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January 2006

Strengthening Operational Agrometeorological Services at the National Level

Proceedings of the Inter-Regional Workshop March 22-26, 2004, Manila, Philippines

World Meteorological Organization Agricultural Meteorology Division

Food and Agricultural Organization of the United Nations

Philippine Atmospheric, Geophysical and Astronomical Services Administration

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Editors

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Science Garden Complex
Agham Road, Dilliman, Quezon City
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Series

WAOB-2006-1

AGM-9
WMO/TD NO. 1277

Washington, D.C. 20250   January 2006

Proper citation is requested. Citation:

Raymond P. Motha, M.V.K. Sivakumar, and Michele Bernardi (Eds.) 2006. Strengthening Operational Agrometeorological Services at the National Level. Proceedings of the Inter-Regional Workshop, March 22-26, 2004, Manila, Philippines. Washington, D.C., USA: United States Department of Agriculture; Geneva, Switzerland: World Meteorological Organization; Rome, Italy: Food and Agriculture Organization of the United Nations. Technical Bulletin WAOB-2006-1 and AGM-9, WMO/TD No.1277. 238 pp.

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Foreword

The agricultural sector is weather dependent and variations in weather/climate as well as their interaction with agricultural operations, from planting to harvesting, determine a significant portion of the yield variations. The growing interest in the possible impact of natural- and human-induced climate variability and long-term climate change on agriculture and forestry have created new demands for information and assessments from agrometeorologists. Also, the increasing demands for food and concerns with the need for achieving greater efficiency in natural resource use while protecting the environment require that much greater emphasis be placed on understanding and exploiting climatic resources for the benefit of agriculture and forestry. Hence, there is now a growing recognition of the importance of operational agrometeorological services for the agricultural, livestock, forestry, and fishery sectors. The series includes:

- Services to help reduce the impact of natural disasters, including pests and diseases;
- Early warning and monitoring systems;
- Short- and medium-range weather forecasts;
- Climate prediction/forecasting; and,
- Services to help reduce the contributions of agricultural production to global warming.

Several of these needs are echoed in documents such as Agenda 21, the World Food Summit Plan of Action, and the United Nations Convention to Combat Desertification (UNCCD). While data are the fundamental building blocks necessary to establish a sound foundation for the provision of operational agrometeorological services, it is the informational products that are the framework for any knowledge-based decision process. The ability to integrate the information from interdisciplinary sources utilizing new computer-based technologies and telecommunications creates a great opportunity to enhance the role of agrometeorologists in many decision-making processes. Information may be in the form of advisories to farmers regarding planting or decisions on spraying. Information may be used in crop management systems that extension services provide to the agricultural community. It may also be incorporated into early warning alerts related to food security or market implications.

Agrometeorological information plays a valuable part not only in making daily and seasonal farm management decisions but also in risk management and early warning systems. Weather and climate information can be used with new technological tools and database infrastructures to assess risk and to quantify probabilities associated with weather and climate variability. The implications are enormous not only for agricultural extension services, which are providing the linkage between new research results and operational applications, but also for policy-level decision makers who are responsible for food security and marketing decisions for agricultural products. Such early-warning information allows improved long-term planning opportunities that will benefit agriculture.

The Thirteenth Session of the Commission for Agricultural Meteorology (CAgM-XIII) of the World Meteorological Organization, held in October 2002 in Slovenia, considered the need to improve agrometeorological services to increase agricultural production and to conserve the environment. They identified this aspect as one of three priority areas to be addressed during the 2004-2007 period. CAgM-XIII recommended that an Inter-Regional Workshop on Strengthening Operational Agrometeorological Services at the National Level be organized.

Accordingly, the World Meteorological Organization (WMO), the United States Department of Agriculture (USDA), and the Food and Agriculture Organization (FAO) organized this Inter-Regional Workshop from March 22-26, 2004, in Manila, Philippines, at the kind invitation of the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). Twenty-eight participants from 19 countries, including the Philippines, attended the Workshop.

I am pleased to note that 21 invited papers from different regions were presented at the Workshop dealing with various aspects on strengthening operational agrometeorological services. I hope that these papers as well as the recommendations for strengthening operational agrometeorological services developed during the discussions at the Workshop and presented in this volume will serve as a very valuable source of information for all the National Meteorological and Hydrological Services (NMHSs) and other agencies involved in the provision of operational agrometeorological services at the national level.

