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INTEGRATING CLIMATE INFORMATION IN AGRICULTURAL EXTENSION: POLICY AND INSTITUTIONAL SUPPORT NEEDS IN THE PHILIPPINES

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ABSTRACT

The changing rainfall pattern has undermined the ability of the farmers to rely on their indigenous knowledge for farm decisions such as when to plant, what crop to plant, when to fertilize and when to irrigate, among others. The climate information, especially through climate forecast is deemed necessary support to farm level decisions at these times. The challenge raised is how to bring this climate information down to the farmer level. In addition to this is the issue of how to translate the information as extension advisory.

This paper discusses the climate information system (CIS) by identifying the suppliers of information, their pathways to the farm level, the various actors that provide extension advisories and how these are ultimately disseminated to the municipal agricultural offices and the farmers. Data were taken from secondary sources and from data base generated by the AMIA 2 CIS project. Ways to sustain the various CIS projects are also suggested.

Results show that challenges to the sustained provisioning of CIS and the corresponding extension advisory include: 1) standards in the establishment and maintenance of the CIS equipment; 2) coping with global modern technologies; 3) meeting human capital requirements; 4) need for a paradigm shift within the DA and the LGUs in order to mainstream the climate forecast and extension advisories in the day to day activities; and 5) commitment of partners to institutionalize collaboration among the providers and the users of CIS.

Policy recommendations to sustain CIS initiatives are as follows: 1) come up with a protocol in the establishment and maintenance of the CIS equipment; 2) invest on modern technologies for climate data collection; 3) harmonize available climate projection models; 4) build human capital to sustain the CIS; 5) mainstream the climate forecast and extension advisories as functions of the DA, LGUs and SUCs; and 6) institutionalize CIS partnerships and collaborations.

Keywords: climate change, climate information, CIS, farmers, farmer decision, extension

TABLE OF CONTENTS

Page

List of Tables

Page

List of Figures

INTEGRATING CLIMATE INFORMATION IN AGRICULTURAL EXTENSION: POLICY AND INSTITUTIONAL SUPPORT NEEDS IN THE PHILIPPINES

Agnes C. Rola, Dulce D. Elazegui, Roger A. Luyun, Jr., Nico Jayson C. Anastacio, Fitz Jimenez, Maria Cristina A. Alvarez and Catherine P. Cervantes

I. Introduction

1.1 Problem Statement

Climate change has been hampering the capacity of farmers to make optimal decisions in farming as it alters rainfall patterns, among other environmental conditions. Conventional knowledge in agriculture now needs to be augmented with current and immediate information about the increasingly unpredictable weather conditions in local communities. Hazards that are faced by farming communities and households due to climate change manifest in flood and drought events which result to damage to crops. Farmers can avoid some of these damages if they can adapt early through climate information services (CIS) and extension advisories.

CIS involves the production, translation, transfer, and use of climate knowledge and information in climate-informed decision making and climate-smart policy and planning (Tall, 2013; Vaughan, 2016). The effective delivery of various climate information services and products requires appropriate institutional mechanisms. Linkages from the international, regional, national to local levels are necessary, not only to generate but also to assimilate climate information and services in their most useful way in decision making. In addition, CIS would enhance adaptation to abnormal conditions and take advantage of good climate conditions.

It is widely recognized that climate products should be user-centered to be useful in decision making. But more often, there is no systematic mechanism for the interaction between users and providers (WMO 2014). The major challenge is translating climate information into sectoral impacts and communicating response options to end users for their application.

From weather to climate timescales, agricultural decisions tend to become more context and farmer-specific; thus requiring greater scope of climate services. These may include translating raw climate information into predictions of agricultural impacts or management advisories, training, assistance with planning and organizing response mechanisms, and evaluation and feedback processes to continually improve information products and services (Tall et al. 2014).

1.2 Early Philippine initiatives of the CIS

There have been initiatives to bring climate information services to the rural communities. For instance, the Climate Field School (CFS) was pioneered by the local government of Dumangas, Iloilo in 2007, through the collaboration of Asian Disaster Preparedness Center (ADPC), the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), Iloilo Provincial Agriculture

Office, with support from the Office of the Foreign Disaster Assistance of the Unites States Agency for International Development (USAID) and the Local Government Unit (LGU) of Dumangas. The model consists of establishing climate data collection equipment, building capacities to process and analyze the data and coordinate with the PAGASA in giving out climate forecast to farmers in the area. It also showcases the importance of building resilient communities to weather uncertainties brought about by climate change but also the need to empower local institutions so they can formulate climate responses, to creatively use local resources to be cost effective, to create and sustain an inclusive participatory institutional system for efficiency, and to find champions to mainstream climate change mitigation and adaptation measures (Dumangas On the Go 2010). Dumangas has an agromet station to provide weather advisories to their farmers and fisherfolk. Monthly seasonal and daily forecast from PAGASA is also released together with extension advisories for the farmers and fisherfolk.

In 2012, the Dumangas model has been scaled up by the Food and Agriculture Organization (FAO) in its Assessments of Climate Change Impacts and Mapping of Vulnerability to Food Insecurity under Climate Change to Strengthen Household Food Security with Livelihoods' Adaptation Approaches (AMICAF) project implemented in the Philippines (together with the Philippine Department of Agriculture (DA)) and in Peru (together with the Peruvian Ministry of Agriculture and Irrigation). This project established Automatic Weather Stations in the study areas and trained the partner DA Regional Field Office (RFO) officials to come up with a regional Seasonal Climate Forecast and Advisory Services.

In Bicol, this type of giving climate information to farmers was further pursued in the USAID assisted "the Bicol Agri-water Project" that also started in October 2012.This initiative builds from the Dumangas' experience by working with three municipal governments in the issuance of the Seasonal Climate Forecast (SCF)from PAGASA. Once the forecast at the municipal level is available, the project uses climate crop models to generate agricultural extension advisories on top of the good practice options being recommended by the local technicians and the local DA RFO. Currently, capacities within the region have been built among the state college and universities (SUCs) to do the modelling. The SUC then connects with the LGUs for the production and dissemination of the advisories. The AMIA 2 piloted the approach in 10 regions of the country. Other initiatives which are variants of the Dumangas approach are available and also discussed below.

1.3 The need to mainstream CIS in agricultural extension

The Dumangas case has slowly gone out of Dumangas, through other projects' initiatives. The Dumangas LGU also passed an ordinance to continuously conduct Climate Field Schools (CFS) in the town. The CFS is an avenue for farmers to learn about the importance of the climate information in agricultural decisions. To sustain and scale up and scale out what has been experienced in Dumangas is still a challenge.

This paper thus builds on the data generated from an AMIA2 funded project (CIS Provisioning in Agriculture) to understand the issues surrounding the implementation and eventual sustainability of integrating CIS in farm decisions. For analysis of the policy and institutional dynamics to produce, process and disseminate CIS in the country, a study (Elazegui et al. 2017) was also commissioned through AMIA2 funds, whose results are reported in this paper.

II. CIS Activities Framework and Study Methodology

2.1 International Standard

The World Meteorological Organization (WMO 2014) identifies a wide range of activities encompassing CIS implementation (WMO 2014). This includes:

1. Historical climate data sets to characterize climate behavior across temporal and spatial scales
2. Climatological analysis - long-term means and trends; climate variability characteristics
3. Monitoring - useful for climate predictions and projections and guiding actions to respond to potential effects, include information on drivers of climate variability e.g., La Niña, El Niño, current drought/flood conditions
4. Seasonal outlooks - rainfall, temperature
5. Climate change information (e.g., projections and scenarios information) - for national adaptation to climate change
6. Training on the use of climate products and services

Established policies and procedures are critical for standardization, reliability, and sustainability of these sets of activities. National entities acquiring data from global and regional centers face the challenge of ensuring compatibility of data across geographical and jurisdictional boundaries. Communication, exchange, and dissemination especially of routine data and products should include their interpretation and relevance to users (WMO 2014).

WMO (2014) sets three categories of users of climate information/services. The first is the internal user, e.g., national meteorological agencies, to generate products for external users. The second category is the external user operating at strategic level, such as government, finance, and insurance, to develop better policies and conduct business more efficiently. The third is the external end-users for whom productivity of their business/enterprises is directly affected by climate variability and change, such as farmers.

The principal CIS operational entities are organizations that routinely produce and provide climate data, monitoring analyses, prediction, and projection products. Climate data sets will be the initial standard operational products of global, regional, and national scales. To ensure future acceptability and reliability of predictions and projections, CIS will need to coordinate with research institutions. Research is important in bridging climate prediction possibilities across timescales and providing reliable information products to various users (WMO 2014).

2.2 Data generation and institutional landscape analysis

Primary data collection was done through a series of key informant interviews with representatives from institutions involved in CIS. These institutions include

PAGASA, Advanced Science and Technology Institute (ASTI), Bureau of Soils and Water Management (BSWM) of the Department of Agriculture (DA), Rice Watch Network (RWaN), and researchers. Furthermore, secondary data were gathered from a collection of related literature, and a number of relevant documents. The collected data were analyzed using institutional analysis. This involves a review of policies related to climate information services; the roles of various actors in the services chain; and challenges in the provision of CIS. Policy recommendations are also offered at the end of the paper.

2.3 Policies related to CIS for agriculture

In the Philippines, policies concerning CIS are based on various national laws, particularly those relating to climate change. These policy instruments mandate specific institutions certain functions and provide for coordination, partnerships, or linkage among different stakeholders for the provision of climate information services (Table 1).

Table 1. Policy instruments related to climate information service for the agriculture sector.

