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Policy and Institutional Challenges in Climate Information Services Provisioning in Philippine Agriculture

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ABSTRACT. Current and immediate information about the increasingly unpredictable weather conditions are needed to augment conventional knowledge in local communities. Policy analysis on climate information services (CIS) provisioning in the agriculture sector is vital and warranted. This paper describes the global and national CIS policies as well as the institutions involved in provisioning through the characterization of pathways from data generation to dissemination. Further, it identifies the various intermediary users of the CIS and how CIS are ultimately disseminated to the municipal agricultural offices and the farmers. Secondary data sources were searched. Primary data were gathered through key informant interviews. Qualitative methods were used in the analysis. This paper concludes that the Philippines needs a better system to provide climate information through more modern technologies, improved capacities, and more stable institutional partnerships, among others. To sustain or bolster the provisioning of CIS, there must be compliance to standards in the establishment, use, and maintenance of the CIS equipment; improved capacities in the dissemination; and commitment of partners to institutionalize collaboration among the providers and the users of CIS.

Keywords: *climate information service, institution, policy, PAGASA, Philippines*

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INTRODUCTION

Current and immediate information about the increasingly unpredictable weather conditions in local communities are necessary to reinforce conventional knowledge in agriculture. The limited access of farmers to various scientific adaptation strategies holds true in developing countries (Ogallo, Boulahya, & Keane, 2000). Hazards such as flood and drought are faced by farming communities and households. These damages can be avoided if farmers can properly adapt through climate information services (CIS).

The response to climatic uncertainties led to the implementation of CIS projects globally, especially in the developing countries (Singh, Urquhart, & Kituyi, 2016). For instance, although uncertainties are still present, the African region has seen potential benefits from using CIS in managing their local agriculture sector (Roudier et al., 2014). Regional centers are located across the African region (e.g., African Centre for Meteorological Applications for Development) to manage the production and provision of climate information to various stakeholders (Singh, Urquhart, & Kituyi, 2016; Vaughan & Dessai, 2014). Not just within the African region, agriculture stakeholders' access to climate information is imperative to ensure that they are able to cope with the extreme climatic conditions (Campbell, Thornton, Zougmore, van Asten, & Lipper, 2014), which could ultimately lead to an increase in their resiliency.

In the Philippines, initiatives have been made to bring CIS to rural communities. The first known case was in the Local Government Unit (LGU) of Dumangas, Iloilo. The model consisted of establishing climate data collection equipment, building capacities to process and analyze the data, and coordinating with the Department of Science and Technology (DOST) - Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) in giving out climate forecast to farmers in the area. It also showcased the importance of building the resiliency of communities against weather uncertainties brought about by climate change and by empowering local institutions (Local Government Unit of Dumangas, 2010). Dumangas have an agrometeorological (AGROMET) station to provide weather advisories to farmers and fisherfolks. Monthly seasonal and daily forecasts from PAGASA were released together with extension advisories for farmers and fisherfolks.

In 2012, the Food and Agriculture Organization (FAO) had scaled up the Dumangas model through a project on the "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). The project was 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 (AWS) in the study areas and trained the partner DA Regional Field Office (RFO) officials to develop regional Seasonal Climate Forecast and Advisory Services.

In the Bicol region, Philippines, this mode of providing climate information to farmers was further pursued in the United States Agency for International Development-assisted Bicol Agri-water Project (BAWP) that also started in October 2012 (Rola, De los Santos, Faderogao, & Faulmino, 2017). This initiative was built on 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 used climate crop models to generate agricultural extension advisories on top of the good practice options that were recommended by the local technicians and of the DA-RFO5. Capacities to do the modelling were then developed among state colleges and universities (SUCs) within the region. Then, the SUCs connected with the LGUs for the production and dissemination of the advisories. This CIS integration into the agricultural extension program was piloted in 10 regions of the country through the Adaptation and Mitigation Initiatives in Agriculture Phase 2 (AMIA2) project.

But to sustain and scale up and scale out what has been experienced in Dumangas remains as a challenge. In this policy analysis, the research questions raised were as follows: "How do we link the national CIS infrastructure to the local initiatives for the benefit of the agriculture sector?" and "What are needed to sustain provisioning of the CIS in the country?"

This paper is an analysis of the policy and institutional challenges in the CIS provisioning in Philippine agriculture. Specifically, it: 1) describes the CIS policy in the global as well as in the Philippine context; 2) describes how national level institution supplies the CIS and characterizes the pathways from data generation to dissemination; 3) identifies the various intermediary users of CIS; 4) analyzes the challenges and opportunities toward sustainable provisioning of the CIS; and 5) offers recommendations to sustain the CIS provisioning in agriculture.

The Climate Information Services (CIS)

The 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 et al., 2014; Vaughan, 2016). The effective delivery of various CIS and products requires appropriate institutional mechanisms. Linkages from the international level to the regional, national, and local levels are necessary, not only to generate but also to assimilate CIS in the most useful way for decision making. In addition, CIS enhances adaptation to abnormal conditions and takes advantage of good climate conditions.