(M. Jarraud)
Secretary-General
World Meteorological Organization

Executive Summary

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The World Meteorological Organization (WMO), the Food and Agriculture Organization (FAO), and the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) sponsored an Inter-Regional Workshop on Strengthening Operational Agrometeorological Services in Manila, Philippines, on March 22-26, 2004. The workshop objectives were: to evaluate how the National Meteorological and Hydrological Services (NMHSs) provide operational agrometeorological services to the various user communities at the national levels; to identify shortcomings and limitations in data, analytical tools, and the methods of provision of operational agrometeorological services; to assess how the organizational structures of the National Services and their links with other government agencies can be adopted in the most cost-effective manner to serve the needs of the customers; to review methods and tools to improve operational agrometeorological services and their delivery to decision makers at all levels in a timely fashion; and, to formulate an effective strategy to build the capacity of the NMHSs in the different WMO regions and strengthen their operational agrometeorological services.

The workshop program consisted of 21 papers. The first two papers focus on operational agrometeorological services from the national perspective. The Philippines is an agricultural country where dramatic increases or decreases in agricultural output have been, in most cases, associated with occurrence of severe weather events and changes in the climate system. Typhoons with its associated strong winds and rains and the global phenomenon, called El Niño, have contributed significantly to the large annual variability of the country's agricultural production. A system for assessing the danger of vegetation fires in Cuban regions is described in the second paper. The early warnings alert is a result of the agrometeorological conditions system that influences the content of soil humidity, living vegetation, and dead biomass. The early alert system was designed to operate at different temporal scales at the national and provincial levels. This system has allowed the country to strengthen preventive activity and to achieve operative efficiency during the high-danger forest fire occurrence in Cuba.

The following seven papers present perspectives from each of the six Regional Associations plus one additional example that focused on an emergency situation from Afghanistan. In RA-I, a questionnaire was prepared. The questionnaire was sent via fax and e-mail to 51 countries and centers. Fifteen countries responded. In RA-I, the flow of information is limited and methodologies have room for improvement. Technology is in high demand, and the density of the observational network is low in many countries. Some countries have only one or two agrometeorological stations, limiting agrometeorological activities. Agrometeorological units are also hampered by lack of trained personnel and limited budgets. Certainly, efforts are needed to assist these countries. The flow of data to users continues to be a high requirement.

Users, especially the farming community, usually request information on the onset of effective rains (to know when to plant) and length of the cropping season (to decide what to plant). They also request information on the behavior of the dry and wet spells within the cropping season and want to know how likely it is that an extreme event will occur. Governments and farmers are both greatly interested in knowing how much grain yields and crop production are expected by the end of the rain/crop season. This knowledge helps strategic panning. Genuine efforts are, therefore, needed to improve agrometeorological services and make their products accessible to users.

From Regional Association II, a number of recommendations were made to strengthen operational agrometeorological services in the region. These include: developing agrometeorological forecasting centers; developing forest meteorology, predicting yield/biomass before planting; studying sand movement or desertification elements; measuring evapotranspiration; establishing the domestic infrastructure of a flux measurement network; developing agrometeorological models for crop growth; developing and evaluating agrometeorological environments using the agrometeorological advice model AMBER; integrating agrometeorological information services; collaborating with the World Agrometeorological Information System (WAMIS); cooperating with the International Society of Agricultural Meteorology (INSAM); strengthening agrometeorology networks including station density, fine equipment, and capacity building; providing more detailed agrometeorology information; and, developing the infrastructure of the information network to transfer agrometeorological information to farmers more easily and faster.

Regarding an agrometeorological service required under emergency situations, a paper was presented describing the Afghanistan example. In this paper, all the requirements were presented for a fully operational agrometeorological service installed in Afghanistan. This ranged from the installation of stations to data transmission, including personal experience to help educate users with archiving, data control, treatments, results, and products issued. Capacity-building through intensive, on-the-job training and courses was also given in Kabul. The use of very sophisticated agrometeorological tools was taught by the staff of the agrometeorological services. Database and information systems and the need for statistical analyses were reviewed. All of these tools are necessary to respond to any question emanating from decision makers in the country and/or Food and Agriculture Organization-Famine Early Warning System Information Network (FEWS-NET), Ministry of Rural Rehabilitation and Development (MRRD), World Food Program (WFP), Irrigation Department, and food security, in general. All of these tools, equipment, and means are presently being use in Afghanistan.