Policy Instrument	Institution concerned	Mandate
EO 128, Jan. 1987 - Reorganizing the National Science and Technology Authority	Philippine Atmospheric, Geophysical and Astronomical Service Administration (PAGASA) - Department of Science and Technology	Undertake activities relative to observation, collection, assessment and processing of atmospheric and allied data for the benefit of agriculture, commerce and industry;
Republic Act No. 9729 or the Climate Change Act of 2009	Climate Change Commission	Oversee the dissemination of information on climate change, local vulnerabilities and risks, relevant laws and protocols and adaptation and mitigation measures
	Department of Environment and Natural Resources (DENR)	Oversee the establishment and maintenance of a climate change information management system and network
	Philippine Information Agency (PIA)	Disseminate information on climate change, local vulnerabilities and risk, relevant laws and protocols and adaptation and mitigation measures
Republic Act No. 101201 or the DRRM Act of 2010	National Disaster Risk Reduction and Management Council (NDRRMC)	Establish a national early warning and emergency alert system through diverse media
	Office of Civil Defense	Establish standard operating procedures on the communication system for warning and alerting local DRRM councils

Republic Act No. 8435 or the Agriculture and Fisheries Modernization Act of 1997	Department of Agriculture; PAGASA, and other government agencies	DA, in coordination with PAGASA and such other appropriate government agencies, shall devise a method of regularly monitoring and considering the effect of global climate changes, weather disturbances, and annual productivity cycles for the purpose of forecasting and formulating agriculture and fisheries production programs
DA Memorandum January 25, 2013	Department of Agriculture	Mainstreaming climate change in DA Programs including the Climate Information System to have a common database to generate timely and reliable data for DRR planning and management; and establishment of agromet stations in highly vulnerable areas
National Climate Change Action Plan 2011-2028	Multi-stakeholder partnership	Establish climate information system for agriculture and fisheries - Food security strategic action plans
National Framework on Climate Change Strategy	Multi-stakeholder partnership	Establish Information, Education, and Communication (IEC) Campaigns and knowledge management as a cross-cutting strategy

2.4 Institutional landscape for CIS

Consistent with WMO's and Tall et al. (2014) classification, these CIS institutions are the: 1) information providers synonymous to internal users that generate the products; 2) intermediary users and/or co-producer of CIS receiving climate information from other sources and translating into climate advisories tailored to farmers' needs (e.g., extension agencies); and 3) the information end-users such as the local planners and farming communities. Intermediary users often serve as link between the national information provider and the local-level end-users (Figure 1).

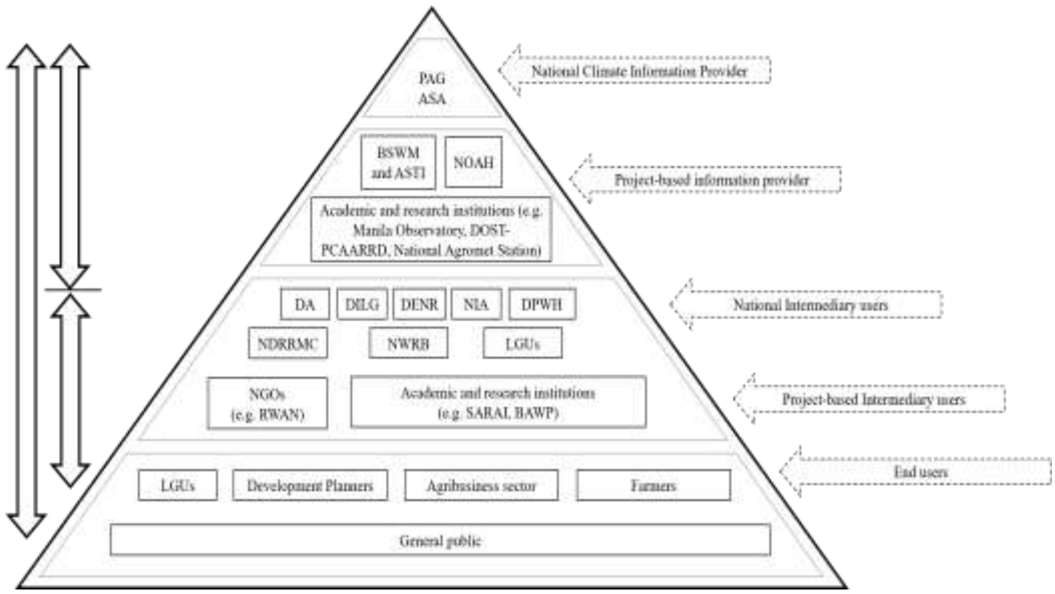

Figure 1. Institutions involved in climate information services for agriculture in the Philippines.

III. Climate Information Provider

3.1 Philippine Atmospheric, Geophysical and Astronomical Service Administration - CIS Products and Pathways

As per EO 128 of 1987, the main provider of hydro-meteorological services in the Philippines is PAGASA, an attached agency of the Department of Science and Technology (DOST). PAGASA performs activities from observation, collection, assessment and processing of atmospheric and allied data, to distribution of CIS for the benefit of various sectors such as agriculture, commerce and industry. PAGASA is a member of the World Meteorological Organization (WMO), a specialized body of the United Nations, thus has to comply with WMO guidelines in providing CIS.
PAGASA products and services include climate monitoring, climate predictions, climate outlook and advisories and tailored-products and services (Table 2).

Table 2. PAGASA climate product and services

Activity Category	Products and services
Climate monitoring	• Day-to-day rainfall and during tropical cyclone(TC) passage • Onset of rainy season • Dry/ wet spell • Northeast/Southwest monsoon monitoring • Temperature anomalies (sea surface temperature (SST), local) • Monthly rainfall and temperature assessment
Climate prediction (sub-	• Monthly/ seasonal/ 6-month rainfall forecast • 10-day probabilistic forecast

Activity Category	Products and services
seasonal/seasonal climate forecast)	• Temperature forecast • Tropical cyclone frequency forecast • Dry/ wet day forecast • Drought outlook
Climate outlook and advisories	• Seasonal outlook (3 to 6 months) • Monthly weather situation and outlook • Dry/ wet spell Situation and outlook • El Niño/ La Niña Advisory • Dry spell/ drought advisory • Press statement
Tailored-products and services	• Statistically downscaled climate projections • Watershed/ dam/ river basin rainfall forecast • 10-day forecast for farm advisories • Climate briefing with NGAs and TWG meetings • Information, education, and communication (IEC)

Source: PAGASA Central Office

PAGASA also has satellite receiving facilities for data from US National Oceanic and Atmospheric Administration (NOAA), Moderate-resolution Imaging Spectroradiometer (MODIS) of the National Aeronautics and Space Administration, Multifunctional Transport Satellites (MTSAT) of the Japan Meteorological Agency (JMA), and aviation facilities served by the World Area Forecast System (WAFS) such as Weather and Flood Forecasting Center (WFFC) (PAGASA Profile).

To enhance its weather data generation capabilities, PAGASA has installed and/or upgraded equipment and facilities throughout the country (Table 3). Radar stations were installed for rainfall detection and movement of tropical cyclone. Upper air stations are used for thunderstorm prediction and aviation, meteorological forecasts and volcanic ashfall monitoring. Automatic Weather Stations (AWS) are all over the country for continuous and automatic monitoring of selected weather elements (Porcil 2009).

Table 3 .PAGASA equipment and facilities.

Type	No
Synoptic Stations	57
Agromet Stations	23
Upper air stations	8
Automatic Weather Stations	155
Automatic Rain Gauge	187
Water level sensors	47
Wind profiler	1
Wind tunnel	1
Automatic Weather Observing System	2
High Frequency Doppler Radar	2
Marine buoys	2
Mobile Doppler radars	2
Doppler Weather radars	16

Source: PAG ASA Profile 2016 from PAG ASA Central Office

Pathways for PAGASA CIS products

Climate Information Monitoring and Prediction Services

PAGASA established the Climate Information Monitoring and Prediction Services (CLIMPS). This originated from the National ENSO Early Warning and Monitoring System (NEEWMS) set up at the height of El Niño in 1986-87. It provides seasonal forecast and timely advisories to various end users, particularly policy makers, economic planners and emergency managers (Figure 2). It includes early warning system, provision of monthly weather outlook to member agencies of the Inter-Agency Committee for Water Crisis Management (Subbiah et al., nd). NEEWMS uses observations from a network of 50 surface synoptic weather monitoring stations and 40-year historical sets of 10-day and monthly rainfall. Information provided to government agencies upon request include rainfall analysis, 10- day, monthly, seasonal, and 12 month rainfall accumulation (Amadore 2002 cited in Subbiah et al.).

