*Operational Agrometeorological Services: International Perspectives*

# Requirements for Agrometeorological Services

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## Abstract

The current status of agricultural production and increasing concerns with related environmental issues calls 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), and the United Nations Convention to Combat Desertification (UNCCD), the World Food Summit Plan of Action and the World Summit on Sustainable Development include elements that 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 geographic information systems (GIS) for improved agrometeorological services were described. The World Agrometeorological Information Service (WAMIS) initiated by World Meteorological Organization (WMO) could help strengthen operational agrometeorological services around the world.

## Introduction

Agricultural production is a biological process which depends on the natural resource base, especially soil and water, and on favorable climatic conditions. Weather and climate have an important bearing on agricultural productivity in different agroecological regions around the world, especially in the arid and semi-arid tropical regions. While climate variability impacted agricultural productivity through the ages, in the past two decades climate change had emerged as a very important concern in sustainable agriculture.

The annual increase in world food production from 1960 to 1984 was 30 million metric tons and between 1984 and 1992, it dropped to 12 million metric tons (Jain, 1996). Recent data from the Food and Agriculture Organization (FAO) showed that the rate of growth of global crop and livestock has slowed down in each of the 3 years between 2000 and 2002. The slow rate of growth in 2002 of less than 1 percent at the global level implies a reduction in output in per capita terms. With population continuing to grow by nearly 90 million per year, the amount of grain produced per person is decreasing. Grain harvest per person showed a continuous decline from 1984 onwards. FAO's latest forecasts for global cereal production in 2003 and the first forecast for utilization in 2003/2004 indicate that output will remain below the expected level of utilization.

Developing countries are projected to increase their cereal demand by about 80 percent between 1990 and 2020 while the world as a whole will increase its cereal demand by about 55 percent (Pinstrup-Anderson, 1996). The projected demand for cereals, meat, and roots and tubers varies significantly among the developing-country regions. Sub-Saharan Africa is projected to increase its demand for these three commodity groups by at least 150 percent. Net cereal imports of the developing countries are expected to increase from 90 million tons in 1990 to 190 million tons by 2020 (Pinstrup-Anderson, 1996). The demand for meat will increase by 58 percent to reach 313 million tons.

The global agricultural scenario described above places a great deal of premium on our ability to continue to enhance productivity on a per hectare basis since the scope of extending cultivation to new areas is quite limited in scope. Given that rainfed agriculture continues to be the main mode of agricultural production, especially in the developing world, productivity enhancements per unit area in the rainfed ecosystems are a must. There is a need for a greater understanding of the effects of weather and climate variability on the rate of development, growth and yields of rainfed crops, and for improved methods of managing weather and climate risks in the rainfed ecosystems. Applications of agricultural meteorology are crucial in both these endeavours.

## Growing Need for Agrometeorological Services

In much of the tropics, especially in the semi-arid tropics, farming systems are mainly rainfed and are affected by inter-annual as well as intra-seasonal climate variability. Farmers had to adapt to the range and frequency of shocks that climate variability brings and they have tried to use the available knowledge and information to develop their coping strategies. But the adoption of improved technologies is too slow, especially in Africa, to counteract the adverse effects of varying environmental conditions, and climate fluctuations continue to be the main factors that prevent a regular supply and availability of food, the key to food security.

There are increasing demands for timely and effective agrometeorological information for on-farm applications by farmers. Farmers need information on expected rainfall for planting and harvesting activities. Rainfall forecasts are also crucial for farmers to determine when and how to apply fertilizers. Agrometeorological information to assist in irrigation planning is very important to both the farming community as well as managers of water resources. The importance of the type of weather information needed for a decision-making process depends upon the nature of the decision itself. For example, present weather and short-term forecasts are used in making daily operational decisions, while the analyses of past climate data are especially useful for planning decisions. Predictions of the potential for the incidence of diseases and pests are usually based on current and past weather conditions in a specific agricultural area and crop type.