From Regional Association III, in most of the national meteorological services, the agrometeorological activity is at a disadvantage with respect to other areas of national meteorology. These disadvantages are directly related to the budget, training, and prioritization in the development of their corresponding services. Most of the services issue bulletins, agrometeorological warnings, and agrometeorological and weather forecasts; carry out agrometeorological studies and research; and some of them study the impacts caused by extreme weather events. Seventy percent of the services acknowledge that they have limitations and deficiencies in obtaining data and analytical tools. Eighty-percent of the services estimate that they have deficiencies and limitations in delivering agrometeorological services. Some major recommendations of Regional Association III include: improving spatial resolution and adapting global models; investing in the dissemination of meteorological tools applied to agriculture for the small and medium farmer; carrying out strategic associations with institutions to increase the agrometeorological stations networks, maintaining the existing ones, and developing competitive agrometeorological products; implementing a regional training program for climate modeling, geographical information systems, and handling of agrometeorological data base and analytical tools; standardizing products, services, methods, and regional climatic and agroclimatic procedures; conducting a program of regional exchange of methodologies and knowledge of the professionals of the different services, by means of seminars, workshops, or hands-on training; and carrying out studies on climate variability and climate change and its impact on agriculture at a regional level.

The questionnaire was sent by Regional Association IV for a survey of operational agrometeorological services in the region, including recommendations for regional improvement. The summary of results included: introduce or improve agrometeorological monitoring services and early warnings and alerts to help reduce the agricultural impact of extreme events; improve observation networks and agrometeorological services technical staff and the extension-related agricultural sector; improve computer tools used to analyze agrometeorological data, meteorological, hydrological, and agricultural drought, and potential forest fire danger; use agrometeorological models to evaluate existing and expected conditions on different agricultural sectors; create capacity and apply operational Geographic Information System (GIS) technology; use high-resolution satellite images [vegetal cover, Normalized Difference Vegetation Index (NDVI), soil humidity, etc.] in the operational agrometeorological services; create capacity in the agricultural meteorology specialty, either National Meteorology and Hydrology Services (NMHS) or agrometeorological information users, identify funding sources and promote financial support to national agrometeorological services with users who guarantee to keep the agrometeorological services; and, create a National Technical Committee that promotes agrometeorological applications that meet the needs of the agricultural sector and coordinates this work among institutions and disciplines.

A questionnaire containing nine questions was circulated in the Regional Association V. Responses were received from four countries: Fiji, Indonesia, Malaysia, and Philippines. Based on the responses, it was revealed that Fiji has no independent agrometeorological services unit, while in Indonesia such a unit was developed in 2003. The main customers of the NMHS in the four countries are government agencies, in particular the Ministry of Agriculture. In Fiji and the Philippines, the industrial companies are also the customers. The services, which are provided in the form of bulletins, assist in conducting strategic studies, provide early warnings, and help with impact assessments. The main constraints for strengthening the operational agrometeorological services in the four countries are lack of human resources, analytical tools such as simulation modeling, and data. Therefore, recommendations given by the countries for strengthening the operational agrometeorological services include training activities on the use of remote sensing technology and simulation modeling for yield monitoring, forecasting, improvement of climate observation networks, and dissemination systems. The use of agriculture simulation modeling for operational agrometeorological services in developed countries such as Australia has already been adopted. In developing countries, such an approach is still in the research stage. There is a need to influence policy makers into making decisions and farmers into deciding crop management strategies. The problems include finding effective ways to disseminate or to communicate such knowledge and information to policy makers and farmers and helping local staff in the use of such an approach.

