decision Analysis creates a demand for probabilistic forecasts. PAGASA used resources from this project to expand their probabilistic monthly forecasts to seasonal (eg 3-monthly) probabilistic forecasts. This effort contributes to the higher resolution modelling for seasonal forecasts in the Philippines. Improvements in the representation of critical meteorological features such as rainfall forecasts are being undertaken by better resolving important topographic feedbacks and effects.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The main pathway to impact is KlimAgrikultura. We have designed the components of KlimAgrikultura to be modular which will increase the chance of the ideas being included in other projects even if not packaged as KlimAgrikultura. PAGASA is currently negotiating new projects and likely to include KlimAgrikultura as a whole in some projects and components in others. As described in the methods (section 5) and the results (section 7) the main modules are

- Packaging PAGASA climate science,
- Crop Climate Calendars
- Matching PAGASA information to climate and weather risks
- Verbal Decision Analysis
- Rapid Climate Decision Analysis.

Packaging PAGASA climate science into information more readily available to agricultural end users has been a successful aspect of KlimAgrikultura with demand for the material from regional PAGASA officers. Although difficult to measure, we expect that this component will have a significant impact in the future.

An immediate impact of this project was to develop Crop Climate Calendars for the major vegetable crops in Benguet which will be useful to the local LGUs and the teaching and extension arms of Benguet State University. Crop calendars for crops such as corn and rice are common in the Philippines for integrated pest management and scheduling harvest storage. Crop *Climate* Calendars identifying the timing of key weather and climate risks are much less common for rice and corn and novel for vegetable production. These Crop Climate Calendars are a boundary object in that they are plastic enough to be meaningful to the world of farming and to PAGASA, yet robust enough to facilitate a common understanding. We are confident in the impact of Crop Climate Calendars because they invite the farmers and advisers to be the experts and provide a structure for PAGASA to learn. In response, PAGASA can then match the weather and climate information that they have available. Attachment 1 is a catalogue of PAGASA information which will be a valuable resource that can be easily updated.

The Crop Climate Calendars and matching to PAGASA information are formats for useful discussion. The main skills required are facilitation skills rather than guidance on the use of the framework. In Australia and the Philippines it is surprisingly easy to identify weather and climate risks, but in many cases surprisingly difficult to reach clarity on the climate sensitive decision. This is in part due to the difficulty in the artificial separation of a single decision with choices and outcomes from the messy, complex process of running a farm. It also highlights a level of vagueness in discussion about vulnerability of agriculture to climate and the need for information.

Verbal Decision Analysis is a statement of the essence of a climatically risky decision. As shown in the results (section 7.1.1) we were able to express all tactical decisions in the simple format of an optimistic or cautious choice, along with an adverse or more favourable state of climate with four outcomes of the reward or regret of optimism and the reward or regret of caution. This provides confidence that the framework can encompass a wide range of tactical decisions. A long-standing critique of Decision Analysis is that it is only suitable for solving text book puzzles rather than real life complex decisions. In our experience clarity is the result of decision analysis rather than a pre-requisite and this clarity comes by drawing out the components from the decision maker.

Our judgement is that the framework for Verbal Decision Analysis has the greatest potential impact from this project on action ready knowledge. Although there are many programs that seek to communicate climate information in the Philippines and Australia, it is rare to find clarity on the climatically risky decisions. Acknowledging the trade-offs between optimism and caution and identifying unavoidable regret when making decisions under uncertainty is a valuable step before introducing the forecast. Another reason for our confidence in the impact of Verbal Decision Analysis is that PAGASA seems confident in running verbal decision analysis because, like the Crop Climate Calendar, it is a framework to ask users a series of questions which then leads into a conversation about the role of climate information.

Taking a quantitative approach to climatically risky decisions with Rapid Climate Decision Analysis (RCDA) has the impact of placing a peso value on the relative risks, rewards, regrets and importantly the value of information. There is more to decision making and risk than the peso value, but an economic approach contributes to the broader discussion on climate risk, poverty and information provided to smallholder farmers. We are less confident about the impact of RCDA because PAGASA staff were less sure about eliciting the budget information required as an input. PIDS and UPLB had to make a substantial effort to prepare the biophysical and economic information for RCDA in vegetables, rice and corn. The interesting finding is that many smallholder farmers and extension workers couldn't readily provide the cost of production. This suggests more programs on farm business are required. This also means that it is difficult to identify the value of climate information and to answer questions such as the appropriate level of investment into frost forecasts.