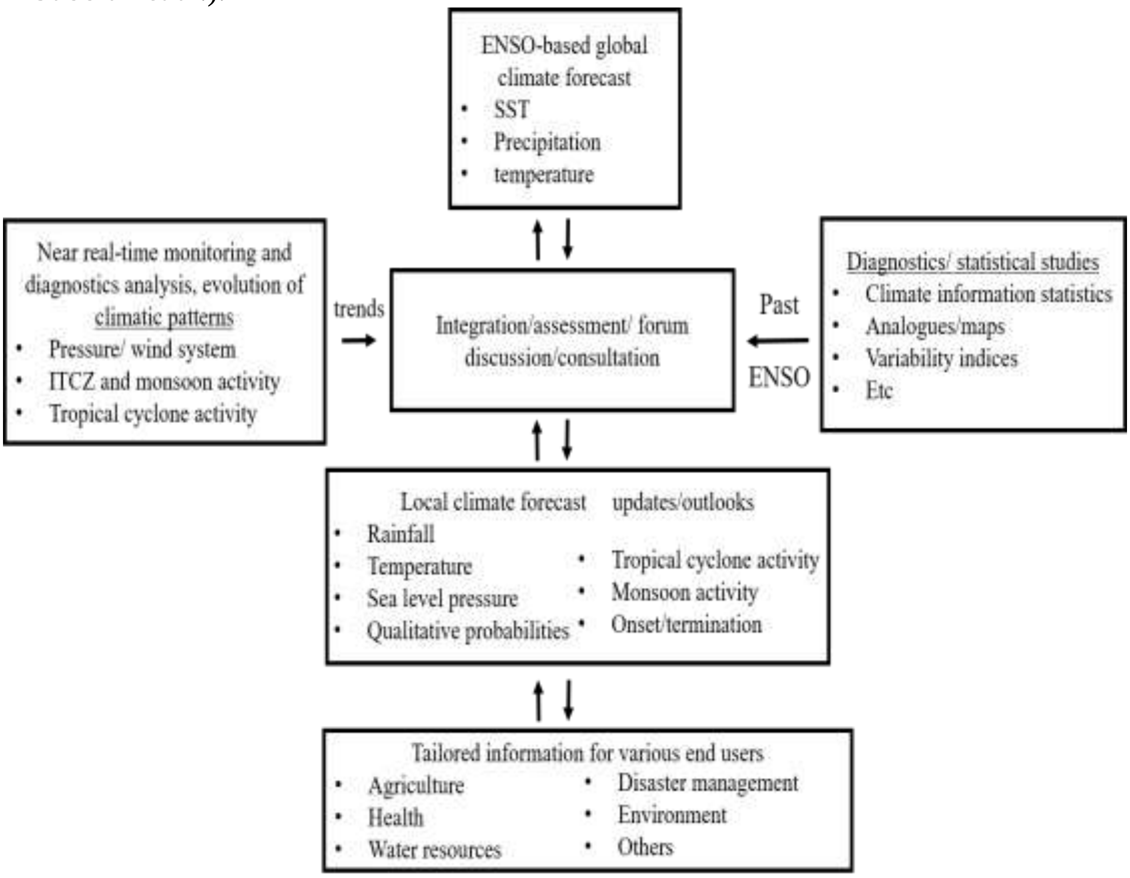

Figure 2. Translation of ENSO-based global climate forecasts into local climate forecasts. *(Source: PAGASA website)*

Weather forecast information

A weather forecast is simply a scientific estimate of future weather condition which is the state of the atmosphere at a given time. Different weather elements are observed and analyzed, and condensed to generate weather predictions which are then transmitted through various means to different collection centers. Ultimately, from these collection centers, the coded weather observations are transmitted to the central forecasting station at WFFC. Furthermore, weather satellite pictures and radar observations are transmitted to different centers, and ground receiving stations via local communication system (Figure 3).

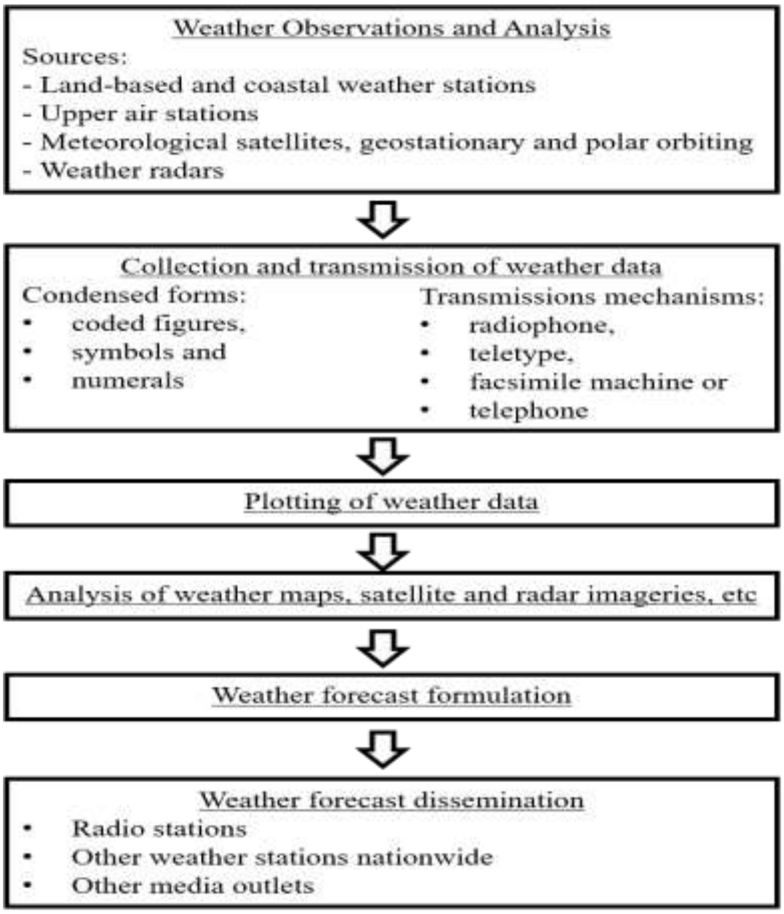

Figure 3. Steps in data generation to dissemination of weather forecast information by PAGASA. *(Source: PAGASA)*

Farm weather services

PAGASA has a Farm Weather Service Section (FWSS) that prepares and disseminates information specifically to help farmers in farm planning and decision making. The products include farm weather forecast and 10-day regional agri-weather information. Weather parameters (e.g., temperature, rainfall) covering the period from 1981 to 2010 were used to establish Agro Climatic Zoning based on the potential/optimum use of agricultural land.

Based on the outlook and weather parameters, farming and fishing advisories are issued. The 10-day regional agri-weather information includes the weather systems that will affect the whole country for the next 10 days and regional agrometeorological situations and prognosis as well as, crop phenology, situations and farm activities in the different regions of the country. These ten-day Regional Agri-Weather and Advisories are circulated through radio stations, agricultural schools and universities, DA, PAGASA field stations, LGUs and researchers (Figure 4). This can also be accessed through the PAGASA website and text/short service messages.

PAGASA personnel also serve as resource speakers in different trainings, meetings, and fora that are organized by different institutions or organizations.

In addition, there are also activities being done by PAGASA that aims to educate the members of the different local government units. It has been conducting IECs and communications workshop with municipal agriculturists for translating data to layman's language, using various visual aids in local dialect, and improving capacity to handle all local data. The Municipal Agriculturists and Agricultural Extension Workers conduct trainings for farmers to enable them to apply basic climate information in their different agricultural activities.

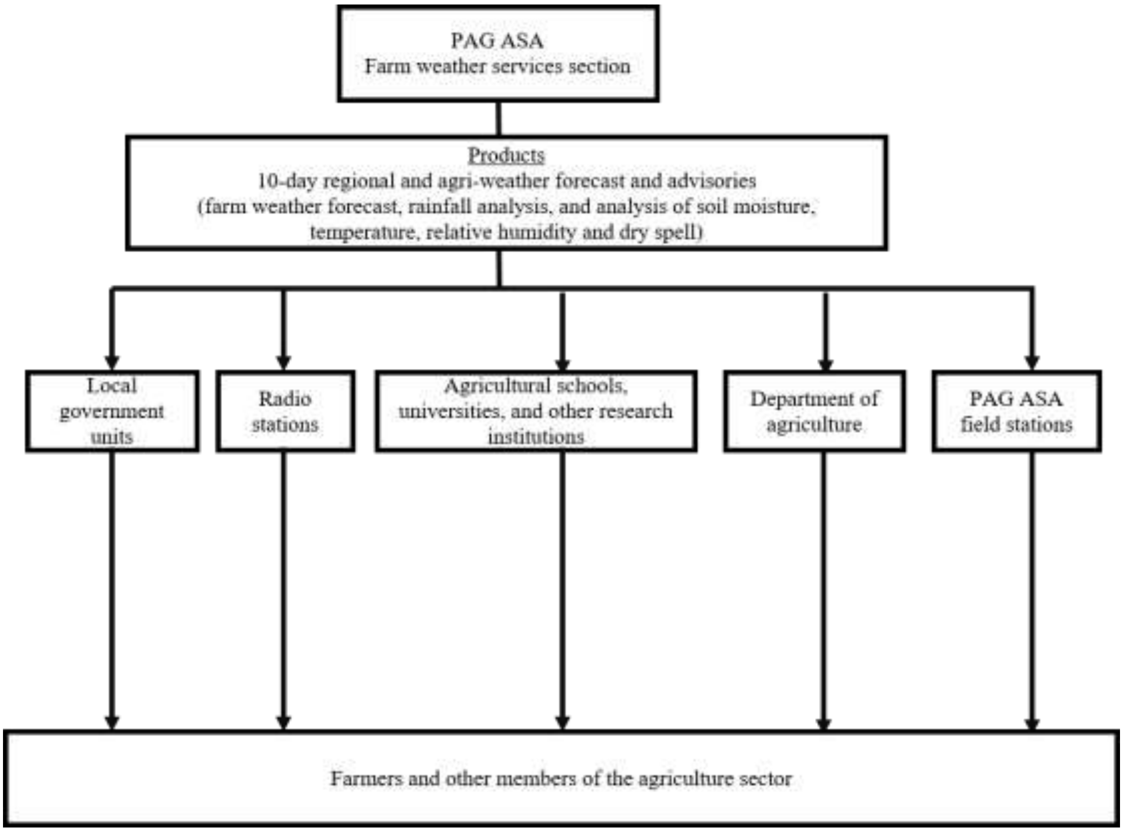

Figure 4. Information pathway from PAGASA FWSS to farmers.