Ideally, climate information should be user-centered to be helpful in decision making. But more often, there is no systematic mechanism for the interaction between users and providers (World Meteorological Organization [WMO], 2014). From weather to climate timescales, agricultural decisions tend to become more context and farmer-specific; thus, requiring greater scope of CIS. These may include translating raw climate information into predictions of agricultural impacts or management advisories, training needs, assistance in the planning and organizing response mechanisms, and evaluation and feedback processes to consistently improve information products and services (Tall et al., 2014).

METHODOLOGY

This policy research used primary data gathered through key informant interviews (KIIs) with representatives of various institutions involved in CIS such as DOST-PAGASA; DOST-Advanced Science and Technology Institute (ASTI); Department of Agriculture's Bureau of Soils and Water Management of the (DA-BSWM); and Rice Watch Network (RWaN), a non-government organization. Interviews conducted covered the process flow of CIS within the respective institution of the key informants and the challenges in sustainably providing CIS, particularly to the stakeholders in agriculture.

Secondary data such as organizational profile and relevant policies were obtained from various documents coming from the institutions mentioned. Likewise, information from related literature were gathered to enrich the discussion.

The primary and secondary data were analyzed through policy and institutional analyses. As emphasized by Vincent Ostrom, "institutions are defined as systems of rule-ordered relationships" (Cole, 2013), which means that the analysis generates understanding of how and why different international and local CIS institutions interact with each other, or where these institutions are situated in the CIS pathways. As an analytical tool, institutional analysis investigates the existing social and institutional structures within a specified context (Corral Quintana, 2004 as cited in Hernandez, Barbosa, Corral, & Rivas, 2018). In this paper, the context examined was the provision and distribution of CIS. The roles (i.e., mandates based on policies) in the services chain of various CIS institutions were identified, including the prevailing dynamics between and among these institutions. Based on the institutional analysis, the issues and challenges confronting these institutions were identified. Lastly, policy recommendations were offered at the end of the paper.

RESULTS AND DISCUSSIONS

Global CIS Framework

The World Meteorological Organization (WMO), a specialized unit of the United Nations, recognized a wide range of activities encompassing CIS implementation (WMO, 2014). This included the following: 1) generation of historical climate data sets to characterize climate behavior across temporal and spatial scales; 2) climatological analysis on long-term means and trends and climate variability characteristics; 3) data monitoring which is useful for climate predictions and projections and guiding actions to respond to potential effects, including information on drivers of climate variability (e.g., La Niña, El Niño, current drought/flood conditions); 4) determining seasonal outlooks such as rainfall, temperature; 5) giving climate change information (e.g., projections and scenarios information) for national adaptation to climate change; and 6) conduct of training on the use of climate products and services.

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 particularly routine data and products also covers their interpretation and relevance to users (WMO, 2014).

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Related to this, the WMO identified three categories of users of climate information/services: 1) the internal users, e.g., national meteorological agencies, who generate products for external users; 2) the external users operating at strategic level, such as government, finance, and insurance, who develop better policies and conduct business more efficiently; and 3) the external end users for whom productivity of their business/enterprise 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; and monitoring analyses, prediction, and projection products. Climate data sets are the initial standard operational products at the global, regional, and national scales. To ensure future acceptability and reliability of predictions and projections, CIS coordinates with research institutions. Research is important in bridging climate prediction possibilities across timescales and providing reliable information products to various users (WMO, 2014).

The Philippines' CIS Policies and Institutions

In the Philippines, policies concerning CIS are based on various national laws, particularly those relating to climate change (Table 1). These policy instruments mandate specific institutions with certain functions to provide coordination, partnerships, or linkages among different stakeholders for the provision of CIS. These institutions include PAGASA under the Department of Science and Technology (DOST), which is likewise mandated to coordinate with relevant national organizations (Executive Order 128, Section 3) to ensure that various efforts related to CIS are harmonized to attain maximum possible societal benefit.

WMO and Tall et al. (2014) provided the following classification of CIS institutions: 1) information providers synonymous to internal users that generate the products; 2) intermediary users and/or co-producers of CIS receiving climate information from other sources and translating those information 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 shows the various institutions in the Philippines involved in CIS based on the classification of the WMO and Tall et al. (2014) as cited in Elazegui, Luyun, and Anastacio (2017).

Table 1. Policy instruments on climate information service for the agriculture sector (Elazegui et al., 2017)

POLICY INSTRUMENT	INSTITUTION CONCERNED	MANDATE
Executive Order No.128, January 1987 - Reorganizing the National Science and Technology Authority	Department of Science and Technology - Philippine Atmospheric, Geophysical and Astronomical Services Administration (DOST-PAGASA)	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 (CCC)	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. 10121 or the Disaster Risk Reduction and Management (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