Impact of social research

The value of social science research for the human problem of managing climate risk.

Despite some notable exceptions, the social sciences have been overlooked or underemphasised in climate applications in most countries. Findings from social science research conducted by PIDS and UPLB have influenced the way that the mandated agencies of PAGASA and the Department of Agriculture deliver climate risk. A potential longer- term impact is the value of well-planned rigorous social research for climate risk in the Philippines.

Ethnographic studies showing that communication of weather and climate risk is more than translating or 'laymanizing' science

The ethnographic studies conducted by UPLB showed a complex taxonomy for weather and climate terms. Climate science distinguishes between warnings, short-term weather, seasonal climate and climate change whereas rice farmers in Calapan referred to sunny/dry weather (days) and weeks and climate and rainy/wet weather and climate. This is fundamentally different from the way that climate science categorises events. The rice farmers interviewed in Calapan associate the term El Nino with extreme drought and La Nina with extreme rainfall. This is problematic as extreme is usually confined to events that are rarer than 1 in 10. In the last century there have been about 25 El Nino events, 25 la Nina and 50 neutral events and so El Nino is better understood as an increased chance of drought. This confusion will lead to a situation where PAGASA statements on El Nino will often be perceived as false alarms. It is also interesting (and concerning for communication) that the corn farmers in Gloria did not distinguish between El Niño and the dry season.

There are many studies on perceptions and attitudes to climate change and seasonal forecasts, a long history of studying attitudes of risk and uncertainty, and the role of fate and providence. The contribution from the cultural domain analysis is to challenge the easy assumption that farmers and climate science have a shared understanding of seemingly straightforward terms such as weather, climate, El Nino and drought.

Social network analysis

An important impact from social network analysis is to challenge the simplified view of individual rational actors who receive weather and climate information and apply it to their decisions. The SNA work by PIDS and UPLB, included testing of concepts and rigorous debate about census approaches versus snowballing and the problem of finding missing nodes. Pilot studies with SNA bulked weather and climate information together, this was common practice across the published SNA studies we reviewed. By distinguishing between warnings, short-term weather forecasts, seasonal climate forecasts and climate change, the SNA work found quite direct networks for information on a typhoon warning compared to more complex networks for information on climate change. An early impact is that one of the final reviewers, Dr Steven Crimp enquired about developing an ACIAR small research development activity (SRA) to share learning from the Philippine partners with work on SNA in PNG. This suggestion from Steven Crimp opens the promising area of learning between partner countries involved in different projects.

The SNA work from this project will have a direct impact on planning extension activities in Benguet and Mindoro. A longer-lasting impact is to encourage a 'social network lens' not only to improve the efficiency and effectiveness of extension by targeting nodes with many connections, but also justice for nodes with low connections that are underserved. An uncomfortable, but important finding is that extension workers often play a minor role in the networks and may be servicing nodes that are already receiving information from multiple sources.

Climate Science

There are many projects addressing climate risk for Philippine agriculture. An important contribution of this project is recognising and dealing with the uncertainty in decision making and the irreducible uncertainty in forecasting future climate. Resources from this project have expanded the probabilistic forecasts from a month to seasonal level. This expansion was initiated to meet the requirements of Rapid Climate Decision Analysis. Other sectors such as the Hydropower engineers have expressed interest in these probabilistic forecasts.

As indicated earlier, this project hasn't been responsible for introducing the idea of probabilistic forecasts to PAGASA, however an impact of this project has been to increase the confidence of PAGASA staff to consider ways to communicate that uncertainty to end-users to provide fuller information which potentially can lead to better decision making.

The PAGASA icon, Ella the Umbrella has four colours (red, yellow, green and blue) that correspond with the same colours used on maps showing categories of well below normal, near normal, normal and above normal. As part of this project we have introduced the concept of the umbrella showing the chance of being in each of the categories. Figure 8.1 shows this development as part of the spreadsheet discussed in section 7.4. As discussed in section 8.4, this concept has been included as an App in PAGASA formats.