Climate Trends and Projections

Climate projections are necessary for climate change impact assessment and national planning. There are two methods of establishing climate projections: (a) historical trend and (b) climate modeling.

In producing climate projections in the Philippines, a recent workshop report (Daron et al., 2016) revealed that there are several groups of climate modelers with contrasting methods. For example, the Met Office Hadley Center in UK, in collaboration with PAGASA, is currently generating downscaled CMIP5 simulations using HadGEM3-RA with a horizontal resolution of 12 km. At the same time, PAGASA is downscaling its own CMIP5 simulations using a range of RCMs, including PRECIS, CCAM and RegCM4. In addition, a cooperation project between PAGASA, FAO-PAGASA and FAO-AMICAF previously provided statistically downscaled climate projections using CMIP3 GCM models (BCM2, CNCM3 and MPEH5). The process of downscaling enhances the scale of climate information from global scale (coarse resolution) to regional and local scale (finer resolution) either by nested-resolution RCM, also known as dynamical downscaling, or statistical methods.Other groups providing future climate projections in the Philippines include the SEACLID/CORDEX Southeast Asia project collaboration between University of Malaysia and Manila Observatory.

3.2. Project-based CIS providers

Other providers of climate information are project-based and collaborative in nature. Examples are: Project on "Establishment of Agro-Meteorological Stations in Highly Vulnerable Agricultural Areas: A Tool for Climate Change Adaptation, and in the Development of Local Early Warning System" led by DA-BSWM. It is also referred to as the 'Agromet cum Climate Change Project.'

BSWM Agromet program

The Agromet cum Climate Change project is a joint undertaking of the BSWM and the ASTI and PAGASA with funding from the DA Philippine Council for Agricultural and Fishery (PCAF formerly the National Agriculture and Fishery Council (NAFC). It started in December 2011. ASTI was involved in the establishment/installation of Automatic Weather Stations (AWS) including data storage, and in ensuring that they comply with the standards of WMO. PAGASA was involved in the training of agro-meteorological and AWS observers, installation of AWS, and recalibration and maintenance of equipment.

Activities include (a) the establishment of 100 automatic weather stations (AWS) with nine sensors, upgrading of 20 existing units of PAGASA and 33 existing units of ASTI by adding three sensors; and installation of 84 standard rain gauges (Table 4); (b) data collection, processing, interpretation, communication, and utilization; (c) capacity building; and (d) development of agro-ecological zone. PAGASA assisted BSWM in validating the locations of the 100 AWS, including the installation, calibration and maintenance of the equipment. They also trained the agro-meteorological and AWS observers. According to a key informant, the target for turnover of these facilities to specific recipients such as LGUs, research outreach stations (ROS) or SUCs is in December 2017. Once turned over, the AWS will have to be maintained properly. Recipients may need to provide for funds to do this.

Table 4. Number of AWS sites covered by DA-BSWM/NAFC Agromet cum climate change project.

Region	Number of AWS				Total
	Installation		Upgrading		
	New	BSWM*	PAGASA	ASTI	
CAR	4	-	2	2	8
Region 1	5	-	2	2	9
Region 2	4	3	2	2	11
Region 3	6	2	1	1	10
Region 4a	5	1	1	1	8
Region 4b	6	-	1	3	10

Region	Number of AWS				Total
	Installation		Upgrading		
	New	BSWM*	PAGASA	ASTI	
Region 5	5	1	2	4	12
Region 6	5	1	1	3	10
Region 7	5	1	-	1	7
Region 8	8	1	2	4	15
Region 9	5	2	-	2	9
Region 10	5	2	1	1	9
Region 11	5	1	2	1	9
Region 12	7	1	2	2	12
CARAGA	6	-	1	3	10
ARMM	3	-	-	1	4
TOTAL	**84**	**16**	**20**	**33**	**153**

**Existing Agromet Stations (manually-operated)*

(Source: Agromet cum climate change: Establishment of Agro-meteorological stations in highly vulnerable agricultural areas: A tool for climate change adaptation and in the development of local early warning system project)

Currently, maintenance of these facilities is done by the DOST regional offices. Each AWS is equipped with nine sensors including rainfall, minimum and maximum temperatures, solar radiations, sunshine duration, wind speed and direction, relative humidity, atmospheric pressure, evaporation and soil moisture. Data from each AWS is stored in a data logger and transmitted real time to a central server at ASTI which can be viewed in the internet (Figure 5). Evapotranspiration, which is used to estimate the crop consumptive use, is also immediately computed from the data through an algorithm based on the FAO Penman-Monteith equation. Data from the weather sensor are sent via SMS at an interval of 10 minutes. PAGASA validates and processes the transmitted data. Data from agromet stations are recorded daily by an assigned observer in a prescribed format by PAGASA. The data are submitted monthly to DA-BSWM by mail. Evaluated data and possible warnings can be seen in the ASTI website. Acquisition of historical data, however, requires a request letter to the ASTI. Historical data are used for hydrologic frequency analysis to determine long term trends and projections, as well as in the development of cropping calendars.

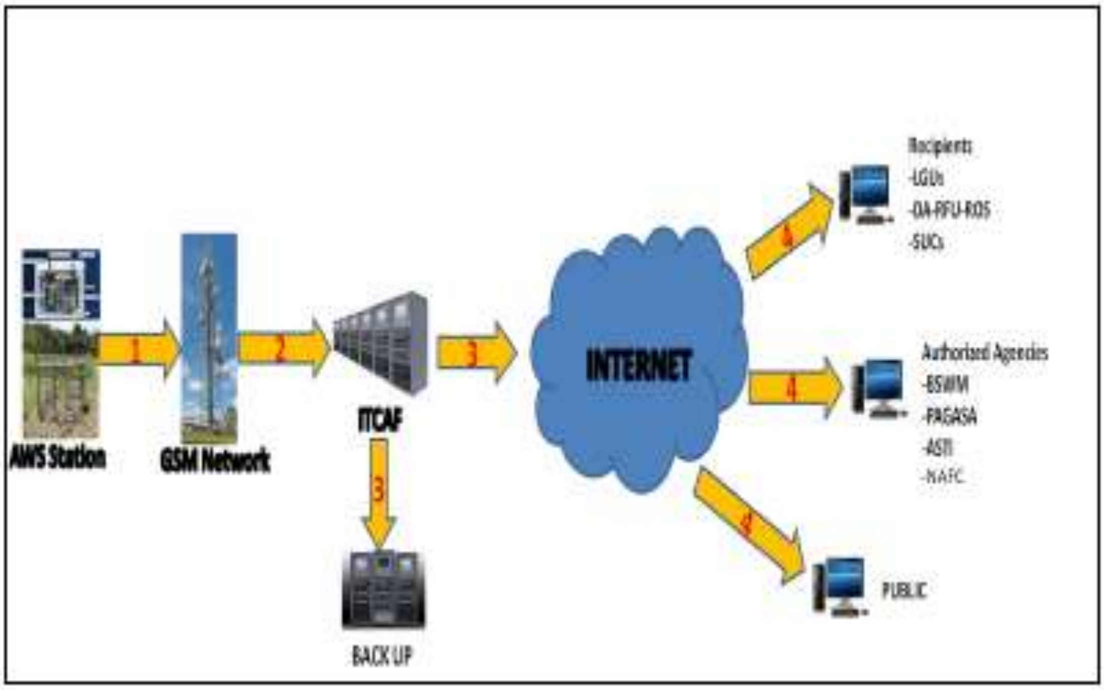

Fig. 5. Data transmission using the automatic weather station, DA-BSWM Agromet cum climate change project.

(Source: Agromet cum climate change: Establishment of Agro-meteorological stations in highly vulnerable agricultural areas: A tool for climate change adaptation and in the development of local early warning system project)

3.3. Intermediary user of climate information and producer of extension advisory

PAGASA also establishes partnership with different government organizations and project-based intermediaries in order to capacitate different agriculture stakeholders (i.e., local government units, farmers, and other members of the value chain) in managing their climate related risks (Figure 6). These institutions generate and gather these climate data through various equipment and sources. In the case of PAG ASA, these data sources include rain gauges, automatic weather stations, and agromet stations. However, although agromet stations and AWS generate almost the same climate data, PAG ASA relies mostly on their agromet stations for more accurate and reliable data (i.e., AWS are susceptible to errors because of its vulnerability). Likewise, AWS also serves as a primary source of climate data of ASTI and different project-based data generators, which are accessed from time-to-time by PAGASA through their respective databases. In the case of some local government units, they access climate data through their partnership with private climate data generators.