Regional Association VI consists of 49 countries from a broad region. A questionnaire was circulated to the members. In evaluating the submitted responses, it was very difficult to find any common lesson. It was concluded that the application of agrometeorological information, advice, and support issued by the meteorological community for the agricultural, horticultural, forestry, and fishery users depends on the traditions and economic environment. The biggest problem for the agrometeorological community is the lack of feedback from the real users because there is an information gap between the producers and users. The general opinion was that the improvement of operational agrometeorological services requires better technology and business policy. To organize/reorganize or simply improve the agrometeorological service, two basic positions are held. First, the users of a service could be various groups with different needs, so there should be the opportunity to prepare various kinds of services. (In this case, it is more appropriate to talk about agrometeorological information systems). Secondly, the service evokes the idea of a printed document in a traditional approach, but we see that in many cases, it is necessary to use other means such as radio broadcasting or television to reach the targeted group. The best solutions seem to be the Internet or direct information transmission such as fax or short message service (sms). In the first position, passive information transmission refers to the absence of influence on the part of the user. In the second position, active information transmission means transferring the information to the user's contact point, and then the user choosing the information for their daily working practice.

In the next section, three papers focus on international perspectives of operational agrometeorological services. The first paper reviews the requirements for agrometeorological services that go well beyond the basic inherent needs of sustaining agricultural productivity. Agrometeorology is a complex multidisciplinary science, and, the services provided by the operational agrometeorologists are growing rapidly.

The current status of agricultural production and increasing concerns with related environmental issues call for improved agrometeorological services for enhancing and sustaining agricultural productivity around the world. The requirements for agrometeorological services were described in the light of emerging issues related to environment, climate change, biodiversity, drought and desertification, food security, and sustainable development. Agenda 21, International Conventions, including the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD), the World Food Summit Plan of Action, and the World Summit on Sustainable Development, have implications for strengthening operational agrometeorological services, which have been highlighted in this paper. Hydrometeorological disasters around the world have been increasing in the recent past and operational agrometeorological services could help the farming community with better preparedness and mitigation strategies. Perspectives from remote sensing and GIS for improved agrometeorological services were described. The WAMIS initiated by WMO could help strengthen operational agrometeorological services around the world.

The next paper presents the activities of the FAO in the field of the "food security information and early warning systems" (FSIEWS) with particular reference to their agrometeorological component. Starting in 1978, FAO has provided technical assistance with multilateral and bilateral financing to more than 50 projects for the establishment of regional and national FSIEWS around the world, to monitor all aspects of food availability, stability of supply, accessibility, and biological utilization. Focusing on the present and future availability of food, the agrometeorological component looks mainly at crop monitoring and yield forecasting, embracing an activity usually carried out by Agricultural Extension Services and National Agrometeorological Services.

The second part of the paper concentrates on FAO's approach in the development of methods and tools (e.g., software, databases, training, publications, and advisory services to farmers) for the agrometeorological user community of FSIEWS. Agrometeorology is an important component of the FSIEWS that monitors the availability of food by evaluating the impact of weather and climate on crop development. The main activities of the FAO Agrometeorology Unit include the development of tools and methods for crop monitoring and yield forecasting, starting with the rehabilitation and/or strengthening of the agrometeorological networks, and all aspects linked to the data transmission, collection, archiving, analysis, and dissemination. The basic philosophy is a total synergy with national and regional institutions and the development of integrated toolboxes, such as AgroMetShell, involving agrometeorology, remote sensing, and GIS tools for data collection, spatialization, and analysis.

The third paper in this section discusses the European Commission Joint Research Centre Monitoring Agriculture with Remote Sensing (MARS) project. The MARS project started in the Joint Research Centre with the main objective to provide to the European Commission decision makers, mainly in the Directorates General Agriculture and Eurostat, early, independent, and objective estimates of the main crop production in Europe (MARS-STAT). Technical support was also provided to the Common Agricultural Policy in several fields including the control of EU subsidies by remote sensing and the establishment of national land parcel identification systems (LPIS). This part of the activities is called MARS-PAC. More recently in 2001, a new activity of support to the European policy for Food Security and Food Aid was initiated (MARS-FOOD). Finally, in 2004, the spectrum of the activities was enlarged to the European fisheries policy and the unit name changed from MARS to AGRIFISH. The paper concentrated on MARS-STAT and MARS-FOOD activities. MARS-STAT is an operational crop yield forecasting and crop acreage estimation for European main field crops. MARS-FOOD main focus is to develop and operate improved methods for crop forecasting in regions outside of Europe, in particular in regions stricken by recurring food shortages.