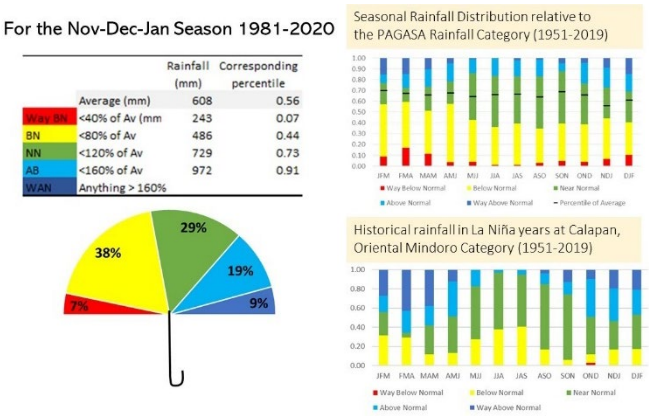

Figure 8.1: Example historical distribution of PAGASA's rainfall categories, including the umbrella representation.

8.2 Capacity impacts – now and in 5 years

The mid-term review in October 2018 was challenging to all project members. To accept and work through critique is an uncomfortable form of capacity building. Younger and older team members from Australia and the Philippines are more thoughtful researchers after this process. To re-group, accept critique, avoid blame, and maintain a positive view of what we are trying to achieve was a difficult but rewarding experience. One of the messages from the mid-term review was to drop some activities, placing an emphasis on doing fewer things well. An example was not to proceed with surveys of agricultural extension workers, but to focus on key informant interviews and focus groups. Because surveys are expected in projects and can be a relatively low-cost way to develop data they can become a default. A hard lesson from the review was only to conduct surveys after careful analysis and design. The Social Network Analysis proceeded with clear planning and productive discussion between PIDS and UPLB on the need to take a census approach vs snowballing.

Preparing and delivering the final project review in November 2020 was a positive experience. As a team we learnt how to use video conferencing and how to prepare short presentations allowing more time for discussion. A number of Philippine team members remarked on how the discipline of pre-recording a presentation, keeping to a tight schedule and respecting the time for hourly breaks were lessons to improve both video and future workshops.

The teams of economists in PIDS and UPLB have improved their skills in decision modelling and decision analysis by working with Professor Kevin Parton and this work has produced a set of case studies and findings reported in the Special Issue of the Philippine Agricultural Scientist. In addition to the <u>results</u> of the Decision Analysis we aimed for the <u>process</u> of Decision Analysis be used by Extension Workers. It is less clear that we have been successful with this, in part because in many cases the extension workers are not aware of the cost of production for different enterprises and lack the confidence to seek this information. As discussed in the impacts section, we have built capacity within PAGASA to use Verbal Decision Analysis as a means of enquiry of end user needs.

Writing workshop and PAS Special Issue

Arguably the most effective capacity building was the journal writing workshop which Prof Kevin Parton (Charles Sturt University) organised and ran a successful online writing workshop for the entire project team, building on some prior workshops he had conducted at CSU face-to-face. This consisted of 6 sessions spread over 3 weeks in June 2020. Each session had a pre-recorded presentation from Kevin to watch prior to an online Zoom session for discussion and interaction (approx. 1 hr). Between 20-25 participants were involved in each of the sessions.

The following topics were covered:

- Introduction
- The Concept Plan
- Selection of Target Journal
- Developing an Outline of the Paper
- Figures and Tables
- Write Introduction and Conclusion
- Putting Flesh on the Bones: Writing the Core of the Paper
- Title, Abstract and Keywords
- Authorship
- Managing the Review and Revision Process

The workshop coincided with the schedule for preparing journal papers for the Special Issue accepted by the Philippine Agricultural Scientist which is an international journal of agriculture published quarterly by the College of Agriculture and Food Science, University of the Philippines Los Baños https://pas.cafs.uplb.edu.ph/. During the writing workshop, lead authors for the PAS papers were prompted to write particular sections starting with the concept plan, and were encouraged to seek feedback from fellow participants. Prof Parton reviewed all of the draft papers, and final papers were sent through an English language editor prior to submission to PAS last August 2020. The papers have recently been updated and returned to PAS following suggestions from reviewers, and we are awaiting further details on the final PAS process and release date.

Capacity has been enhanced through hardware including 2 laptops for PIDS and for UPLB 2 Dell Laptops, Lenovo Thinkpad Laptop, Macbook Pro, 2 Sony voice recorders, Brother Printer and a single user license for Stata software.