Agricultural weather and climate data systems are necessary to expedite generation of products, analyses, and forecasts that affect agricultural cropping and management decisions, irrigation scheduling, commodity trading and markets, fire-weather management, and other preparedness for calamities, and ecosystem conservation and management. There is convincing evidence available from different parts of the world that judicious application of meteorological, climatological, and hydrological knowledge and information, including long-range forecasts, greatly assists the agricultural community to develop and operate sustainable agricultural systems and increase production in an environmentally sustainable manner. Medium and long-range forecasts, coupled with past climatological data, are valuable for long-term planning decisions related to farm management. The need for reorienting and recasting meteorological information, fine tuning of climatic analysis and presentation in forms suitable for agricultural decision making and insulation of marginal farmers with small holdings from the adverse impacts of weather vagaries has become more pressing. Also, the growing concerns with the need for achieving greater efficiency in the natural resource use while conserving the environment is placing a much greater emphasis on understanding and exploiting the climatic resources for the benefit of agriculture and forestry.

Concurrent to the growing need for agrometeorological information, the developments in communications and electronic media, in particular the ever-expanding cyberspace linkages through the web, are placing greater demand on operational agrometeorological services. Information is needed and is being sought through the rapid search engines. Private initiatives to meet the increasing demands for information are growing and are giving scope to criticisms against publicly funded organizations for their inability to provide information in a manner similar to those of the private initiatives.

The challenge in front of the agrometeorologists around the world is that more than ever before, there is a great need to more effectively integrate and deploy the skills we have developed in operational, experimental, and theoretical aspects of agricultural meteorology to make agricultural production systems more reliable, more efficient, and above all, more equitable in the world at large.

## Requirements for Agrometeorological Services

*Perspectives from Environment, Climate Change, Biodiversity, Drought and Desertification, Food Security, and Sustainable Development*

The need for improved agrometeorological services purely from a food production perspective was described earlier. Over the past three decades, there is a greater awareness of the importance of protecting the environment, adapting to climate change, arresting loss of biodiversity, coping with the impacts of drought and desertification, ensuring food security, and promoting sustainable development.

Over the past 12 years in particular, the world has seen a surging interest in environmental matters affecting mankind and its future. The organization of the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, in June 1992, led to the production of Agenda 21. Two major international conventions were negotiated separately from, but in parallel with, preparations for UNCED and were signed by most governments at Rio de Janeiro. These included the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD). Subsequently, the United Nations Convention to Combat Desertification (UNCCD) was negotiated and entered into force on December 26, 1996.

In addition to the above, the World Food Summit Plan of Action (WFSPA), which was developed in 1996, and the commitments outlined in the WFSPA were also accepted by the international community. In August-September 2002, the World Summit on Sustainable Development (WSSD) was held in Johannesburg, South Africa, to take stock of the achievements, challenges, and new issues arising since 1992 when UNCED was held.

In the following sections, a short description is presented on the perspectives on agrometeorological services emerging from Agenda 21, the international conventions, and the WFSPA.

**Environment**

UNCED was an unprecedented event because significant topics of vital importance to the peoples of the world, particularly in relation to sustainable development, were addressed at the highest level. The conference made it clear that we can no longer think of environment and economic and social development as isolated fields. The centrepiece of UNCED is the Agenda 21 (Centre for Our Common Future, 1993), a global plan of action, which resulted from the consensus among all the countries. Agenda 21 aims at reconciling the twin requirements of a high-quality environment and a healthy economy for all peoples of the world.

From the point of view of operational agrometeorological services, the following elements in Agenda 21 are of interest:

a) Strengthening the knowledge base and developing information and monitoring systems for regions prone to desertification and drought, including the economic and social aspects of these ecosystems. Improvement and strengthening of meteorological and hydrological networks and monitoring systems to support data collection for research into the interactions between climate, drought and desertification, and for assessment of their socio-economic impacts.
b) Developing comprehensive drought preparedness and drought-relief schemes, including self-help arrangements, for drought-prone areas. Research into seasonal forecasting and the strengthening of drought early warning systems and integrated packages at the farm and watershed level such as alternative cropping strategies, soil and water conservation, and promotion of water harvesting techniques.
c) Identification of hazard-prone areas which are most vulnerable to erosion, floods, landslides, earthquakes, snow avalanches, and other natural hazards, and development of early-warning systems and disaster-response teams.
d) Protecting forests from fires, pests, poaching, mining, and reducing pollutants that affect forests, including air pollution that flows across borders.