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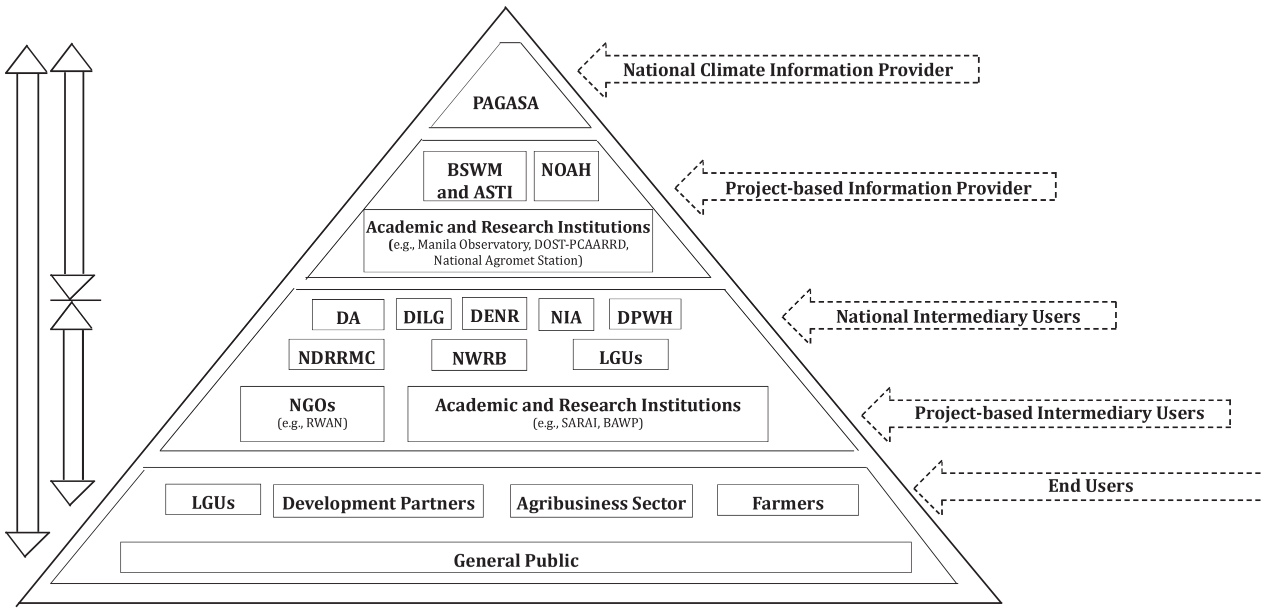
Table 1 Continued

POLICY INSTRUMENT	INSTITUTION CONCERNED	MANDATE
Republic Act No. 8435 or the Agriculture and Fisheries Modernization Act of 1997	Department of Agriculture; PAGASA, and other government agencies	In coordination with PAGASA and other appropriate government agencies, they 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
Memorandum on “Mainstreaming Climate Change in the Department of Agriculture’s Programs, Plans, and Budget”	Department of Agriculture	Mainstreaming climate change in the Department of Agriculture’s programs including the climate information system to have a common database to generate timely and reliable data for disaster risk reduction 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



ASTI: Advanced Science and Technology Institute
BSWM: Bureau of Soils and Water Management
DA: Department of Agriculture
DENR: Department of Environment and Natural Resources
DILG: Department of the Interior and Local Government
DPWH: Department of Public Works and Highways
LGUs: Local government units
NIA: National Irrigation Administration
NDRRMC: National Disaster Risk Reduction and Management Council
NGOs: Non-government organizations
NOAH: Nationwide Operational Assessment of Hazards
NWRB: National Water Resources Board
PAGASA: Philippine Atmospheric, Geophysical and Astronomical Services Administration

Figure 1. Institutions involved in climate information services for agriculture in the Philippines (Elazegui et al. 2017)

National Level Climate Information Provider

The main provider of hydro-meteorological services in the Philippines is PAGASA, an attached agency of the DOST. It 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 WMO, thus, it has to comply with WMO guidelines in providing CIS.

PAGASA services include climate monitoring, climate predictions, climate outlook and advisories, and tailored products (Table 2). It also has satellite-receiving facilities for data from the US National Oceanic and Atmospheric Administration (NOAA), Moderate-resolution Imaging Spectroradiometer (MODIS) of the National Aeronautics and Space Administration (NASA), 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).

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

Pathways for PAGASA CIS Products

Climate information monitoring and prediction services. PAGASA established the Climate Information Monitoring and Prediction Services (CLIMPS), which originated from the National ENSO Early Warning and Monitoring System (NEEWMS) set up at the height of El Niño in 1986-1987. CLIMPS provides seasonal forecast and timely advisories to various end users, particularly policy makers, economic planners and emergency managers (Figure 2). Its purposes include early warning system and provision of monthly weather outlook to member agencies of the Inter-Agency Committee for Water Crisis Management (Subbiah, Kalsi, & Kok-Seng Yap, n.d.). Observations from a network of 50 surface synoptic weather monitoring stations and 40-year historical sets

Table 2. Climate products and services of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA, n.d.-a)

ACTIVITY CATEGORY	PRODUCTS AND SERVICES
Climate monitoring	• Day-to-day rainfall and during tropical cyclone passage • Onset of rainy season • Dry/Wet spell • Northeast/Southwest monsoon monitoring • Temperature anomalies (sea surface temperature, local) • Monthly rainfall and temperature assessment
Climate prediction (sub-seasonal/ seasonal climate forecast)	• Monthly/Seasonal/Six-month rainfall forecast • 10-day probabilistic forecast • Temperature forecast • Tropical cyclone frequency forecast • Dry/Wet day forecast • Drought outlook
Climate outlook and advisories	• Seasonal outlook (3-6 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 non-government agencies and technical working group meetings • Information, education, and communication