Prior to the generation of these climate information and extension advisories, climate data are processed by different institutions and converted to forms that could be processed easier by different intermediary climate information providers (e.g., 10-day weather forecast of PAG ASA)

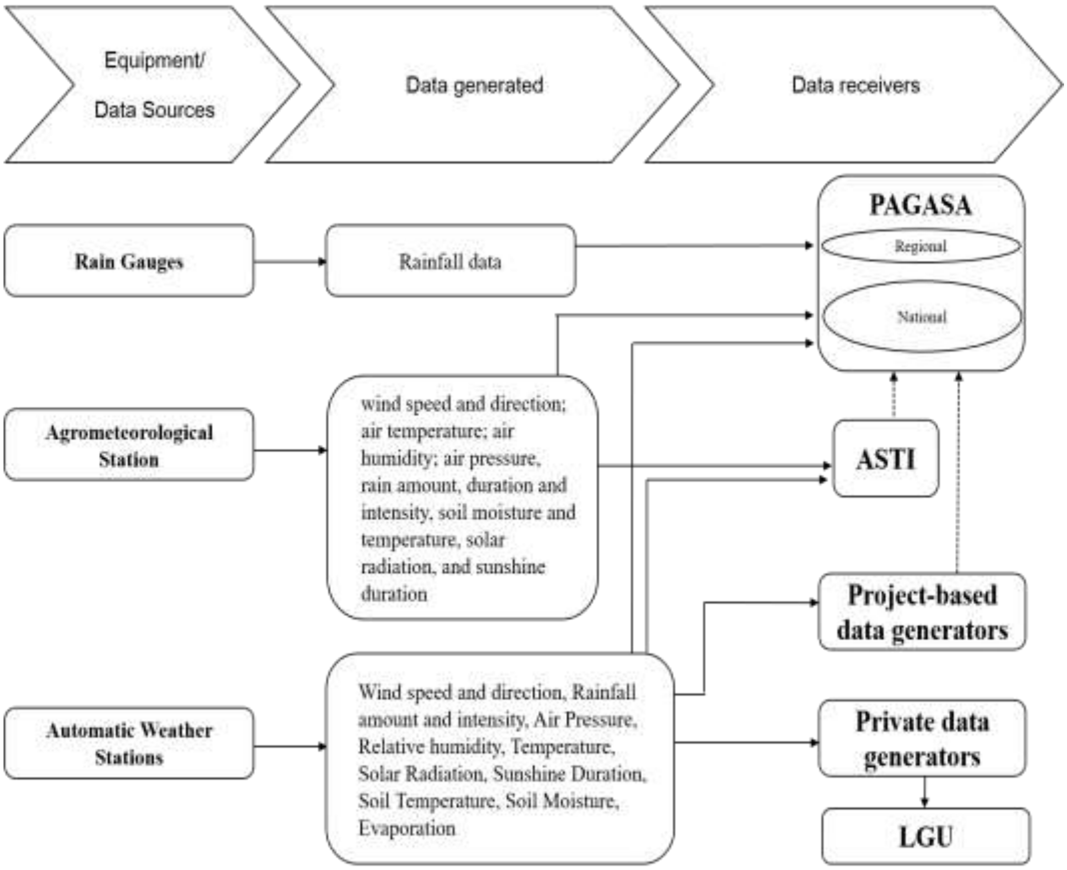

Figure 6. Summary climate data flow.

3.4. Local Government Institutions

There are local government units with initiatives to produce climate information to their constituents. For instance, the Municipal Local Government Unit of Dumangas disseminates farm weather advisories through its Municipal Agriculture Office (MAO) (Figure 7). These advisories enumerate guidelines by which the farmers and fisher folks could base their responses during various weather conditions. To better communicate these advisories, the LGU translated them into their local language, which is Hiligaynon. Aside from Dumangas, Iloilo, Guinayangan, in Quezon, Tirona in Tarlac, and Irosin, Sorsogon also generate the CIS and advisory.

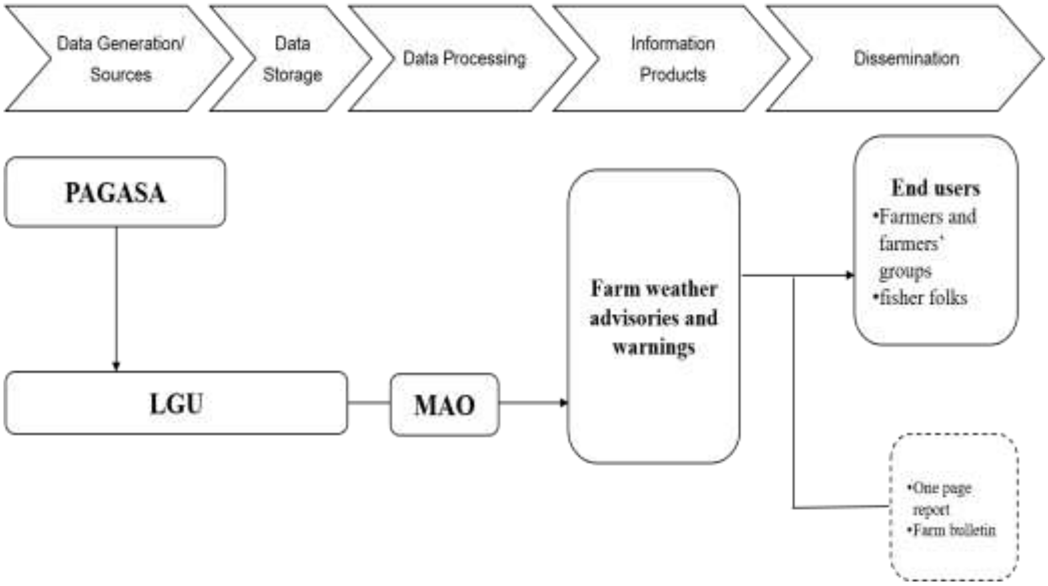

Figure 7. Climate information flow, Dumangas LGU

3.5. Project-based intermediaries

At the local level, intermediary users/co-producers are implementors of project-based activities and most are also collaborating with PAGASA. Examples are:

"Smarter Approaches to Reinvigorate Agriculture as Industry in the Philippines" or Project SARAI.

The project is based in UP Los Baños and funded by DOST-PCAARRD. Its components include 1) Model Development and Crop Forecasting; 2) Environmental Characterization and Development of Integrated Crop Management); 3) SARAI Knowledge Portal; 4) Capacity and Knowledge Sharing; and 5: SARAI Mainstreaming). It generated its climate historical data from PAGASA to be used in model building; unlike the other projects, SARAI estimates its own climate forecast.

The project aims to develop a national crop forecasting and monitoring system for six priority crops: rice, corn, banana, coconut, coffee, and cacao. It uses advances in information technology, cropping systems modeling, geographic information systems (GIS), and field sensors. This can be used in decision support models and early warning system to guide farmers and policy makers. Some of the technologies developed by the project include the SARAI Knowledge Portal, cost-efficient soil moisture sensors and meters, Water balance-Assisted Irrigation decision Support System (WAISS), Smarter Pest Identification Technology (SPId Tech), SARAI-Enhanced Agricultural Monitoring System (SEAMS), crop suitability maps, and Integrated Crop Monitoring Forecasting System (ICMF). All modeling activities are done at the UPLB; with the regional SUC partners as generators of downscaled regional climate data.

The project is supported by weather data from AWS installed in various State Universities and Colleges (SUCs) (i.e., Isabela State University, Bataan Peninsula

State University, Cavite State University, Central Luzon State University, Cebu Technological State University, Central Mindanao State University, Mindoro State College of Agriculture and Technology, Misamis Oriental State College of Agriculture and Technology, Southern Philippines Agri-business and Marine and Aquatic School of Technology, University of Southern Mindanao, Western Philippines University, West Visayas State University-Pototan), and research institutions (e.g., PhilRice). Data generated are then transformed at the UPLB using numerical models and other science-based judgements into advisories to farmers. These advisories include ideal planting dates, irrigation decision support system, crop suitability and vulnerability, and pest and disease incidence. For instance, they can be advised when to irrigate based on the moisture content of the soil and the stage of growth; they can drag images of pests in the platform to be identified and to know how to manage them; they can have access to interactive maps to guide in farming decisions; and they will receive crop alerts and advisories based on weather outlook (Figure 8).

Various communication channels are used by the project to disseminate these advisories to their target stakeholders. These include a web-based knowledge portal, and a mobile application, as well as trainings and other IEC campaigns, publications. The project utilized a wide range of communication channels in order for it to reach a high number of its target stakeholders. The first phase of the project was completed this April 2017 and a second phase is under negotiation.

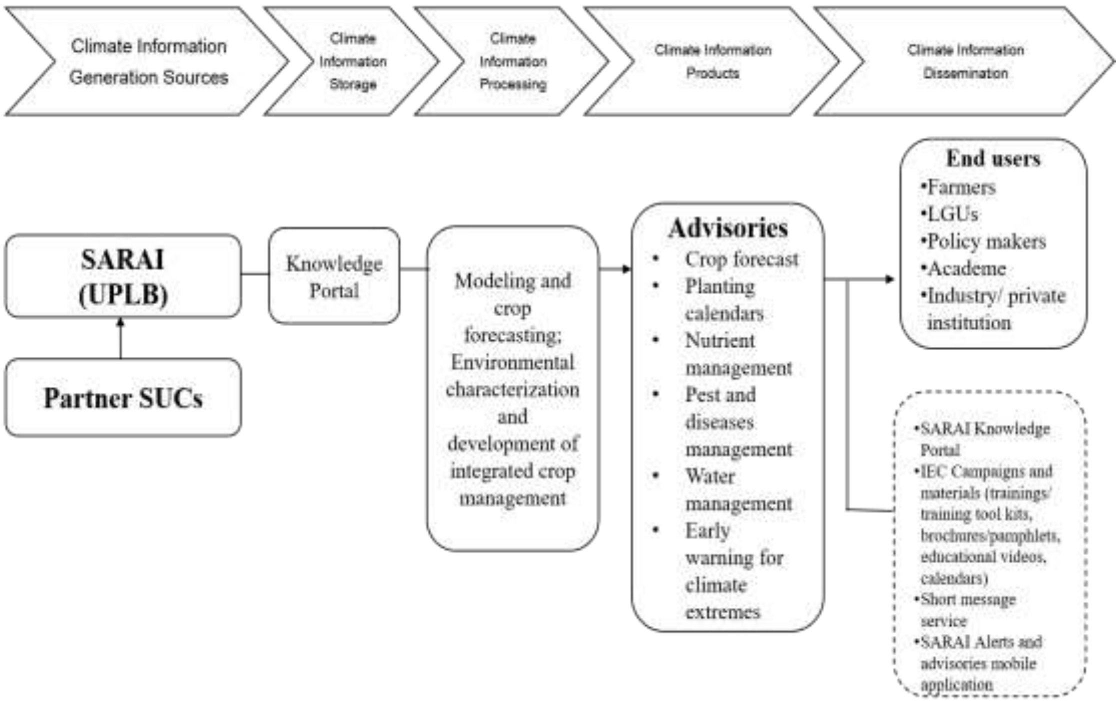

Figure 8. Climate information and advisory flow, Project SARAI.