The Jollibee Group Foundation (JGF) in the Philippines has a flagship program (Farmer Entrepreneurship Program) that helps smallholder farmers become agro-entrepreneurs who can directly supply corporate buyers such as Jollibee Foods Corporation. The program engages through partnerships with different institutions, clustering, and mentoring of farmers. The JGF approached Dr. Caning Predo (UPLB) post project in Feb 2021, with particular interest in their work on Crop Climate Calendars. UPLB are currently preparing a budget and MOA for a 6 month project focussing on Onions in Nueva Ecija in regards to Crop Climate Calendars, and have also mentioned that JGF have approached BSU similarly for work on vegetables.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

The analysis by UPLB economists suggest that the value of forecasts at their current level of skill for the Calapan region of Mindoro is about PhP 109/ha/season (AUD $3.0 which is about 2.5% of the gross margin). Fertiliser decisions on corn have a higher benefit AUD $13.40 which is 10% of the gross margin. These amounts are comparable with the range of values published internationally (Meza et al. 2008) and for Australian studies (Parton et al. 2019).

Accurate estimates of value of information at a regional level require careful scaling up of field-level calculations. A simple scaling assuming 100% adoption and no impact on price indicates that although the value of the rice fertiliser decision is less than a quarter of the corn decision at a single field, the relative size of rice and corn production on Oriental Mindoro lead to a regional value of SCF for rice fertiliser decisions of about $24,400 compared to a regional value of the corn fertiliser decision of AUD $5,000.

An interesting example of economic impacts came from the Mindoro workshop, where the coast guard announced that there would be a weather event 36 hours before its occurrence. This results in early cancellation of ferry trips which leads to loss of agricultural produce especially the highly perishable goods. This problem can be exacerbated as farmers are encouraged to harvest vegetables prior to the onset of a typhoon. The workshop recommended a technical working group with PAGASA, the Coast guard and municipal agricultural officers. In much of the discussion of disaster risk reduction there is limited attention to the economic costs of warning (and risk averse responses to warnings) as well as the benefits for human safety.

8.3.2 Social impacts

There are many social aspects of climate risk, this project is looking at the use of information from PAGASA and a consistent finding is that not all farmers receive warnings and even fewer receive forecasts. Because the extension officers are part of the Local Government Unit, the workshops have been effective ways to communicate some of the challenges for farmers to those responsible for disaster risk reduction.

The Philippines has now implemented Republic Act No. 10639 as the Free Mobile Disaster Alerts Act. Telecommunication companies are mandated to send out weather advisory regularly and free of charge. Even with this law, there are famers without phones.

The national workshop in Manila and the regional workshops in Calapan and Gloria, pointed to the needs of poorer farmers who may access warnings, but don't have internet access and can't access forecasts. A general finding is that the forecasts should be through text, since it is the easiest and fastest way to receive information, and it works even when they are unable to watch television or listen to the radio.

Farmers that live in upland areas such as Benguet and Gloria are more isolated. Not only are they less likely to receive timely information about weather conditions, but also the forecasts tend to be less applicable to their location.

8.3.3 Environmental impacts

In the focus group discussion there are a number of references to the impact of extreme events on soil erosion. It follows that better forecasts have the potential to reduce this risk. It is interesting that some participants argue that flooding is not only due to climate events, but also due to logging contributing to the flooding.

8.4 Communication and dissemination activities

The main communication products for the project are KlimAgrikultura, the free access special issue of the Philippine Agricultural Scientist and policy briefs. Workshops and meetings have been held during the latter part of the project which have drawn together a wide group of key Philippine government agencies and NGOs. Resources from the project have contributed to a PAGASA App that includes the probabilistic forecasts.

The clearest path to impact for the project is KlimAgrikultura as a modular training course and as a process embedded within ATI and PAGASA. Covid has restricted extensive testing and roll out of KlimAgrikultura but ATI have been able to arrange a number of opportunities (Table 8.1).

Table 8.1: KlimAgrikultura pilot workshops held in Benguet, Mindoro and Leyte.