Chapter 32 of Agenda 21 calls for a more active role for farmers in influencing decisions. Operational agrometeorological services should include steps to promote more direct participation of farmers in agrometeorological field studies and in designing appropriate strategies for the provision of agrometeorological information to the users.

**Climate Change**

There is evidence that global warming over the last millennium had already resulted in increased global average annual temperature and changes in rainfall, with the 1990s being the warmest decade in the Northern Hemisphere. During the past century, changes in temperature patterns have had a direct impact on the number of frost days and the length of growing seasons with significant implications for agriculture and forestry. Land-cover changes, changes in global ocean circulation and sea surface temperature patterns, and changes in the composition of the global atmosphere are leading to changes in rainfall. These changes may be more pronounced in the Tropics. For example, crop varieties grown in the

Sahel may not be able to withstand the projected warming trends and will certainly be at risk due to projected lower amounts of rainfall as well.

The UNFCCC came into force on 21 March 1994 and the Principles of UNFCCC (Article 3) highlight the need for countries to take precautionary measures to anticipate, prevent, or minimize the causes of climate change and mitigate its adverse effects.  Article 3.4 underscores that policies to protect the climate system should be integrated with national development programs, which necessarily include agriculture.  Similarly, Article 3.3, still without mentioning agriculture, underlines that all sources and sinks have to be taken into consideration.

The Commitments of UNFCCC (Article 4) call for cooperation in preparing for adaptation to the impacts of climate change and for the development and elaboration of appropriate and integrated plans for water resources and agriculture.  Agriculture has the potential to adapt much faster in all those sectors where the management component plays a major part, i.e., essentially for field crops, livestock rearing, inland fisheries, and some forms of marine plant and animal production.

The 3rd Conference of the Parties of the UNFCCC, held in Kyoto during late 1997, led to the Kyoto Protocol.  Compared with the UNFCCC, the Kyoto Protocol focuses much more explicitly on agriculture and forestry, in particular on sustainable forest management practices and on the promotion of sustainable forms of agriculture in the light of climate change considerations.  It is interesting to note the wording "in the light of climate change considerations," which stresses also climate extremes and variability, and, not just the sources of unsustainable agricultural practices.

Adaptation to the adverse effects of climate variability and climate change is of high priority for nearly all countries, but developing countries are particularly vulnerable.  Effective measures to cope with vulnerability and adaptation need to be developed at all levels.  Operational agrometeorological services should recognize the necessity for integrating agrometeorological adaptation strategies to climate change in the development of best agricultural practices.  In developing adaptation strategies to cope with risk management at the farm level, it is essential to learn from the actual difficulties faced by farmers.  Agrometeorologists must play an important role in assisting farmers with the development of feasible strategies to adapt to climate variability and climate change.  Some farming systems with an inherent resilience may adapt more readily to climate pressures, making long-term adjustments to varying and changing conditions.  Other systems will need interventions for adaptation that should be more strongly supported by agrometeorological services for agricultural producers.  This applies, among others, to systems where pests and diseases play an important role.

Seasonal to inter-annual climate forecasts will definitely improve in the future with a better understanding of the dynamic relationships between atmosphere, land, and oceans.  However, the main issue at present is how to make better use of the existing information and dispersion of knowledge to the farm level.  Direct participation by the farming communities in the pilot projects on the dissemination and use of climate forecasts will be essential to determine the actual value of forecasts and to identify the specific user needs.  Old (radio) and new (Internet) communication techniques, when adapted to local applications, may assist in the dissemination of useful information to the farmers and decision makers.