The USAID Bicol Agri-Water Project (BAWP)

This project aims to enhance knowledge and skills of stakeholder in integrating climate information in agricultural decisions focused in the Bicol region.

BAWP established one AWS and 20 rain gauges under the stewardship of barangays in selected municipal study sites in Camarines Sur and Albay. Rainfall data collection is community based. Selected members of the irrigators' associations were trained by PAGASA on how to collect rainfall data from the rain gauge. The daily data series at the sitio level is now more than four years. The trend analysis generated from the series leads to the appreciation of the communities on the reality of the micro climate as revealed by the differential rainfall trends even in the same barangay. The MAO is in charge of the maintenance of rain gauges and management of local rainfall data. It links with PAGASA in the generation of observed climate and rainfall forecasts (Figure 9).

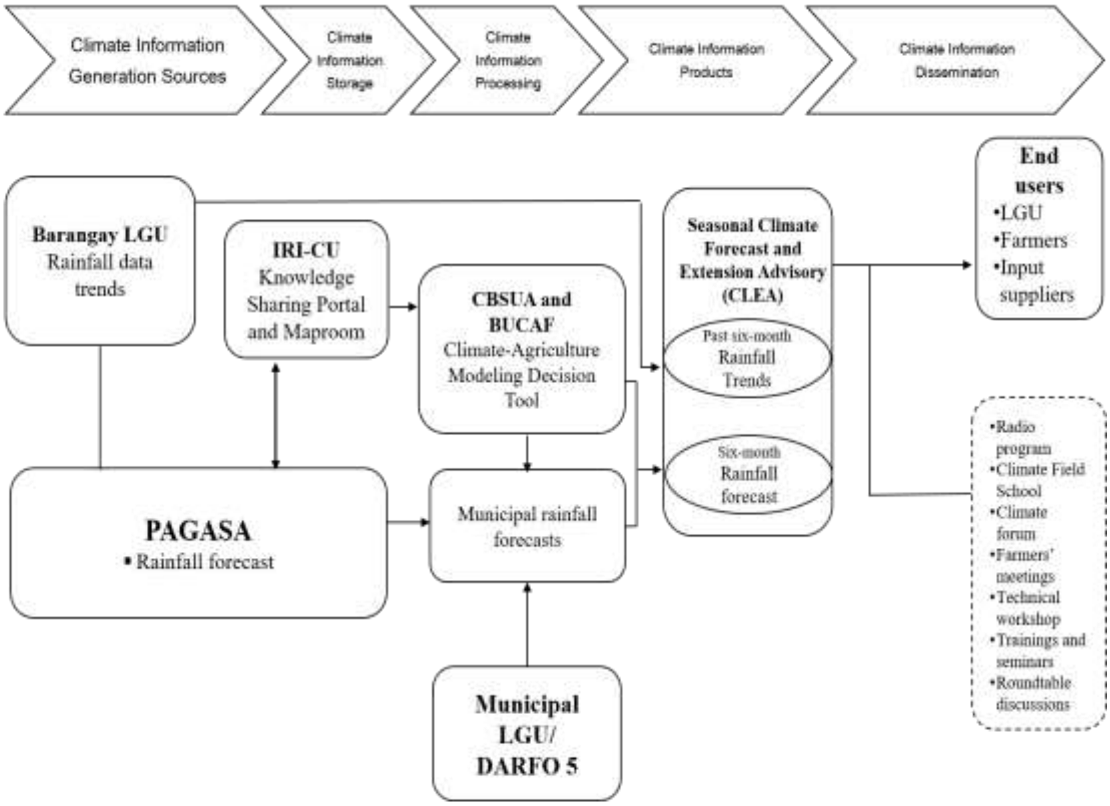

Figure 9. Climate information and advisory flow, BAWP project

BAWP also conducted training for production of seasonal climate forecast and extension advisory (CLEA). CLEA is a one page brief presenting a combination of good practice options and results of the climate crop model. It is packaged by the local government with help from the SUCs and the Department of Agriculture Regional Field Office 5 (DA RFO 5) and contains six-month climate outlook for the municipality and advisories on ideal times for planting and harvesting, crops or varieties to plant, and crop and water management practices suitable to the climate outlook. In consultation with the DA RFO5 , the MAO identifies good practice options as part of the CLEA recommendations.

BAWP, in partnership with IRI, trained the Central Bicol State University of Agriculture (CBSUA)/Bicol University College of Agriculture and Forestry (BUCAF) faculty for agricultural data processing using decision support tools such as the Climate-Agriculture Modeling Decision Tool (CAMDT). IRI also maintains a Knowledge Systems Portal (KSP) for storage of climate data for Bicol Region which is accessible in the IRI website.The BAWP will end in September 2017, but this activity will go on.

The project partners at the region including the SUCs and the study municipal LGUs together with the DA RFO5 and PAGASA will continue providing the seasonal climate forecast and advisory to farmers beyond the project life. This sustainability is assured through the municipal ordinances, the MOA amongst partners (SUCs, LGUs, PAGASA, DARFO5) and the resolution at the barangay levels. Also, continuity is possible through the local capacities built during the project life.

The BAWP model was piloted by the DA-AMIA 2 program in 10 regions of the country. Twenty seven (27) municipalities across these regions have capacities to formulate the CLEA, and 10 SUCs have had capacities built for climate crop modeling. Efforts for these partners to have sustained activities through MOAs are on-going.

Rice Watch Action Network (RWAN)

RWAN is one model of non-government institutions considered as intermediary user. Through multi-stakeholder partnership (e.g., with PAGASA, DA, AMIA, FAO, UPLB), it provides regular forecast and risks management advice to farming and fishing communities. It has trained LGUs on localized climate services such as local weather observation; farm weather advisory creation; dissemination of advisories; and weather and impacts benchmarking. It holds Municipal Climate Forum and launched the Saka SMS program for communicating warning (Figure 10).

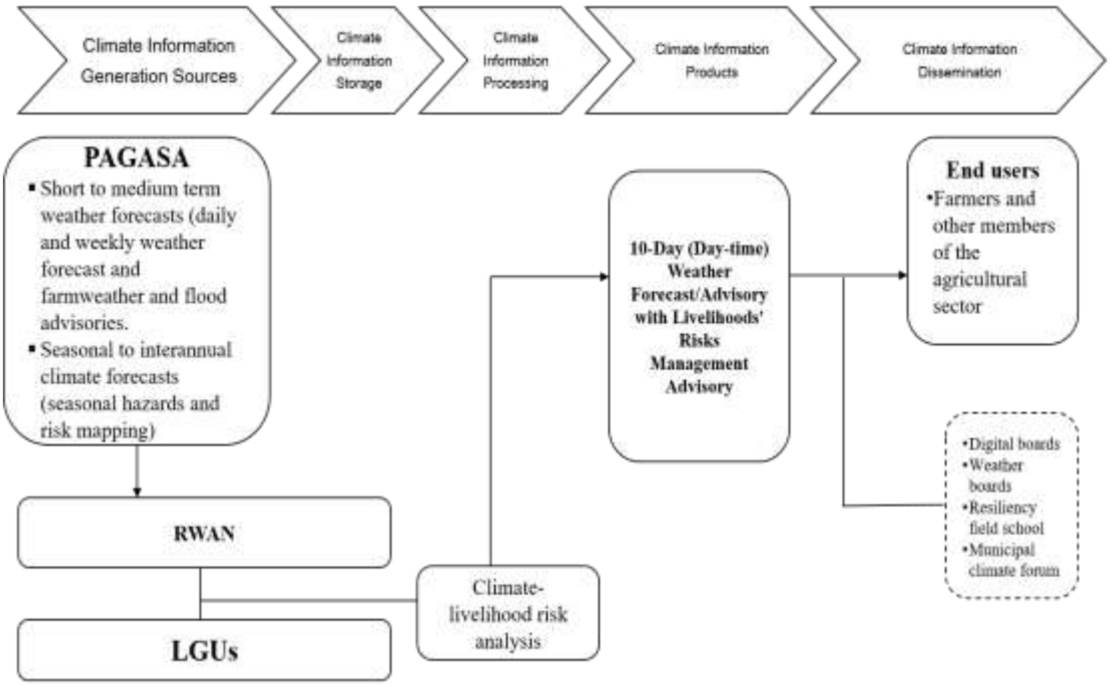

Figure 10. Climate information and advisory flow, RWAN project

PAGASA and RWAN conduct Climate Resiliency Field School (CRFS) in different agricultural areas of the country. The CRFS aims to, among others, provide early warning service to help farmers manage climate/weather-related risks; and enhance farmers/fishers knowledge on climate variability and anticipatory abilities to inform livelihood decisions. Climate information will also help LGUs in climate change action planning.

Climate information, which RWAN releases in "laymanized" advisories, is especially important in areas prone to extreme weather conditions (e.g., drought, frost, typhoons). Furthermore, in order to better communicate it with the local stakeholders, these advisories are translated in their local language. The efforts of RWAN in raising community awareness of climate science and understanding past, present and future climate trends and impacts to livelihoods and communities is an exemplary practice of making CIS relevant to adaptation decision-making.