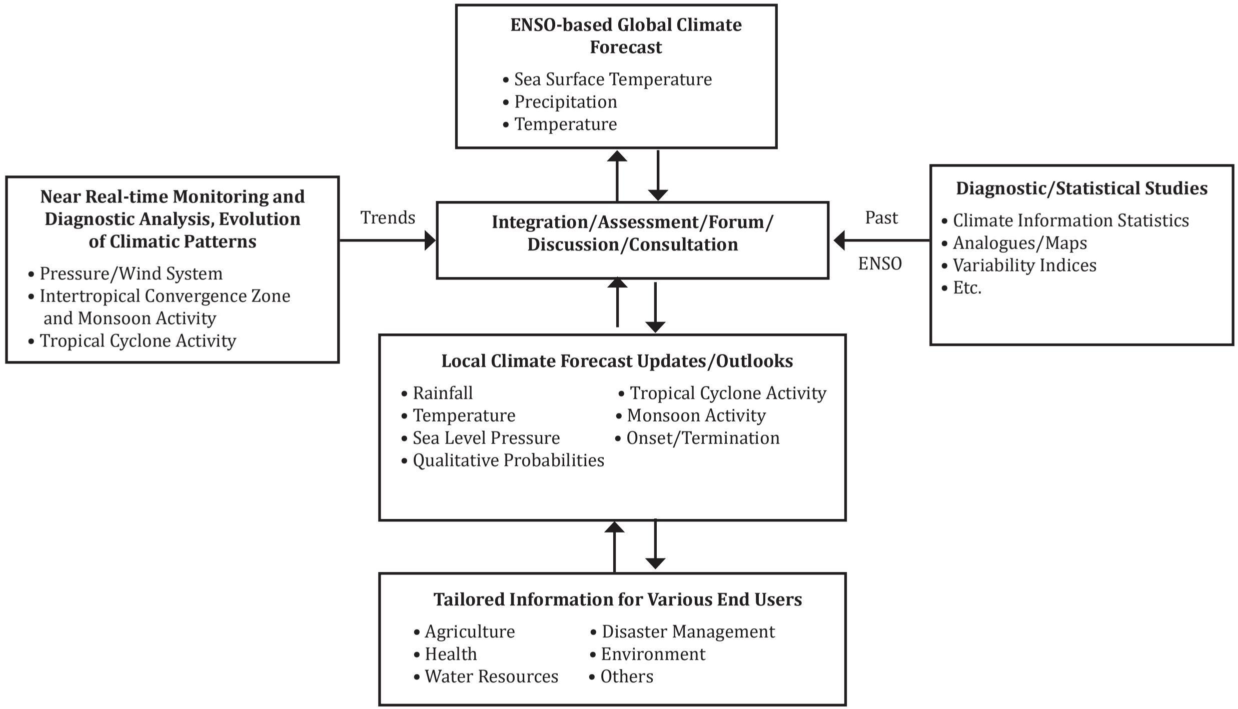


Figure 2. Translation of El Niño Southern Oscillation (ENSO)-based global climate forecasts into local climate forecasts (PAGASA, n.d.-b)

of 10-day and monthly rainfall were used by the NEEWMS. Government agencies requested information such as rainfall analysis, and 10-day, monthly, seasonal, and 12-month rainfall accumulation (Amadore, 2002 as cited by Subbiah, Kalsi, Kok-Seng, n.d.).

Weather forecast information. A weather forecast is a state of the atmosphere expressed through scientific estimate of future weather condition. PAGASA sees to it that different weather elements are observed, 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).

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

Based on the outlook and weather parameters, farming and fishing advisories were issued. The 10-day regional agri-weather information included the weather systems that affect the whole country for the next 10 days and the regional agrometeorological situations and prognosis as well as crop phenology, situations, and farm activities in the different regions of the country. These 10-day Regional Agri-Weather and Advisories were circulated through radio stations, agricultural schools and universities, Department of Agriculture, PAGASA field stations, LGUs, and researchers (Figure 4). Advisories were accessed through the PAGASA website and text/short messaging service. PAGASA personnel also served as resource speakers in different trainings, meetings, and fora organized by different institutions or organizations.

There were other activities done by PAGASA that intended to educate the members of the different LGUs. PAGASA conducted information, education, and communication campaigns and workshops with municipal agriculturists on translating data to layman's language,