## Biodiversity

Every cubic centimeter of the biosphere has been altered by human-induced changes in the climate and the chemical composition of the atmosphere, and this carries major implications for biological diversity. On the other hand, plants, animals, and microbes absorb and break down pollutants; help maintain a benign mix of gases in the atmosphere; regulate the solar energy the earth absorbs; moderate regional weather and rainfall; modulate the water cycle, minimizing floods and drought and purifying waters. Hence, it is clear that there are major interactions between climate and biological diversity. In the light of the growing concerns with the protection of biodiversity, the global community ratified the Convention on Biological Diversity (CBD), which entered into force on December 29, 1993. The Convention, which is based on a broad ecosystem approach, contains three national-level obligations: to conserve and sustainably use biological diversity and to share its benefits.

From the point of view of operational agrometeorological services, the following elements in CBD are of interest:

a) Promoting environmentally sound and sustainable development in areas adjacent to protected areas where special measures need to be taken to conserve biological diversity; and,
b) Rehabilitating and restoring degraded ecosystems.

Generally speaking, any natural resource conservation measures to maintain land productivity through sustainable agricultural practices could effectively contribute to the maintenance of biological diversity.

## Drought and Desertification

Drought is the consequence of a natural reduction in the amount of precipitation over an extended period of time, usually a season or more in length, often associated with other climatic factors (such as high temperatures, high winds, and low relative humidity) that can aggravate the severity of the event. Drought occurrences are common in virtually all climatic regimes. Of the many climatic events that influence the earth's environmental fabric, drought is perhaps the one that is most recognized by farmers around the world, especially in the arid and semi-arid tropics, as the most important extreme meteorological event that affects their crops and livestock and causes severe economic losses.

In view of the widespread impacts of droughts on agriculture, there is considerable interest in developing strategies for coping with droughts. An important component of such strategies is prediction and early warning with good lead time, about impending droughts, which provides the best solution for the minimization of the loss of life and property damages. Prediction and early warning information and products are vital in enhancing food and agricultural production as well as in the utilization and management of fresh water, energy, and other natural resources that are sensitive to extreme weather and climate events.

The United Nations Convention to Combat Desertification (UNCCD), which entered into force on 26 December 1996, gave a great deal of importance to early warning systems including use of seasonal climate forecasts. The following areas identified in the Convention could be of specific interest for operational agrometeorological services:

a) Establishment and/or strengthening, as appropriate, of early warning systems, including local and national facilities and joint systems at the sub regional and regional levels;
b) Strengthening drought preparedness and management strategies, including drought contingency plans at the local, national, sub regional and regional levels, which take into consideration seasonal to interannual climate predictions;
c) Early warning and advance planning for periods of adverse climatic variation in a form suited for practical application by users at all levels, including especially local populations; and,
d) Development of sustainable irrigation programs for both crops and livestock husbandry.

**Food Security**

Food security is a major problem in most countries with low per capita food production and a high dependence on agriculture. Recent food security problems have originated mostly from weather-related hazards and extreme events such as droughts, floods, and cyclones.

The World Food Summit (WFS), which was hosted by FAO in Rome in November 1996, prepared the WFS Plan of Action with the main objective to improve food security at all levels, and to significantly reduce the number of undernourished people.

Poverty is seen as one of the main factors behind food insecurity, but the WFS document stresses the links between poverty and such factors as natural disasters and climate-related ecological changes. Climate fluctuations are indeed the main factors that prevent a regular supply and availability of food, which is the key to food security.

The WFS elaborated seven Commitments, of which Commitment 3 (sustainable policies and practices essential to adequate and reliable food supplies and to combat pests and drought and desertification) and, to a lesser extent, Commitment 5 (prevent and prepare for natural disasters and man-made emergencies and to meet transitory and emergency food requirements) are very relevant for the climate community in a sustainable development perspective.