The next section deals with a critical review of significant shortcomings and limitations in data, analytical tools, and the dissemination of agrometeorological information. In the first paper in this section, a lengthy review of the problems was presented, and recommendations were made for improvements. Some of the major recommendations include: data sets must have a minimum metadata base, standard format, standard quality control procedures and adequate continuity of records; personnel must be trained to recognize inconsistencies of data and establish appropriate patch-point methods to maintain continuity; software must be compatible with both temporal and spatial data sets to allow for the integration of point source data with geo-referenced digital data sets, modeling technology, and remotely sensed data; new technology in telecommunications should be used to bridge the gap between automated data collection systems and web-based information systems; GIS metadata are required for appropriate coordinate systems, projections, etc.; guidelines are needed to report national crop yields including sub-national trends and geo-spatial time trends; an industry, international standard for agroclimatic data, particularly crop data, should be developed; more telecommunication research that develops new applications using web-based technologies and automated observations should be supported; current measures of standardization are considered mature for meteorological data, poor for crop data, and emerging for soils data; and, spatial interpolation methods for specific applications should be recommended.

The second paper in this section notes the shortcomings with analytical tools and methods of operational agrometeorological services. Improvements in communication technology and in the understanding of the physical components of the plant/earth/atmosphere interface have combined to increase the quality, sophistication, and potential utility of agrometeorological services provided to the agricultural industry. Regardless, many problems and shortcomings in analytical techniques and in the way in which the products are provided remain. These include long-term issues, such as the spatial analysis of agrometeorological variables and concerns about the economic challenges facing many elements of the agricultural industry worldwide. Recent advances in the development of spatial analytical techniques such as GIS offer some solutions to these difficulties. To become more effective, agrometeorologists need to demonstrate the utility of their products, including potential economic benefits. Finally, in order to provide the best quality agrometeorological information in the future, greater collaboration is needed between the major information participants and the information provision system: farmers, agricultural meteorologists, and agricultural extension services.

The final paper in this section deals with the extremely important topic of dissemination of agrometeorological information. Much climate data are available that can only be utilized if there is a flow of information to agri-business and farmers. As dissemination is the distribution of information, two-way communication channels are a necessity. The content of the message must be relevant to the decisions of the client. The process should involve the identification of climate sensitive decisions, interactions between the climatologists and the role players to develop technological products that should be evaluated prior to introduction at an operational level. Dissemination of agrometeorological information is illustrated with examples from the Florida Consortium, FARMSACPES in Australia, seasonal forecasts in Burkina Faso, and irrigation scheduling in Mexico. Critical factors for successful dissemination include good communication channels preferably based on a relationship between the agrometeorologists and the role players in the agricultural industry, and the collaborative development of products that can bridge the gaps and be relevant to climate-sensitive decision making in agriculture. The way forward is to form good relationships so that new agrometeorological applications can be developed as a cooperative and collaborative learning process to bridge the identified gaps in the knowledge chain and thus enable meteorological science to contribute to the economic benefit of the agricultural industry.

The last section presents six papers that discuss needs and linkages between agrometeorological services and the agricultural sector. The first paper discussed a global overview of the agricultural demand point of view. Agriculture, which provides our basic needs and is one of the biggest employers, is one of the most weather dependent sectors. A crucial role of the National Meteorological Service (NMS) is timely provision of accurate information on agrometeorology. With few NMS under the agriculture portfolio, priorities rarely focus on serving agriculture. Even those with observation networks do not always provide services, often due to the shortcoming in their analytical capability. Along with staff and budget constraints, the service suffers from poor understanding of the diverse agricultural users and their requirements.

Information requirements vary with different farming practices, while research and education require more detailed information with different emphasis. Among the variables with strong effects on crop growth and farm management are daily temperature, precipitation, solar radiation, and wind speed. More general information is required in advance by agricultural policy makers, planners, and institutional support systems for better planning. With challenges in climate change, desertification, and biodiversity, many NMS can play a crucial role in improving understanding and finding ways to mitigate and adapt. The NMS can take advantage of advances in computer and communication technology to improve analytical capability and service delivery. With limited resources available, an effective way to benefit from the progress is through cooperation among countries within a region. By putting together the best resources and expertise, the limited resources can be more efficiently utilized. Presently, many climate institutions provide near real-time global observations of the ocean and atmosphere and periodically post the analytical results of their implications on regional climate. NMS can also accept feedback for the improvement of the service.