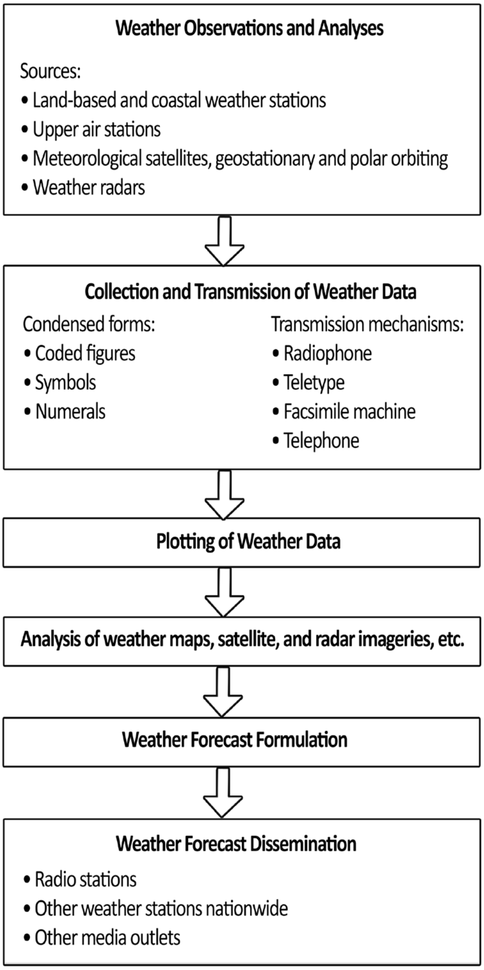


Figure 3. Steps in data generation to dissemination of weather forecast information by PAGASA (PAGASA, n.d.-c)

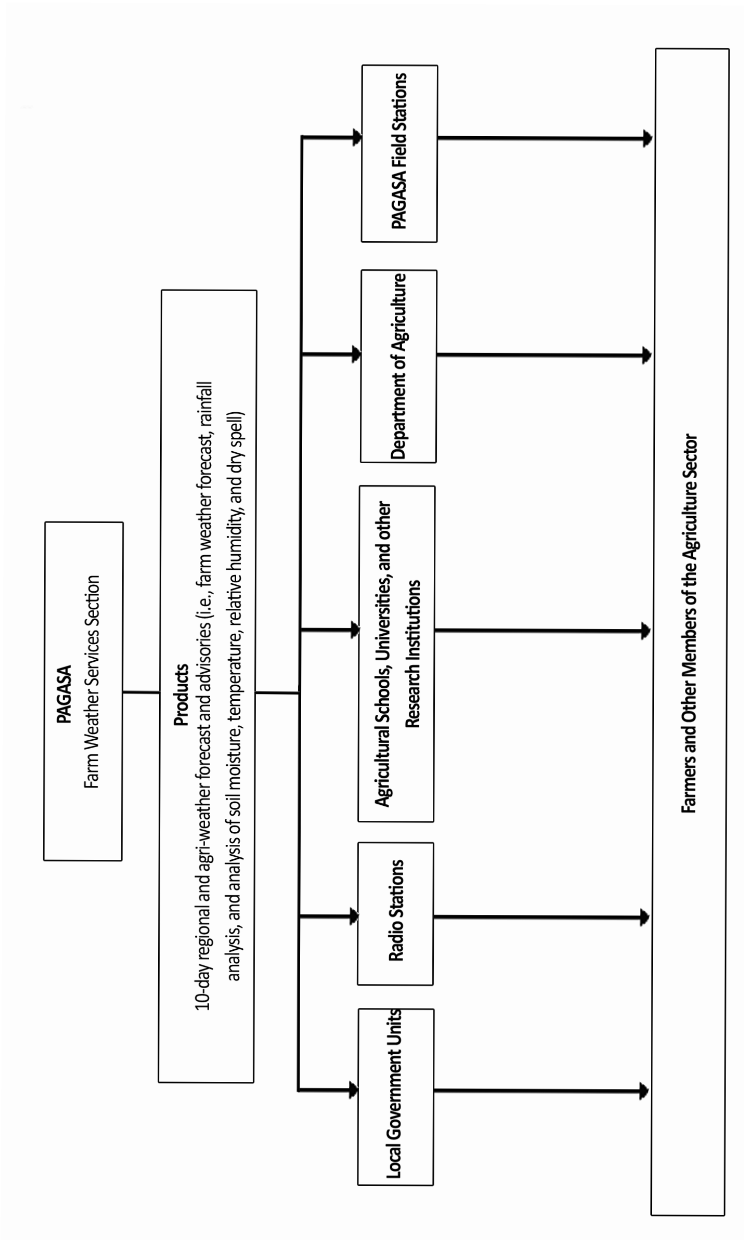


Figure 4. Information pathway from PAGASA's Farm Weather Services Section to farmers

using various visual aids in local dialect, and improving capacity to handle all local data. The municipal agriculturists and agricultural extension workers conducted trainings for farmers that enabled them to apply basic climate information in their different agricultural activities.

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

In producing climate projections in the Philippines, Daron, Jones, Scannel, Corbelli, and Cinco (2016), in a workshop report, revealed that there were several groups of climate modelers with different methods. For example, the Met Office Hadley Center in United Kingdom, in collaboration with PAGASA, generated a downscaled Coupled Model Intercomparison Project Phase 5 (CMIP5) simulations using Hadley Center Global Environment Model version 3 (HadGEM3-RA) with a horizontal resolution of 12 km. At the same time, PAGASA downscaled its own CMIP5 simulations using a range of Regional Climate Models (RCMs), including Providing Regional Climates for Impacts Studies (PRECIS), Conformal-Cubic Atmospheric Model (CCAM), and Regional Climate Model 4 (RegCM4). In addition, a cooperation project between PAGASA, FAO-PAGASA, and FAO-AMICAF previously provided statistically downscaled climate projections using CMIP3 Global Circulation Models (GCM). 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 that provided climate projections in the Philippines were the Southeast Asia Climate Downscaling Experiment (SEACLID) and the Coordinated Regional Climate Downscaling Experiment (CORDEX) Southeast Asia project collaboration between University of Malaysia and Manila Observatory.