Commitment 3 makes repeated reference to climate and climate change (including the UNFCCC) and the related problems of desertification, the loss of biodiversity, and the depletion of the ozone layer, which are all related, at least indirectly, to the unsustainable use of climate resources. This Commitment stresses the need for disseminating and applying climate forecast information that will increase sustainable agricultural, fisheries, and forestry productivity, and be of particular benefit to developing countries.

Commitment 5 emphasizes the need to maintain, promote, and establish the preparedness strategies and mechanisms, including development and application of climate forecast information for surveillance and early warning, drought, flood, other natural disasters, and pest and disease alertness. It also underlines the need to support international efforts to develop and apply climate-forecast information to improve the effectiveness and efficiency of emergency preparedness and response activities, with special efforts to create synergy and avoid duplication.

## Sustainable Development

The World Summit on Sustainable Development (WSSD) was held in Johannesburg, South Africa, in August-September 2002 to take stock of the achievements, challenges, and new issues arising since UNCED held in 1992. But more than that, it was an "implementation" Summit, designed to turn the lofty goals, promises, and commitments of Agenda 21 into concrete, tangible actions (United Nations, 2003). The Plan of Implementation adopted at WSSD carries certain elements of direct interest to operational agrometeorological services. These include:

a) Improving the efficient use of water resources in agriculture;
b) Developing programs for mitigating the effects of extreme water-related events;
c) Reducing the risk of flooding and drought in vulnerable countries;
d) Developing and strengthening early warning systems and information networks in disaster management;
e) Improving early warning systems for predicting extreme weather events, especially El Niño/La Niña;
f) Providing affordable local access to information to improve monitoring and early warning related to desertification and drought; and,
g) Supporting efforts to prevent and mitigate the impacts of natural disasters by translating available data, particularly from global meteorological observation systems, into timely and useful products.

## Requirements for Agrometeorological Services

*Perspectives from Natural Disaster Prevention and Mitigation*

During the past four decades, natural hazards such as droughts, floods, storms, tropical cyclones, and wildland fires have caused major loss of human lives and livelihoods, the destruction of economic and social infrastructure, as well as environmental damages. There is evidence available from different parts of the world that there was a rising trend of natural disasters from 1993 to 2002 (Figure 1a). Of a grand total of 2,654 disasters during this period, floods and windstorms account for about 70 percent of the disasters, while the remaining 30 percent of the disasters are accounted for by droughts, landslides, forest fires, heat waves, and others (Figure 1b). The economic cost associated with all natural disasters has increased 14 fold since the 1950s (World Disasters Report, 2001). World wide, annual economic costs related to natural disasters have been estimated at about $50 to $100 billion.

Communities that are most exposed to risk from climate extremes and natural disasters and are potentially at risk from climate change, are those with limited access to technological resources and with limited development of infrastructure. Small farmers with limited means in most of the developing countries are at risk. The losses they suffer from the impact of natural disasters cannot be entirely eliminated, but timely and appropriate mitigation measures can certainly reduce the impacts. Planning, early warning, and well-prepared response strategies are the major tools for mitigating the losses. The longer in advance a warning can be given about potentially damaging conditions, the easier it will be to mitigate and reduce its impact. Operational agrometeorological services must recognize the need for such advance warnings to help the farming community and integrate them in the advisories that are issued.