Other project-based intermediary CIS providers

The FAO-DA RFO 5 project provided seasonal climate forecasts for Bicol region. After the project, DA RFO continued the activity and produced an advisory every 6 months containing PAGASA's rainfall forecast for the provinces, climate outlook, weather systems, impacts outlook, good practice options and various support (production, technical, marketing, post-harvest processing).

The "Project Output on Consolidation Capacities for DRR Agriculture and Fisheries" jointly undertaken by Caraga State University, DA and BFAR created one web portal and one mobile application for both agriculture and aquaculture sectors. Accessible through the internet, the portal contains weather forecasts, farm bulletins, and good practice options. The project's daily forecast contains weather data such as average temperature, rainfall, relative humidity, wind speed and direction. Information dissemination is through broadcast and text messaging.

Another CIS provider is Weather Philippines, by the Aboitiz Foundation and supported by SM Foundation, which funded the cost and installation of AWS in different parts of the country.

3. 6. Information end-user

There are CIS end-users both at the national and local levels. At the national level, end-users widely range from development planners, policy makers, to agro-industry (i.e., seed and fertilizer producers and distributors). In the context of this study, the primary end-user of the climate information is the agricultural sector, particularly the farming and other vulnerable communities. The use of CIS would allow the farmers to manage and cushion the impacts of changing climatic condition to different phases of agricultural production (i.e. land preparation, harvesting, and post harvesting).

To enhance commitment and better understanding of the roles and responsibilities of different institutions at the local level, PAGASA and DA have drawn a memorandum of understanding for new User Interface Platform (UIP) (Selvaraju et al. 2013). This led to improved climate outlooks catered to the needs of the users. The provincial and municipal level agriculture staff is in charge of communicating the advisories to the village level authorities and end users. The barangay "captains" were assigned to monitor and observe weather from newly installed weather stations and for communicating this information to the PAGASA regional services division.

IV. Comparative Analysis of Available CIS Models' Information Pathway and Content

4.1 Comparison of information pathway among the primary and intermediary CIS providers

Climate Information passes to different pathways starting from data generation up to dissemination of advisories. PAGASA and LGUs serve as the main sources of CIS information and advisories. PAGASA processes data to generate forecast/projections. PAGASA sends climate information containing 10-day forecast, monthly forecast and seasonal climate forecast. LGUs on the other hand, provide information and advisories containing GPOs in farming and fishing. This information are stored in CIS providers databases. RWAN and LGU Dumangas store on their own data banks while SARAI and BAWP use their knowledge portals. This information are processed to come up with farm and fishing advisories. Then CIS providers develop localized printed advisories.

Each CIS provider together with their partners creates its own advisory. RWAN and LGU Dumangas target users at the municipal level. BAWP creates advisories for barangay/community level while SARAI generates for their specific sites. Many CIS providers produce the same farm advisories that are localized. In addition, SARAI project is unique in offering nutrient and pest disease management and crop forecast. BAWP is also different in giving advisories that contain Good Practice Options about irrigation management and other crops. On the other hand, SARAI and BAWP both recommend the best planting calendar. Lastly, CIS providers have different modes of dissemination depending on their end users. The common ways for sharing these advisories are through farm bulletins, climate forum and distribution of printed materials (Table 5).

Table 5. Comparison of information pathway of CIS providers

	RWAN	**BAWP**	**SARAI**	**LGU Dumangas**
Data Generation/ sources	PAGASA, RWAN, LGUs	LGU, PAGASA	UPLB-SARAI	PAGASA, LGU-Dumangas
Data Storage	RWAN & LGUs databases	IRI-CU database/ Knowledge Portal	Knowledge portals	LGU database
Data Processing	PAGASA, RWAN, LGUs,	PAGASA, IRI, LGU (municipal), DA RFO 5,	UPLB	PAGASA, LGU-Dumangas

	RWAN	BAWP	SARAI	LGU Dumangas
		local SUCs		
Information Products	Farm weather advisories and warnings	Seasonal Climate Forecast and extension advisory (CLEA)	Advisories: Crop forecast, planting calendars, nutrient management, pest and diseases management, water management, early warning for climate extremes	Farm weather advisories and warnings
Dissemination	Weather boards, Resiliency field school, municipal climate forum	Radio programs Farmers' meetings, Climate field school	SARAI Knowledge Portal, IEC Campaigns and materials (trainings/ training tool kits, brochures, pamphlets, educational videos, calendars), Short message services, SARAI Alerts and advisories mobile application	One page material, Farm bulletin

4.2 Comparison of information content among the intermediary CIS providers

In the Philippines, climate information are generated by different institutions, and disseminated to different users (e.g., farmers) through various means. Some of these CIS providers are project-based and managed by different SUCs and NGOs. While most of these project-based CIS providers are funded by National Government Agencies (NGAs), there are also those which are funded by international development agencies such as USAID and FAO. These CIS providers use Automatic Weather Stations (AWS) that are installed by USAID-BAWP, PAGASA, BSWM, and UPLB-SARAI Project. In addition, some MLGUs use PAGASA's Agromet station data like in Dumangas.

As mentioned earlier, CIS providers produce advisories that contain: Good Practice Options (GPOs) in farming and fishing recommended by DA RFOs and LGU- MAOs. Farm and fishing advisories contain techniques and tips in land preparation, rice water management, livestock and fishing management. In addition, BAWP and SARAI projects use crop models in their advisories. BAWP uses the model developed by IRI known as Climate Agriculture Modeling Decision Tool (CAMDT). These projects are tied with SUCs (CBSUA, BUCAF and UPLB) which run these models to generate the best planting calendar specific to their sites. In disseminating these advisories, BAWP and SARAI created web portals that are accessible via internet. In addition to the web portals, CARAGA CRM4Aqua also created a mobile application, where different stakeholders could access their farm and fishing weather advisories. Moreover, BAWP, SARAI, LGU Dumangas use printed materials as advisory to their farmers. In the case of Dumangas, they give printed advisories to the farmers' group and association that are also posted on their farm bulletin. The extension advisories by these CIS providers mostly cater the farmers, fisherfolk, LGU offices, policy makers, academe and general public. They use different languages like Filipino, Ilokano, Hiligaynon, English and other dialects to communicate better to their users (Table 6).

Table 6. Comparison of information content of CIS providers

	RWAN – LGU-Gerona, Tarlac	**BAWP CLEA**	**SARAI**	**LGU – Dumangas, Iloilo**
Extension Advisory provided	Livelihoods' Risk Management Advisory	Best planting window, Good practice options in rice, irrigation water management, Good practice options for other crops, livestock and fisheries	Crop forecast Planting calendar Nutrient Management Water Management Early warning system for climate extremes	Farm Advisories
Language used	Filipino, Ilokano English	English, Filipino and other local dialects.	English, Filipino	English, Hiligaynon

V. Challenges of CIS and Extension Advisory Sustainability in Philippine Agriculture

Seemingly, there are many challenges that can constrain the effective delivery and sustainability of CIS. These include: 1) standards in the establishment and maintenance of the CIS equipment; 2) coping with global modern technologies; 3) meeting human capital requirements; 4) need for a paradigm shift within the DA and the LGUs in order to mainstream the climate forecast and extension advisories in the day to day activities; and 5) commitment of partners to institutionalize collaboration among the providers and the users of CIS. This also relates to capacities of different institutions concerned to support CIS.

5.1 Establishment and maintenance of the CIS equipment

Currently, this role is assigned to the PAGASA. PAGASA has beefed up its CIS collection equipment and has the protocol for maintenance especially of AWS.

It is also recognized that there are many weather station network websites providing CIS. PAGASA, in cooperation with different SUCs and LGUs, should take this opportunity to conduct a national and regional climate network adequacy assessment to determine where CIS should be provided. Priority should be given to areas planted to principal crop especially on regions without records or with poor historical records, where parameter observations are very difficult, regions sensitive to change, and key measurements with inadequate spatial and temporal resolutions. In accordance with climate monitoring principles of WMO, these identified areas should be given high priority in the installation of any new weather observation station o r AWS.

Another concern is the security and maintenance of the installed instruments against vandalism, theft, and pest (ants) infestation, and natural wear and tear. The transfer of obligation to safeguard the CIS facilities to local constituents where the AWS was installed also poses accountability problems in case of damage or loss.

Compounding the technical constraints is the high cost of weather instruments which are more often sourced from abroad. Replacement of damaged parts is expensive since there are no repair facilities in the country. Those maintaining the equipment also have poor access to institutions providing technical assistance. The problem is complicated by the need to comply with R.A. No. 9184, referred to as the Government Procurement Reform Act. The procurement process also takes a long time, thus causing gaps in data collection during the span of time the equipment was not working. Knowledge on the life span of sensors and spare parts is therefore essential for procurement planning. Linkage with suppliers of spare parts is also essential.

Weather stations and instruments are spread throughout the country. While the number of AWS installed is increasing, the archipelagic structure and mountainous terrain of the country suggests that there are areas where they are needed. Meanwhile, there are areas covered by several project-based CIS providers, thus resulting in the installation of several AWS in the same location. This suggests the need for institutional collaboration, e.g., consultation with provincial government unit and PAGASA in identifying project sites such that more areas could be covered.

5.2 Technology challenges

Since access to data depends on subscription to telecommunication such as text messaging, monitoring real time data in weather stations is difficult in some areas because of poor signal as well as inadequate cellular phone load by observers as well as users.

In establishing historical climate trends based on ground measurements, one constraint may be the limited length of data records. The limited number of agrometeorological stations with complete set of weather instruments and with at least 30 years of records limits the hydrologic frequency analysis of weather parameters for effective forecasting. This results in fragmented, irregular or sporadic analysis, done only by research institutions for a particular area or project.