The next paper discusses the need for linkages between weather services and the agricultural sector. From the National Weather Service (NWS), adequate funding is essential for the maintenance of a modernized observational network that includes data needed for agricultural analysis. Cooperating agencies must provide recognition and support for the urgency of NWS to improve both short-term forecasts and long-range outlooks. While the accuracy of these forecasts has improved in recent years, natural disaster reduction and mitigation of extreme events in agriculture will be enhanced by further improvements. Agricultural agencies are tasked with helping the people protect soil, water, and wildlife as well as sustain agricultural growth and development. As advances in information and biological technologies move forward, fundamental changes will likely occur through the agricultural sector in the 21st Century. The demand for weather and climate information will likely continue to expand for a wide spectrum of agricultural applications. In government, the information will be used for crop, forest, pasture and livestock conditions, irrigation reserves, crop yield potentials, and marketing outlooks. In research, the information will be used to develop model simulations (yield, physiology, pest, and irrigation management), weather-based generators, and scenario analyses in operational applications. In farming and agribusiness, the information will be used for advisories, daily farm management decisions, and long-term agricultural planning. Finally, more coordinated and integrated national policy on natural disaster reduction and mitigation of extreme events on agriculture will necessitate linkage of operational services with communities affected by these events. Achieving all of these goals requires proactive leadership and cooperation among agricultural weather and weather service providers at the national, regional, and state levels, and with the agricultural user community at all levels.

The next paper focuses on a climate information application in Indonesia. At present, the use of climate (forecast) information is very low. At Indramayu, a vulnerable district to El Niño-Southern Oscillation (ENSO) events, farmers are always suffering from drought and flood whenever El Niño and La Niña occur. Some of the reasons are that end-users (farmers) have difficulty in understanding climate forecast information that contains probability, and there is no effective dissemination system of climate forecast information to end-users. Farmers are also not aware of the economic value of climate forecast information. As a consequence, the level of farmers' adoption to climate forecast information is low and they have no capacity to tailor their cropping strategy to climate forecasts. To increase farmers' adoption to climate forecast information, their knowledge of climate and its application should be improved. A process called Climate Field School (CFS) is introduced to increase farmers' knowledge on climate information application. The basic concept of CFS is to disseminate climate information applications to end users by translating the information from scientific language into field language and then translating field language into farmers' language through field school. Based on the result of the evaluation, it was indicated that the CFS might be an effective way to educate farmers (end-users) on climate information application. The main challenge in the implementation of CFS is the development of modules. Integrated efforts between universities, research agencies, and related government agencies are required.

The fourth paper emphasizes the importance of extension services and the supportive role of agricultural research. The climatic and environmental resource base of crops plays a dominant role in their survival, growth, and development. Therefore, weather and climate, crops, other parts of the resource base, and crop weather and crop/climate relations need the continuous attention of applied research. This helps not only to protect the resource base and sustain the quality and quantity of crop yields, but it also is a basis for the farmers' income. However, to make sense, the products of science as well as forecasts and advisories must increasingly be made available to assist the farmers through operational agrometeorological services, which range from agroclimatological characterization to management of natural resources. To explain the actual scarcity of agrometeorological services, particularly in developing countries, the author developed a diagnostic and conceptual framework that pictures the generation and transfer of agrometeorological information from the existing support systems to its adaptation, dispersion, and teaching at the farm level. This framework lessens the confusion between the goals and means in generating agrometeorological services. Diagnosis of current agrometeorology practices shows a need for agrometeorology to arrive at on-farm agrometeorological services. This is illustrated with ample examples from an earlier defined list of such services. It is concluded that agrometeorological in-service education of extension intermediaries is essential to train farmers in field classes, improve their income, and protect the agricultural production environment from degradation. This ultimately materializes in down-to-earth agrometeorological services in well-defined farming systems.