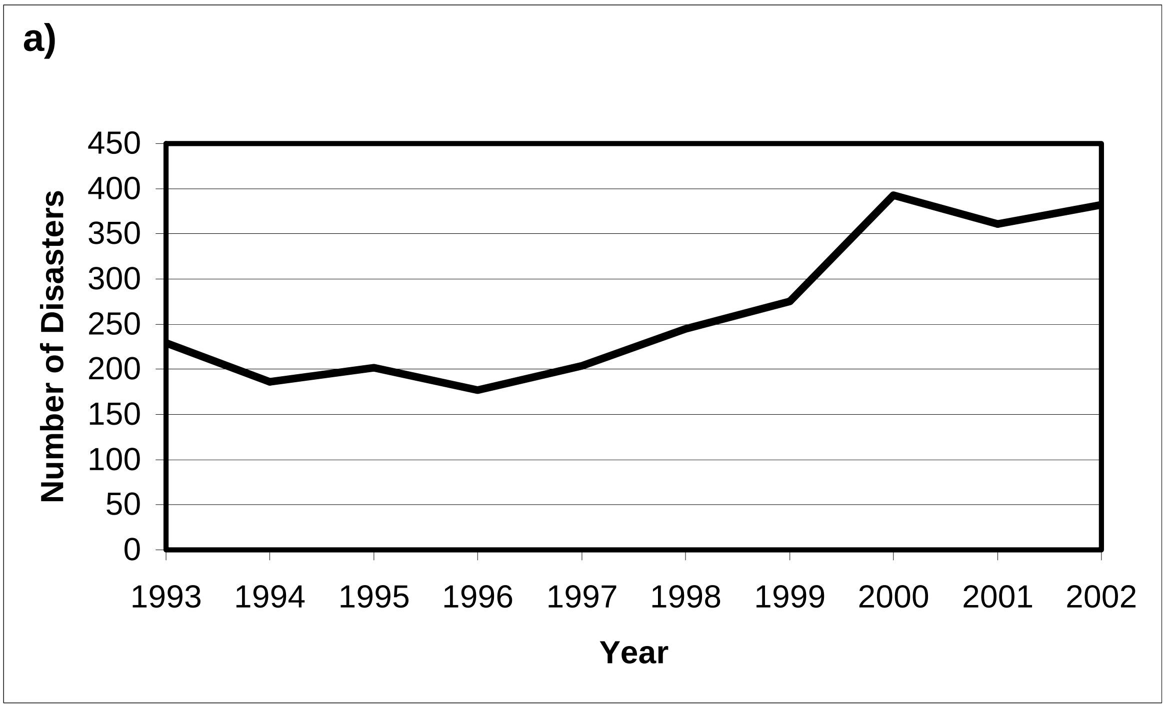


Figure 1a. Annual variations in the occurrence of hydrometeorological disasters during 1993-2002.