Intermediary Users of Climate Information

PAGASA established partnership with different government organizations and project-based intermediaries in order to capacitate different agriculture stakeholders (i.e., LGUs, farmers, and other members along the value chain) in managing their climate-related risks (Figure 5). These institutions generated and gathered climate data from various

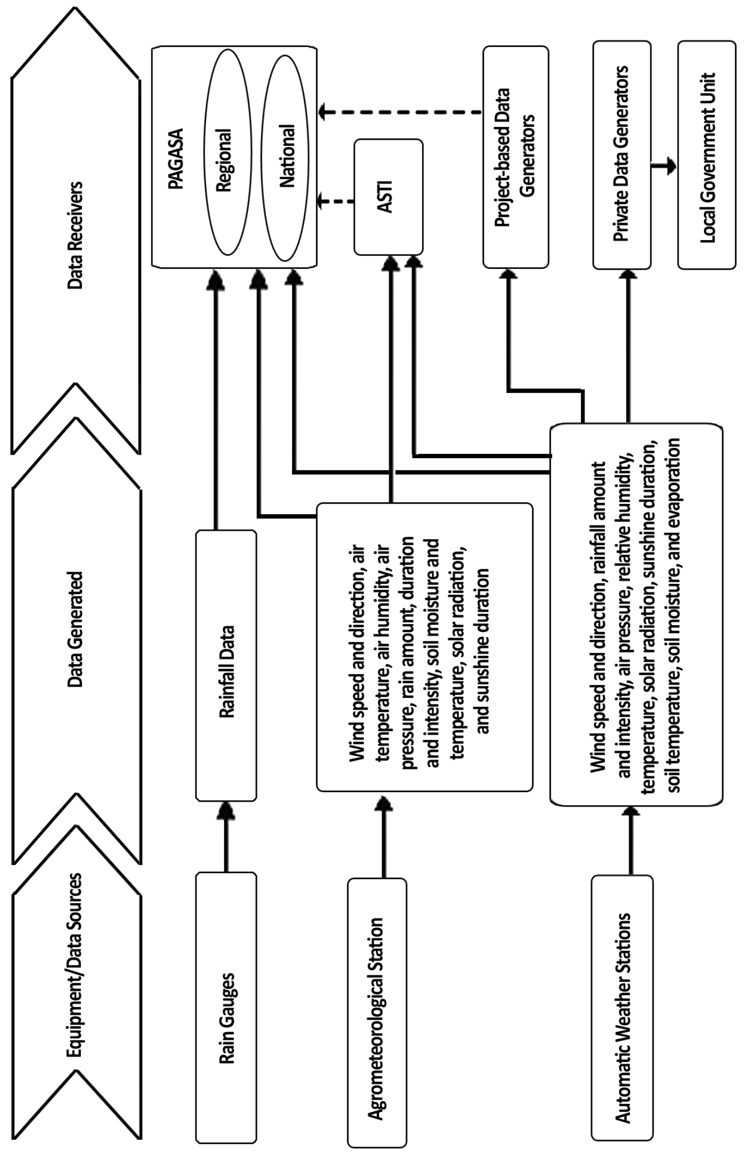


Figure 5. Summary of climate data flow

sources. In the case of PAGASA, the data sources included rain gauges, AWS, and AGROMET stations. However, although AGROMET stations and AWS generated almost the same climate data, PAGASA relied mostly on the AGROMET stations for more accurate and reliable data. The AWS also served as a primary source of climate data of different project-based data generators which were accessed from time-to-time by PAGASA through their respective databases. In the case of some LGUs, they accessed climate data through partnership with private climate data generators.

Prior to the generation of climate information and extension advisories, climate data were processed by different institutions and converted to useful forms by different intermediary climate information providers (e.g., 10-day weather forecast of PAGASA) before they were translated into extension advisories.

Local government institutions. There were local government units (LGUs) with initiatives to produce climate information for their constituents. For instance, the LGU of Dumangas disseminated farm weather advisories through the municipal agriculture office (MAO) (Figure 6). These advisories enumerated guidelines by which the farmers and fisherfolks could base their responses during various weather conditions. To communicate better these advisories, the LGU translated them into the local language, Hiligaynon. Aside from Dumangas in Iloilo, Guinayangan, Quezon; Tirona, Tarlac; and Irosin, Sorsogon also generated their own CIS and advisories.