KLIMAGRIKULTURA			
Jan 2020, Baguio City, Benguet (3 days)	High Value Crops	Pilot KlimAgrikultura	7 farmers and 10 Agricultural Extension Workers (AEWs) – (9F & 8M)
Mar 2020, Calapan City, Oriental Mindoro (3 days)	Rice and Corn	Pilot KlimAgrikultura	12 farmers and 22 Agricultural Extension Workers (AEWs) – (14F & 20M)
Oct 2020, Baybay City, Leyte (2 days)	Rice and Corn	Pilot KlimAgrikultura	11 farmers and 4 Agricultural Extension Workers (AEWs) – (13F & 2M)
Nov 2020, Baybay City, Leyte (2 days)	Rice	Pilot KlimAgrikultura	11 farmers and 3 Agricultural Extension Workers (AEWs) – (8F & 6M)

ATI conduct pre- and post-workshop tests on all their training courses. In the pilot testing phase, the increase in knowledge test score was 25% at Benguet and 30% at Mindoro. ATI sets a passing rate at 60% and rates a successful pilot project as one where over 65% of participants exceed this level. The pass rate was 76% at Benguet and 88% at Mindoro. In Leyte, the training sessions had to be reduced to 2 days instead of 3 due to Covid restrictions. For the first KlimAgrikultura pilot in Leyte in Oct 2020, the passing rate was 66.67%.

Figure 8.2 shows the dissemination plan for KlimAgrikultura presented by ATI. The first pathway is to integrate into the climate smart farm business schools which includes online training of trainers for climate change focal people for each commodity who will work with the Agricultural Extension Workers (AEWs) who will deliver to farmers. The second pathway is to work through Local Government Units and private organisations by developing online training material for the Municipal Agriculturalists who will act as intermediaries passing the training onto AEWs.

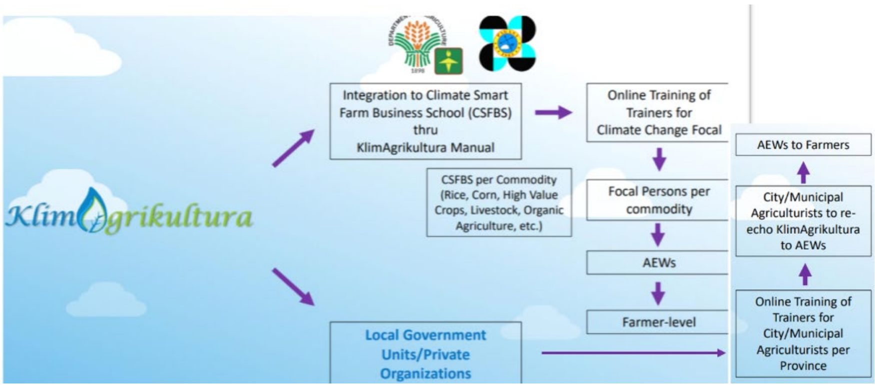

Figure 8.2: Dissemination activities for KlimAgrikultura

There has been demand from other LGUs for KlimAgrikultura and considerable interest generated from the final stakeholder workshop. Institutional support from ATI and PAGASA will be essential for the future success of KlimAgrikultura. Attachment 2 shows how PAGASA plans to incorporate KlimAgrikultura into future activities and the ongoing process of PAGASA Modernization Program which aims to enhance PAGASA's weather data collection and information dissemination services for use in decision-making in disaster preparedness, climate change adaptation, water resources management, and agriculture. The modernisation program which comes from the PAGASA Modernization Act directs PAGASA to partner with other Government agencies and private entities for the collection and dissemination of climate information.

Further dissemination activities in the latter part of the project are listed in Table 8.2.

Table 8.2: Dissemination meetings held in the latter part of the project.

National Stakeholders workshop May 2019	22 participants from numerous organisations, plus 30 project personnel
June 2020. Social networks and access and utilisation of weather and climate information.	PIDS internal brownbag, 39 participants
Sept 2020 Regional Forum on La Niña - MIMAROPA Region	LGU-MDRRMO,DA-RFOs, LGU-MAO, PDRRMO, Regional DRR(No. of Peak Facebook Live Public Viewers - 1100, No. of Zoom Participants - 77)
Oct 2020 PIDS public webinar on weather and climate information	PIDS public webinar on Weather and Climate Information Needs of Smallholder farmers – (No. of webex participants 165, Peak number of viewers on Facebook- 100)
Oct 2020	DA, Water Managers, DRR, LGU, Academe, National Govt, NGO, Private, Electric Distribution