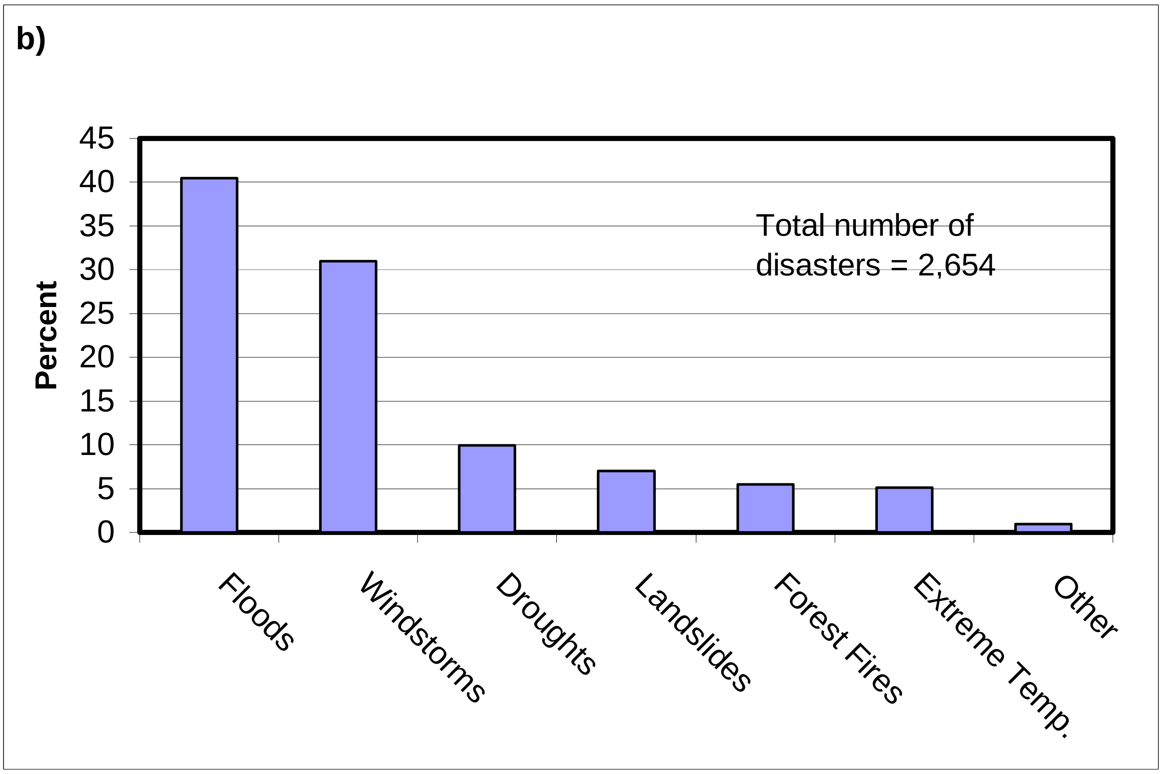


Figure 1b. The percentage of different hydrometeorological disasters as a percent of total number of disasters during 1993-2002.

Major advances in technology, notable progress in scientific understanding, and the accuracy and timeliness of weather and flood warnings have significantly improved over the last few decades. Today the accuracy of forecasts of large-scale weather patterns for 7 days in advance is the same as those for 2 days in advance only 25 years ago (Obasi, 1998). Now forecasts for up to 10 days are showing remarkable accuracy, and there is now capability to provide some skillful information on expected weather patterns several seasons in advance.

For example, early information on El Niño episodes is now allowing advanced national planning, with considerable advantage in many sectors of the economy, such as in water resources management, tourism, and fisheries and agricultural production (Obasi, 1996). In the case of the 1997-98 El Niño event, advances in El Niño-related science and in monitoring the sea-surface temperatures in the Pacific Ocean, enabled scientists in the National Meteorological and Hydrological Services (NMHSs) to predict its formation longer in advance than all the previous events. With recent developments in communication technology, including the use of Internet, information on the El Niño was disseminated in a rapid and timely manner throughout the world. These enabled many governments to take appropriate measures, and stimulated international cooperation and integrated efforts to address the associated impacts. Similarly, the accuracy of tropical cyclone track forecasts and the timeliness of warnings have been steadily improving in the past few years.

Operational agrometeorological services should recognize the potential of working closely with the departments and agencies involved in natural disaster preparedness and mitigation to provide quick and efficient help to the farming community.

## Requirements for Agrometeorological Services

*Perspectives from Satellite Remote Sensing and GIS Applications*
Remote sensing provides spatial coverage by measurement of reflected and emitted electromagnetic radiation, across a wide range of wavebands, from the earth's surface and surrounding atmosphere. The improvement in technical tools of meteorological observation, during the last 20 years, has created a favourable substratum for research and monitoring in many applications of sciences of great economic relevance, such as agriculture and forestry. Each waveband provides different information about the atmosphere and land surface: surface temperature, clouds, solar radiation, processes of photosynthesis and evaporation, which can affect the reflected and emitted radiation detected by satellites. The challenge, therefore, is to develop new systems extracting this information from remotely sensed data, giving to the final users, near-real-time information.

Over the last two decades, the development of space technology has led to a substantial increase in satellite earth observation systems. Simultaneously, the Information and Communication Technology (ICT) revolution has rendered increasingly effective the processing of data for specific uses and their instantaneous distribution on the web.

The meteorological community and associated environmental disciplines, such as climatology including global change, hydrology, and oceanography, all over the world are now able to take advantage of a wealth of observational data, products, and services flowing from specially equipped and highly sophisticated environmental observation satellites.