Information end user. There were CIS end users both at the national and local levels. At the national level, end users widely ranged from development planners and policy makers to agro-industry suppliers, producers, and distributors. In the context of this study, the primary end user of the climate information was the agriculture sector, particularly farmers and other vulnerable communities. The use of CIS allowed the farmers to manage and cushion the impacts of changing climatic condition along 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 the Department of Agriculture entered into a memorandum of understanding for a new user interface platform (UIP) (Selvaraju et al., 2013). This improved climate outlooks that catered to the needs of the

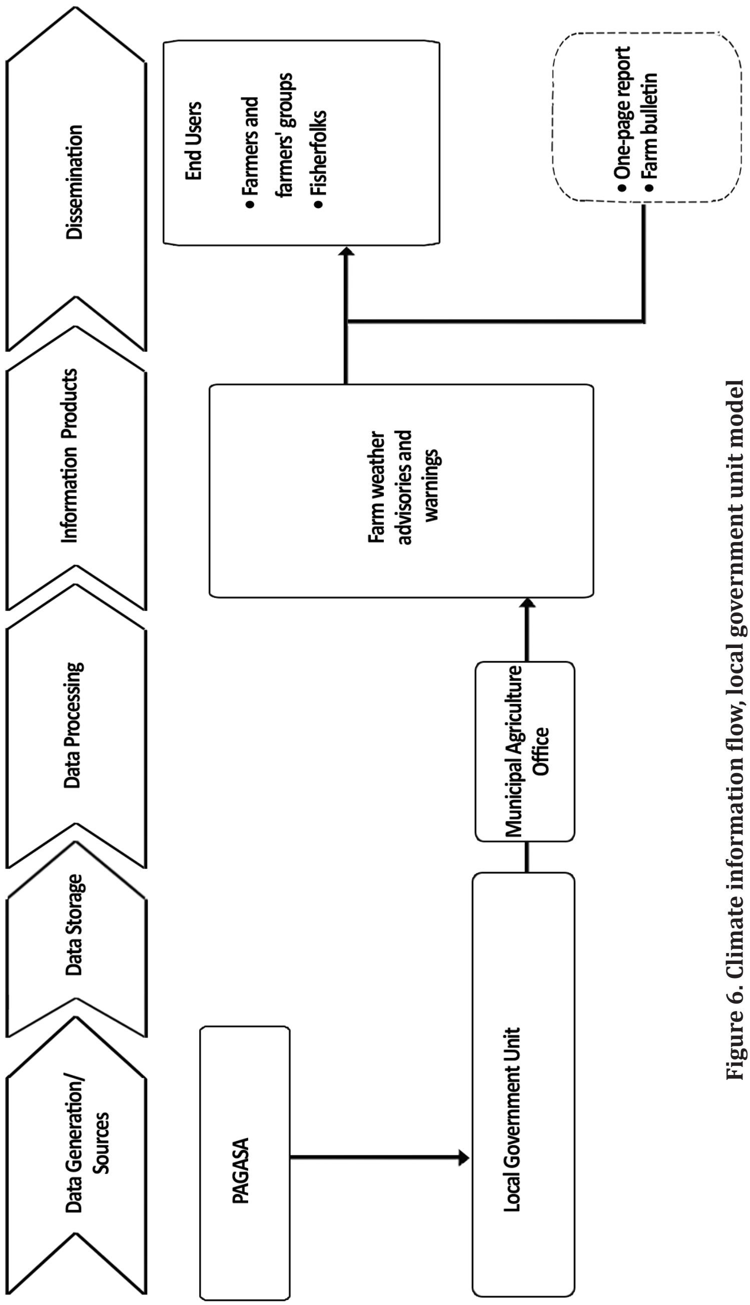


Figure 6. Climate information flow, local government unit model

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users. The provincial and municipal agriculture staff were responsible for disseminating advisories to the barangay authorities and farmers. The barangay chairpersons were assigned to monitor and observe weather from newly installed weather data collection instruments and to send back data to the PAGASA regional services division.

Challenges and Opportunities of CIS Provisioning and its Sustainability in Philippine Agriculture

With key informant interviews, the authors sought insights of experts from the various agencies involved with the CIS regarding challenges that constrain effective delivery and sustainability. The experts' responses covered the following: 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 Department of Agriculture 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 CIS providers and users. This related to capacities of different institutions to support CIS.

Establishment and maintenance of the CIS equipment. This role was assigned to PAGASA. The Agency has beefed up its CIS collection equipment and has the protocol for maintenance of AWS. It was also recognized that many weather station network websites were providing CIS. PAGASA, in cooperation with different SUCs and LGUs, should conduct a national and regional climate network adequacy assessment to identify where to provide CIS. Priority should be given to areas planted to principal crops especially in regions without records or with poor historical records of weather data, or where parameter observations are very difficult, regions sensitive to change, and key measurements with inadequate spatial and temporal resolutions. According to climate monitoring principles of WMO, these identified areas should be assigned high priority in the installation of new weather observation station or AWS.

A major concern was the security and maintenance of the installed instruments against vandalism, theft, pest (ants) infestation, and natural wear-and-tear. The transfer of obligation from PAGASA to local constituents where the AWS was installed in order to safeguard the CIS facilities posed accountability problems in case of damage or loss.

Compounding the technical constraints was the high cost of weather instruments, which were more often procured from abroad. Replacement of damaged parts was expensive since there were no repair or after-sales facilities in the country for such equipment. Those maintaining the equipment also had poor access to institutions that provide them the technical knowledge on how to properly maintain these equipment. The problem was further complicated by the need to comply with Republic Act No. 9184, referred to as the Government Procurement Reform Act, which covered procurement of equipment and maintenance budget as well. The stringent procurement process often took a long time, and adding to the causes of delay in data collection was the period of time when the equipment needed servicing. Knowledge on the life span of sensors and spare parts was therefore essential in procurement planning. Linkage with suppliers of spare parts is necessary.