Regional Forum on La Niña - Northern Luzon	Utility, Public Service, Media, PLGU and PAGASA PRSD (No. of Peak Facebook Live Public Viewers -3,176, No. of Zoom participants - 56)
Nov 2020 Webinar on PAGASA products and Services through KlimAgrikultura)	47 participants from DA-ATI, DepEd, DSWD, LGUs, Farmer Association, academe(from Region 1-5), 13 speakers and PAGASA organizing committee
Nov 2020 Final Stakeholders Workshop Presentation on the Key Findings of the ACIAR	75 total Participants, 40 Participants from National Agencies, DOST,DA,DILG,NEDA,BSWM,OCD,DHSUD and LGU PIA,PAO and NGO-RWAN ACIAR Manila and Australia, SARDI, reviewers 35 from partners (PAGASA-16,UPLB -10,PIDS – 4 and ATI-4)

The Payong PAGASA mobile app is an extension application of PAGASA's Farm Weather Information System. This is being updated to include an additional module for seasonal climate forecasts based on concepts developed in this project (Figure 8.3). With PAGASA as a partner in the project we have a conduit to the majority of the Philippine community.

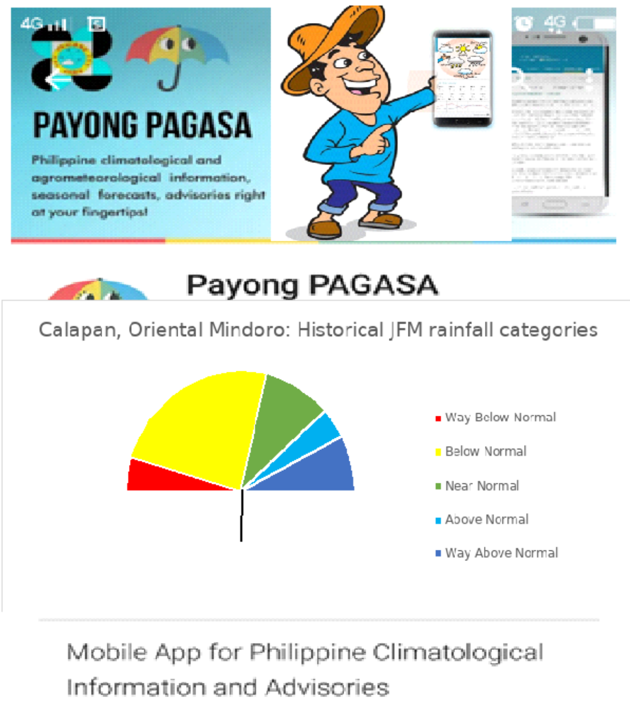

Figure 8.3: Example interface in the Payong PAGASA mobile app.

9 Conclusions and recommendations

9.1 Conclusions

The aim of this project was to improve the exchange of information between PAGASA and key decision makers involved in managing climate and weather risk of smallholder farmers. We have tried to address the five ingredients for successful climate services identified by The World Meteorological Organisation WMO (2013): 1) understand the demand side, 2) include sector expertise, 3) co-production of information, 4) communication for the last mile, and 5) assess and reassess.

We are fortunate to have PAGASA as an active partner rather than a stakeholder or information provider in this research on climate risk. This partnership involved social research and applied economic research by PIDS and UPLB to understand the demand side and engage with sector expertise through regional universities and LGUs in Benguet and Mindoro. The partnership with ATI and development of KlimAgrikultura presents the potential for communication for ‘the last mile’.

The cross-discipline approach has been a strength of this project. Despite some notable exceptions, the social sciences, including economics, have been overlooked or underemphasised in climate applications in Australia and the Philippines. Perhaps worse than being excluded is only to be engaged as a ‘downstream’ process. Hartman (2015) reacted to a call for social science to translate and communicate the message of climate science as follows: *“To turn to expert humanities researchers not for the depth of their knowledge concerning values and ethics, or historical trends in human thought and behaviour, but for their ability to translate a highly technical scientific message into the popular idiom is not unlike engaging an accomplished composer to tune your guitar.”* In a similar vein, the agricultural economist Bill Malcolm (1994) referred to the *“agricultural scientist way of thinking, which is to build the technical model and add a few dollar signs on the outputs at the end”.* Applied economics has much more to offer than putting a peso value on forecasts and this is especially the case when it comes to thinking clearly about the value of information for decision making under uncertainty. Perhaps above all is the notion of being comfortable acting with partial understanding and unavoidable scientific uncertainty (Jasanoff. 2007).