Due to the availability of new tools, such as GIS, management of an incredible quantity of data such as traditional digital maps, database, models, etc., is now possible. The advantages are manifold and highly important, especially for the fast cross-sector interactions and the production of synthetic and lucid information for decision makers. At the national and local level, possible GIS applications are endless. For example, agricultural planners might use geographical data to decide on the best zones for a cash crop, combining data on soils, topography, and rainfall to determine the size and location of biologically suitable areas. The final output could include overlays with land ownership, transport, infrastructure, labor availability, and distance to market centers.

The developments in remote sensing and GIS hold much promise to enhance integrated management of all available information and the extraction of desired information to promote sustainable agriculture and development. Active promotion of the use of remote sensing and GIS in the NMHSs could enhance improved agrometeorological applications. To this end, it is important to reinforce training in these new fields. The promotion of new specialized software should make the applications of the various devices easier, bearing in mind the possible combination of several types of inputs such as data coming from standard networks, radar and satellites, meteorological and climatological models, digital cartography, and crop models based on the scientific acquisition of the last 20 years.

**World Agrometeorological Information Service to Strengthen Operational Agrometeorological Services**

Disseminating agrometeorological information is part of a process that begins with scientific knowledge and understanding and ends with the evaluation of the information. The Internet is one of the new and cost-effective technologies that can provide this information in an accurate and timely manner. Additionally, the Internet can also be effectively used to offer training modules to agrometeorologists to help them improve the quality of the agrometeorological products, which they produce.

During an Inter-Regional Workshop on Improving Agrometeorological Bulletins organized by WMO in Bridgetown, Barbados, in October 2001, participants recommended the development of a dedicated web server for dissemination of agrometeorological products (Sivakumar, 2002). As a follow-up to this recommendation, the Commission for Agricultural Meteorology (CAgM) of WMO organized an Expert Group Meeting on Internet Applications for Agrometeorological Products in Washington, D.C., during May 2002. The meeting recommended the establishment of the World AgroMeteorological Information Service (WAMIS).

The goal of WAMIS is to make agrometeorological products issued by WMO members available to the global agricultural community on a near real-time basis. These products are produced on either a weekly, monthly, or yearly time frame and the format of the products will range from text and MS Word files to PDFs. Provision of a central location for agrometeorological information also enables members to quickly and easily evaluate the various bulletins and gain insight into improving their own bulletins. To further help members improve the quality and presentation of their agrometeorological bulletins, WAMIS will also host training modules.

In December 2003, the Secretary-General of WMO sent a letter to all PRs requesting members to nominate a WAMIS focal point. As of the end of February 2004, responses were received from 90 countries.

Currently, the WAMIS web site is operational and can be accessed at www.wamis.org. WAMIS aims at strengthening operational agrometeorological services to the agricultural community worldwide through effective dissemination of agrometeorological products. The training modules hosted on WAMIS should help the agrometeorologists, especially in the developing countries, in the preparation and dissemination of improved agrometeorological products, thereby strengthening their ability to provide better services.

## Conclusions

One common theme that emerges clearly from the discussion on the requirements for agrometeorological services from an international perspective is the need for the provision of improved agrometeorological services, not just for enhancing agricultural productivity, but also for protecting the environment and biodiversity, coping with climate change, and drought and desertification for ensuring sustainable development. Agenda 21 as well as the different International Conventions emphasize the need for better early warning systems of hydro-meteorological disasters that impact agriculture, especially droughts, floods, and cyclones. Preparedness strategies to cope with the impact of the meteorological extreme events require better information and monitoring systems and effective early warning systems. There is also much emphasis on better dissemination and application of climate forecasts, in particular the El Niño/La Niña events, for increasing and sustaining agricultural productivity. Operational agrometeorological services should recognize the potential of working closely with departments and agencies involved in natural disaster preparedness and mitigation to provide quick and efficient help to the farming community. Remote sensing and GIS applications hold a lot of promise for improving operational agrometeorological services and more attention needs to be paid to enhancing such applications. New initiatives such as the World Agrometeorological Information Service (WAMIS) could help strengthen operational agrometeorological services through the provision of agrometeorological products on a near-real time basis on the Internet and through training modules to enhance the quality of agrometeorological products.

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