Weather stations and instruments were spread throughout the country. While the number of AWS installed increased, the archipelagic structure and mountainous terrain of the country determined the areas where they were needed most. There were areas covered by several project-based CIS providers, which resulted in the installation of several AWS in the same location. This indicated the need for institutional collaboration, e.g., consultation with provincial government units and PAGASA in identifying areas to be covered as project sites.

Technological challenges. Since access to data depended on subscription to telecommunication services such as text messaging, monitoring of real time data in weather stations was difficult in some areas because of poor or unstable signal as well as inadequate cellular phone load of observers and the users. In establishing historical climate trends based on ground measurements, one constraint was the limited length of data records. The limited number of AGROMET stations with complete set of weather instruments and with at least 30 years of records, restricted the hydrologic frequency analysis of weather parameters for effective forecasting. This resulted in the fragmented, irregular, or sporadic analysis, done only by research institutions for a particular area or project.

Furthermore, the homogeneity of climate data from ground measurements was 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.

Requirements for human capital. 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, for instance, in CIS data collection and analysis. When the project-based intermediary user leaves the area, continuing the activity becomes a problem.

The data generated by these projects were 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, especially by research institutions. If the local database can be built up over the long term, with the proper management by PAGASA, these will be very useful to climate science in terms of localized or downscaled climate forecasting and projections. A 30-year time series data will be useful to both hindcasting and forecasting. Thus, the sustainability of data management and the providers or intermediaries should be ensured. PAGASA and the DA RFOs can partner with various SUCs and research institutions in the regions to help them transform local climate data into more useful regional or local farmer advisories.

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

Institutionalizing partnerships among CIS providers and users. Political support and local governance were vital in the dissemination of climate information to different end users. There was difficulty when CIS, particularly those introduced by project-based intermediaries, got lower priority (i.e., manpower and budget allocation) from local chief executives. Moreover, hiring of personnel, such as observers assigned to weather facilities was subjected to political dynamics. As an example, a change in an administration (e.g., mayor) after an election resulted in the change in the data observer, and thus, requiring another retooling.

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

Other institutional constraint faced by CIS was the scarce budget considering the work volume and area of coverage as in the case of the Farm Weather Services Section (FWSS) of DOST. Despite the high demand for their services, shortage in manpower has restricted the work that could be rendered. This was also true to the case of the Advanced Science and Technology Institute (ASTI), particularly on the maintenance of the AWS and ground validation. PAGASA regional offices were not sufficient to monitor the different weather facilities nationwide.

CIS across different levels and scales has provided opportunities for institutional partnerships not only among government institutions and LGUs but with non-government entities as well. 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 in the delivery of climate information on a wider scope.

Aside from research-based weather monitoring systems, there were also many privately-owned systems with the potential for long-term climate monitoring, primarily because of their strategic location. The conversion of these weather stations for long-term operations can be pursued. Moreover, the practice of some project-based CIS intermediary users to turn over the system to the LGUs or farmers' associations is a vital move to sustain CIS once the project ends. Trainings provided by projects, e.g., rainfall data collection and analysis, stewardship of weather instruments/facilities, have strengthened commitment of local communities to sustain CIS. Tall et al. (2014) noted the importance of involving end users in institutional arrangements especially in the co-design and co-production of climate services. In this light, there is a need to institutionalize partnerships at the local level to sustain CIS data generation, information production, dissemination, and use.

CONCLUSIONS AND RECOMMENDATIONS

For farming communities to become resilient, climate information is important and necessary. Policies are existing for the provisioning of CIS in Philippine agriculture sector, and there is a clear pathway of service delivery. The Philippines has been investing in more climate data collection instruments to be able to generate more location-specific information. However, challenges toward having more stable institutional arrangements, and capacities and technologies for disseminating the information and especially translating these into agricultural extension advisories are stifling the effectiveness of such investments. To sustain CIS efforts, the study offers the following policy recommendations (Elazegui et al., 2017):

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 in regions with poor spatial resolution or with poorly observed parameters; regions sensitive to change; and key measurement with inadequate temporal resolutions. CIS providers should consult provincial government units to pinpoint these areas and consult PAGASA for validation of location of weather instruments.

Maintenance of CIS equipment should be regularly done. Proper care and maintenance of equipment are also very important. While calibration is done by the PAGASA; the number of personnel at this time may not be enough to perform the calibration of all the AWS. PAGASA has to train the regional offices to do this.

Invest in modern technologies for climate data collection. Technical infrastructure for observations and monitoring for quality control is also important to ensure reliability of data or 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 3D printing of instrument casings. The technology is already available in the Philippines, in fact several students in the University of the Philippines Los Baños are already doing this for their 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.

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 a 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 stresses the importance of climate information in considering various options.

Institutionalize CIS. The conversion of private and research-based weather monitoring stations for long-term operations should be pursued, 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 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 database 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), the access, relevance, reliability, and usability of climate information are critical. 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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