The next paper reviews the tools and methods for agrometeorological monitoring in the West African Sahel. Agrometeorological monitoring in the Sahelian countries consists of collecting, processing, and analyzing various data and information that can affect the outcome of the agricultural season. It combines observational data from national meteorological, hydrological, agricultural extension, plant protection, and livestock breeding offices, as well as satellite data provided by the AGRHYMET Center. From May until the end of October, multidisciplinary working groups (MWGs) in each country publish decadal and monthly bulletins. At the regional level in the AGRHYMET Center, data and information coming from the national components are combined with satellite data to elaborate regional syntheses that are published at different times. In these publications, the current situation is analyzed and compared with that of the previous period, the previous year, and the average. Forecasts of seasonal rainfall and crop yields, which are refined from month to month, are also given. Color maps illustrate the amounts of rainfall, sowing dates, crop water requirements, satisfaction indices, yield estimates, zones with particular pests, and the advance of the vegetation front. Hard copes and electronic versions of these publications are mailed to subscribers. They are also posted on the Center's website: www.agrhymet.ne.

The final paper in this section presents a summary of sugarcane advisory services in Colombia using an automated data network. The application of meteorological and climatological information obtained through the Colombian sugarcane industry's automated weather network is discussed. A primary concern is to minimize the number of cases when the ash and smoke from sugarcane burning causes annoyances to the residents of population centers of the Cauca Valley in Colombia. The most important topics related to this agricultural practice include: the technology; different types of information required; climatological and statistical data on the wind's behavior; procedures to obtain all this information; and, steps to apply it. The application of meteorological information for monitoring sugarcane burns makes it possible to decide whether to burn or not, depending upon whether the prevailing conditions in the place at the time foreseen for the burning so permit, without affecting the areas that are to be protected from ash fallout or smoke presence.

Following the workshop presentations, there were several brainstorming sessions focusing on strengthening services. The group prioritizes their conclusions and recommendations. The following is a list of the workshop recommendations to strengthen operational agricultural meteorological services. There is a need:

- To improve the spatial resolution of the application of agrometeorological products, and strengthen the density of agrometeorological station networks;
- For the NHMS to accord recognition to the agrometeorological stations established and maintained by other national, regional, and international institutions focusing on agricultural, forestry, fisheries, and rangelands issues and assist, support, and collaborate with them;
- For routine interactions between agrometeorologists, agricultural extension services, and other intermediaries to provide better services to farmers;
- For a comprehensive strategy for capacity building at the national and regional level including short- and long-term education and training, roving seminars, workshops, and conferences that will build on synergies among institutions and organizations responsible for capacity building;
- For sharing of data, tools, methodologies, and experiences through the exchanges of experts among member countries and regional centers;
- For promoting the generation and application of climate information by increasing the awareness and understanding of policy makers of its importance for sustainable development from national to the local levels;
- To involve communication experts in the process of disseminating agrometeorological information;
- To implement the training programs for enhancing the capacity of farmers in using climate information for supporting farm activities;
- For coordinated and integrated national agricultural weather policy to ensure that operational services to agriculture and food security are met;
- To involve users in the identification of specific climate-sensitive issues in order to facilitate their operational decisions;
- For modern tools, such as remote sensing and GIS, that may help reduce the impact of traditional limitations such as data scarcity;
- To actively publicize the efforts and successful endeavors, including an assessment of economic benefits, if possible;
- For the development and provision of agrometeorological products that should involve active interaction with farmers and/or the agricultural industry;
- For an international standard for reporting crop data along with minimum requirements for metadata, database formats, and database content that should be accepted by industry, international centers, and academia;
- For promoting the use of participator research in the establishment and implementation of projects involving agrometeorology in sustainable development; to apply efforts in order to establish and/or improve phonological observations on a regular basis, due to their fundamental role in agrometeorology;
- To obtain financial resources for agrometeorological activities, to present to different national and international agencies well-supported and completed projects for their consideration; and,

- For taking into account the day-to-day increasing advantages of new technologies, to try to enrich the users of agrometeorological products with more precise, timely, and local information and easier to use information. This means developing a framework fitting the concepts of “precision agriculture” and “per-specific application.”

These proceedings represent a formulation of ideas from diverse perspectives on ways and means to strengthen operational agrometeorological services at the national level. The editors thank all of the authors for their outstanding contributions.