Social research has contributed understanding of users’ needs, their social networks and the way that they think about and categorise weather and climate risks. Applied economics research has highlighted the climate risky decisions that smallholder farmers face and the potential value of information on the coming season. Of far more importance than the <u>results</u> of economic analysis using Decision Analysis we aimed to codify some of the <u>methods</u> and concepts of Decision Analysis. It is important to clarify that we are not aiming to produce more Decision Support Systems, nor are we aiming directly at the smallholder farmer. As aptly put by Dr Caning Predo UPLB, farmers are interested in the fruit of decision trees, not the tree. Our target audience was extension workers and PAGASA staff who would use decision analysis as a framework to generate useful information to enhance their thinking about uncertain climate forecasts applied to risky decisions.

Drawing the components of the project together in modular form in KlimAgrikultura has been rewarding. It is pleasing to have a distinctly Philippine flavour to the overused term “climate smart”, and to prepare the modular steps towards having action ready knowledge that presents relevant PAGASA climate science through a focus on the decisions of smallholder farmers.

9.2 Recommendations

Ongoing support for KlimAgrikultura

The potential for KlimAgrikultura depends on institutional support from PAGASA and ATI. There may be opportunities for ACIAR and Philippine partners to discuss this with PCAARRD. We have designed KlimAgrikultura to be modular. While there are advantages to the two-day training exercise designed by ATI, there are components that could be re-packaged within future projects where PAGASA is a partner.

SARDI Climate Applications is continuing development of Verbal Decision Analysis and Rapid Climate Decision Analysis as part of projects in the grains and wine grape industry Australia and an ACIAR Small R&D activity no SAC/2018/164 led by CSIRO in southern India. We will share these developments with PAGASA over the coming years.

The importance of including HydroMet services as partners rather than clients of R4D in climate risk

Where climate risk is a significant aspect of an ACIAR project there are advantages with including the Hydro Met service as a research partner rather than a stakeholder or supplier of information. This is increasingly important as the World Meteorological Society is calling for all Hydro Met Services to shift from being the wholesaler of information to a climate services model. Involving PAGASA improved the sharpness of the social research by distinguishing between warnings, weather forecasts, seasonal climate forecasts and climate change projections. Embedding the research outcomes with PAGASA greatly increases the usefulness and use of the outcomes. Most, if not all projects on climate risk in the Philippines will interact with PAGASA.

Being clear about uncertainty when dealing with climate risk.

It is best practice for climate science to communicate the uncertainty of forecasts. All modern met services produce an ensemble of forecasts of the future. Only indicating the most likely outcome, or the mean of the ensemble is partial information. There are times of the year when an El Nino event is occurring that the ensemble spread is much narrower, and this should provide much greater confidence. Where available, past measures of skill should also be included. In this project we used Decision Analysis as a way to frame risky decisions and value incomplete information about the future. We believe that there is merit in promoting Decision Analysis providing the framework is used as a basis for discussion and enquiry of the decisions facing smallholder farmers rather than as a recommendation.

The value of social sciences

We recommend that ACIAR and PCAARRD consider funding quality social research into the human problem of managing climate risk in agriculture. There are talented social scientists in PIDS and UPLB. A recommendation from the End of Project Review by Dr Steve Crimp was to share some of the skills from members of the project team with his work in PNG. This opens up the interesting question of learning across projects and across countries. It is important to acknowledge the insights from rigorous social research and that it should be given equal status to the natural sciences. This will avoid the lazy assumptions that the social sciences are an add-on for communication of natural sciences or as a form of market research.

The benefits of the writing workshop

A clear message from all partners in Australia and the Philippines and from experienced to junior staff was the benefit of the writing workshop. Almost all participants are used to preparing reports but appreciated the way the workshop provided a step by step approach to writing clear journal papers with succinct, but strongly supported arguments. As suggested by the End of Project Review this short course led by Kevin Parton would be valuable for other projects.

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10.2 List of publications produced by project

The table below includes details on the 12 journal papers awaiting publication in a Special Issue of the Philippine Agricultural Scientist https://pas.cafs.uplb.edu.ph/ . Once published, these will be freely available online.