Furthermore, homogeneity of climate data from ground measurements is usually affected by instrumental and environmental changes such as site relocation, instrument upgrades, and urban heat island effect (Willems, 2015). Satellite-based remote sensing is now being used as an alternative source of climate data to address this problem.

5.3 Human capital requirements

The presence of intermediary users and co-providers opened opportunities for a more-localized CIS. Related to this is the retention of skills and interest of trained personnel, e.g., in CIS data collection and analysis. When the project-based intermediary user leaves the area, continuing the activity becomes a problem.

The data these projects generated will be useful in increasing appreciation of communities for science-based information, local early warning system, and even as backup data for PAGASA. A database of five-year series local climate data could be used for experiments, e.g., by research institutions. If the local database will be built up over the long-term, with the proper management by PAGASA, it will be very useful to climate science in terms of a localized or downscaled climate forecasting and projections. Thirty year (30) time series data will be useful to both hindcasting and forecasting. Thus, sustainability of these data management and the providers or intermediaries should be ensured. PAGASA and the DA RFOs can partner with the various SUCs and research institutions in the regions to help them transform local climate data into more useful regional or local farmer advisories. For instance, partner institutions of SARAI and UP NOAH can be tapped since they already know the protocol.

Project-based intermediary users have also built capacities for decision making of local stakeholders. For instance, the BAWP project has trained local agriculture planners and SUCs in using climate crop models for use in farmer advisories. On the other hand, RWAN has engaged stakeholders in participatory assessment of climate hazards and risks on their livelihood and participatory adaptation planning.

In the use of climate models, there are several groups of climate modelers with contrasting methods of producing climate projections in the Philippines. PAGASA, being the mandated government agency to provide climate projections, must be able to find ways to compare, combine and communicate the different climate projections, effectively.

5.4 Mainstreaming the climate forecast and extension advisories activity in DA offices and local government agricultural offices

Political support and local governance is vital in the dissemination of climate information to different end users. The difficulty happens when the local executives have lower priority (i.e., manpower and budget allocation) to CIS, particularly those introduced by project-based intermediaries. Moreover, hiring of personnel, e.g., observers assigned to weather facilities is subject to politics such that for instance, change in Mayor after an election results in changing observer, implying the need for retooling.

Communicating climate information that would be appreciated, understood, and utilized by target end-users, for guided or improved decision making is a big challenge to CIS providers. Awareness raising is still needed to enable end-users to better understand climate information. Raw climate information such as rainfall and temperature must be clearly translated into impacts on agricultural systems (crops, rangelands, pests, diseases) and farm management advisories (Tall et al. 2014). A key informant from PAGASA pointed the challenge of communicating uncertainties. With climate information expressed as forecast and projections, effective communication strategies would entail translation of these projections to impacts on farmers' livelihood. Impact-based forecasting is being promoted by WMO to make climate information more relevant to decision making. But PAGASA cannot do this alone, thus the participation of other agencies especially by the DA for the agricultural sector, is crucial.

CIS is also facing some institutional constraints. For instance, based on KII, FWWS of DOST has very limited budget as against the work and area that they have to cover. It also affects the number of personnel that they have. They are only few people working in their section, even if there is a large demand for their services. The problems on budgetary constraint and lack of manpower are also true with the experience of ASTI, particularly on the maintenance of the AWS and ground validation. PAGASA regional offices are not sufficient to monitor on different weather facilities nationwide.

5.5 Institutionalizing partnership among the providers and the users of CIS

CIS across different levels and scales has provided opportunities for institutional partnership not only among government institutions but also with local government units and non-government entities. It has also served as an avenue for raising awareness and building capacities for community-based CIS. It has expanded linkage of a central agency such as PAGASA to various CIS providers for a wider-scope delivery of climate information.

Aside from research-based weather monitoring systems, there are also many private owned systems that have potential for long term climate monitoring, primarily based on their strategic location. The conversion of these weather stations to long term operations should be promoted. Moreover, the practice of some projects-based CIS intermediary users to turn-over the system to the LGUs or farmers' associations is a strategic move to sustain CIS once the project ends. Training provided by projects, e.g., such as rainfall data collection and analysis, stewardship of weather instruments/facilities, has strengthened commitment of local communities to sustain CIS. Participatory Action Research (PAR) and post-season reviews have proven effective for capturing farmer feedback on the quality and usefulness of services provided to them. Tall et al. (2014) noted the importance of involving end-users in institutional structures/arrangements in the co-design and coproduction of climate services. In this light, there will be a need to institutionalize partnerships to sustain CIS data generation, information production, dissemination and use.

VI. Policy Recommendations

6.1 Come up with a protocol in the establishment and maintenance of the CIS equipment

Following a national and regional climate network adequacy assessment, PAGASA in cooperation with regional SUCs and LGUs should identify project sites where CIS should be provided. Priority should be given to areas planted to principal crops, especially on regions with poor spatial resolution, with poorly observed parameters, regions sensitive to change, and key measurement with inadequate temporal resolutions. CIS providers should consult provincial government units on where these areas are and consult PAGASA for validation of locations of weather instruments.

Maintenance of CIS equipment should be regularly done. Proper care and maintenance of equipment is also very important. Calibration is done by the PAGASA; but the personnel at this time is not enough to maintain the calibration of all the AWS. PAGASA may start to train the regional offices to do this, for easy access to the AWS.

6.2 Invest on modern technologies for climate data collection

Technical infrastructure for observations and monitoring for quality control is also important to ensure reliability of data/information (including those from non-traditional sources). The issue of prohibitive costs of weather instruments can be addressed by developing low-cost instruments using open-source electronics platforms like Arduino and 3-D printing of instrument casings. The technology is already available in the Philippines, in fact several students in UPLB are already doing this for their research thesis. The important aspect in this development is proper testing and calibration, and these would require some government funding.

The PAGASA Modernization Roadmap has been crafted for implementation in 2018. Programs include enhancement of weather data collection and information dissemination services.

6.3 Harmonize available climate projection models

With multiple sources using different models in generating climate projections, end users will have a hard time choosing the suitable climate projections. PAGASA, being the mandated government agency to provide climate projections, must be able to find ways to compare, combine, and communicate the different climate projections effectively. Using a number of models may result to a better range of possible future conditions.

While it is important to have real time weather data provided by new AWS, it is equally important to analyze historical trends and determine probabilities of say, a certain amount of rainfall (effective rainfall), and even detect climate change. These are very important in developing a cropping calendar, which includes cropping patterns, planting and harvest dates, irrigation schedules, and other farming activities. Ideally, historical records should be analyzed together with real time data for determining trends and probabilities. For stations with limited years of data, regional (global) data (e.g. MarkSim DSSAT Weather File Generator) can be used to find correlations with weather parameters on the station to generate historical records. For areas with no weather stations at all, these can be done with data from adjacent stations. These could be done nationally and regionally by PAGASA and DA, with the help of SUCs and research institutions.

6.4 Build human capital to sustain the CIS

Building human capacity through community engagement should be continuous. This includes training in collecting inputs, coordinating use of information, and facilitating communication. Farmers should be involved in the design, production, and evaluation of CIS to foster trust and local relevance. Capacity building should include upgrading of technical skills in climate data management; promoting common standards in generating and packaging CIS products; and developing communication skills for disseminating tailored climate products and feedback. Capacity building should also include collaborative development of projects that engage both providers and users.

There is need to build local capacities for forecast, and climate crop modeling for the long term. Capacity building must also enhance the use of science-based decision support tools which also stress the importance of climate information in considering options.

6.5 Mainstreaming the climate forecast and extension advisories as functions of the DA,LGUs and SUCs

To make CIS more relevant, it must be delivered at a local scale and in a timely manner. Advisories must be clear and tailored to specific needs of farmers. For example, recommendations must be specific to corresponding growth stage of crop and must provide enough lead time to make decisions before, during and after the season. Thus, there Is need to mainstream this activity among the functions of the DA,LGUs and SUCs.

There should also be awareness raising activities about CIS entities and their operations/products, and their use/application. This could include regular dialogue, and other forms of medium accessible to farmers. Aside from the Climate Forum periodically held by PAGASA, mainstreaming Regional Climate Outlook Forums could also be effective in harnessing collaboration and consensus among users of climate information (WMO 2014).

Sustainability of project-based data should be addressed. It is important to mainstream CIS provision in local programs and activities to ensure continuity particularly of project-initiated CIS. Intermediary users should continue archiving of data to build a data base which could be more useful in climatology.

6.6 Institutionalize CIS

The conversion of private and research-based weather monitoring stations to long term operations should be promoted, especially if these systems are located in high priority areas.There must be an established protocol to coordinate with PAGASA to officially validate data.

The Philippine Unified Information System (PUMIS) managed by PAGASA may be an opportunity for an integrated data banking. PUMIS works as an integrated database system where all the climate related information generated by different institutions could be stored. This system follows the standards of the WMO, thus there are certain requirements to consider. PAGASA complies with the WMO standards based on Global Framework for Climate Services. Considering the different CIS intermediaries, establishment of an integrated data base would require standardized data from various sources and single data format; quality control, regular calibration of weather instruments, and consideration of different specifications of equipment used by the different CIS providers.

With the proliferation of CIS providers and actors involved (e.g., government officials, researchers, development planners), access, relevance, reliability, and usability of climate information are critical concerns. Sustained partnerships should be established among CIS providers and users. Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems. There should be an institutional mechanism to promote impact-based forecasting. This will improve understanding of climate information by users and decision makers and how to respond given the associated risks.

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