Ref	Paper title	Authors	Case Study area
#1	Making climate science more useful for decision making: a synthesis of multi-disciplinary perspectives from conversations with smallholder farmers in the Philippines.	Peter Hayman, Juan M. Pulhin, Canesio D. Predo and Bronya Cooper	All
#2	From climate data to actionable climate knowledge: DOST-PAGASA experience providing climate services to smallholder farmers in Calapan, Mindoro	Thelma Cinco, Wilmer Agustin, Bronya Cooper, Alexis Declaro, Rosalina de Guzman, Edna Juanillo, Rosemarie Marasigan, Analiza Solis, Peter Hayman	Calapan, Mindoro
#3	Mapping access and use of weather and climate information to aid farm decisions in the Philippines	Clarissa Ruzol, Laizha Lynn Lomente, Juan Pulhin	
#4	Analyzing social networks in upland farming communities for improving the design of education and information programs: The Case of Atok, Benguet	(PIDS) Aubrey D. Tabuga, Anna Jennifer L. Umlas, and Katrina Mae C. Zuluaga	Atok, Benguet
#5	Determinants of the use of weather and seasonal climate information among smallholder maize farmers in Bulalacao, Oriental Mindoro, Philippines	Jeffrey Andrew L. Losloso, Canesio D. Predo, Asa Jose U. Sajise, Juan M. Pulhin, Ma. Victoria O. Espladon	Bulalacao, Mindoro
#6	Impacts of extreme weather events and coping mechanisms of smallholder highland farmers: Case of Typhoon Ompong (Supertyphoon Manghut) in Benguet, Philippines	(BSU)Cheryll C. Launio	Benguet

Ref	Paper title	Authors	Case Study area
#7	Local Knowledge on Climate Hazards, Weather Forecasts and Adaptation Strategies: Case of Cool Highlands in Benguet, Philippines	Cheryll C. Launio (BSU), Ruth S. Batani, Christita Galagal, and Kacy O. Labon	Benguet
#8	Gender and the use of climate information in agricultural decision-making amidst climate change: The case of rice and corn production in Oriental Mindoro, Philippines.	Larissa Gata, Jeffrey Losloso and Pamela Nilo	Mindoro
#9	Economics of Cabbage Production and Critical On-farm Decisions in Atok, Benguet, Philippines	Sonny N. Domingo, Anna Jennifer L. Umlas, Katrina Mae C. Zuluaga	Atok, Benguet
#10	Application of Rapid Climate Decision Analysis Support Tool in Assessing Climate-Sensitive Farming Decisions in Calapan and Gloria, Oriental Mindoro, Philippines	Dan Leo Z. Diona II, Jeffrey Andrew D. Losloso, Canesio D. Predo, Juan M. Pulhin, Patricia Ann J. Sanchez, Asa Jose U. Sajise, Catherine C. De Luna, Kevin A. Parton, Peter T. Hayman	Mindoro
#11	The economic value of weather forecasts on selected rice and corn farming decisions in Calapan and Gloria, Oriental Mindoro, Philippines	Dan Leo Z. Diona II, Mia Barbara D. Aranas, Asa Jose U. Sajise, Canesio D. Predo, Juan M. Pulhin, Catherine C. De Luna, Maricel A. Tapia-Villamayor, Ma. Larissa Lelu P. Gata	Mindoro
#12	Use of a crop model for management decisions in rice production: The case of Calapan, Oriental Mindoro, Philippines	Jan Idel Emmanuel F. Castañeda, Patricia Ann J. Sanchez, Canesio D. Predo, Juan M. Pulhin	Calapan, Mindoro

11 Appendixes

11.1 Appendix 1:

List of Appendixes:

Available at the website used for the Final Review. Alternatively, please contact Bronya.Cooper@sa.gov.au or Peter.Hayman@sa.gov.au

https://sites.google.com/view/aciar-arck/final-report-appendixes?authuser=0

1. PAGASA products and services for Agriculture.doc
2. PAGASA integrating KlimAgrikultura, Jan 2021
3. UPLB report on co-learning and co-development workshops, Feb 2020
4. PIDS report on co-learning and co-development workshops, Jan 2020
5. UPLB preliminary report on CDA and SNA, Jan 2020
6. PIDS preliminary report on SNA, Feb 2020
7. KlimAgrikultura Facilitator's Manual
8. MinSCAT final report
9. BSU final report