Commission for Agricultural Meteorology (CAgM)

The First
Fifty Years

Weather and climate information
Sustainable agriculture
Adaptation strategies to climate change

World
Meteorological
Organization
Weather • Climate • Water

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FOREWORD

M. Jarraud, Secretary-General

When humans first started planting crops and raising cattle thousands of years ago, the dependence of agriculture on weather and climate was evident. Would there be enough rain for the crops to germinate and grow? Why do only certain crops or plants grow in a region? Would there be enough grass for the cattle to eat? These were probably some of the first questions that our forefathers asked when they planted crops or raised livestock. Of all human endeavours, agriculture was perhaps the first sector where humans realized that there are strong interactions between the sector and the weather. Over time, humans developed practices that were based on their understanding of weather and climate patterns. Some of these included the appropriate time of the year to plant and harvest a crop or move livestock from summer to winter grazing areas. They were, of course, mystified and frustrated by the variability of the seasons and even the day-to-day weather, and as a coping strategy developed folktales and rules of thumb for the weather and climate patterns. Such practices have been used over the centuries, and continue to be used right up to the present day.

In the 19th century, the progress of scientific methods and theories increased and led to the development of new agricultural management practices. There was also the issue of natural disasters impacting agriculture, such as droughts and diseases, including the potato blight, caused by an airborne fungus, that led to the Irish Potato Famine in the 1840s. It would be many years before scientists realized the interrelationships between this fungus, weather and the potato crop. With the increase in knowledge and importance of meteorology, the international community recognized the need for international collaboration in this field. In 1873 the International Meteorological Organization (IMO) was created. As time went on, scientific methods and reasoning continued to improve and knowledge of the atmosphere, plants, trees, animals, insects and the soil increased dramatically. In the first half of the 20th century, scientists increasingly realized the interaction between these different fields of study and began to integrate these diverse disciplines into the new field of agrometeorology. In view of these advances, the IMO Commission for Agricultural Meteorology was established in 1913, although its first meeting could not be held until 1923 owing to the First World War. Subsequently, this commission held seven meetings, with the last one being held in Toronto in 1947.

After the Second World War, the United Nations was formed and the World Meteorological Organization (WMO) was created on 23 March 1950 as a specialized agency of the United Nations and the successor to IMO. Therefore, WMO inherited more than 75 years of practical experience in international cooperation in meteorology and its various applications to human activities, including agriculture. Soon after the creation of WMO, the WMO Commission for Agricultural Meteorology (CAgM) was created and its first session held in Paris in November 1953. From its inception until today, CAgM has organized 13 sessions and has contributed significantly to the strong relationship with the other United Nations agencies, especially the Food and Agricultural Organization of the United Nations (FAO).

As one of the eight technical commissions of WMO, CAgM's role is to provide guidance in the field of agricultural meteorology by studying and reviewing available science and technology; to propose international standards for methods and procedures; to provide a forum for the examination and resolution of relevant scientific and technical issues; to promote training and the transfer of knowledge and methodologies, including the results of research, between WMO Members; and to promote international cooperation and maintain close cooperation in scientific and technical matters with other international organizations.

In the 1950s and 1960s, the scourge of desert locusts across most of northern Africa and southwestern Asia prompted studies by entomologists and meteorologists of the locust movement and its relation to weather and climate. In order to combat this problem, the relationship between WMO and FAO was strengthened through CAgM. In addition, during the 1960s and 1970s, the two organizations, along with UNESCO, worked closely together in producing publications on agroclimatic zoning and, later, collaborated closely on food security issues.

In the 21st century, in a world of rising populations, diminishing arable land (especially in developing countries), declining non-renewable energy supplies and increasing awareness of potential environmental degradation, there is a great need for sustainable management in the agricultural sector of the world's economies. The concept of sustainable agriculture encompasses ecological, economic and social concerns in which weather and climate are of great importance.

CAgM, through its work over the past 50 years, has demonstrated that judicious application of meteorological — including climatological and hydrological — knowledge and information, and seasonal and long-range forecasts, can considerably assist the agricultural community in developing and operating sustainable agricultural systems and increasing production in an environmentally sustainable manner. CAgM played an important role in providing leadership and guidance in the implementation of WMO's Agricultural Meteorology Programme, through its working groups, rapporteurs and expert teams, and produced a number of very useful reports and publications.

This brochure, prepared with input from two past presidents of CAgM, Wolfgang Baier and Kees Stigter, and the present president, Ray Motha, presents a fascinating summary of CAgM's work over the past 50 years and I wish to thank them for their input. Sadly, Mr Baier passed away soon after submitting his contribution to this brochure and CAgM will remember his very active role in the Commission over the years.

I am confident that this brochure will help to provide a better understanding of the activities and commitment of CAgM in promoting the applications of meteorology to agricultural cropping systems, forestry, agricultural land use and livestock management and in developing agrometeorological applications and services in the Member countries through the transfer of knowledge and methodologies.

M. Jarraud
Secretary-General

Definition

Agricultural meteorology as an accepted term first came into use in the 1920s. In its first 40 years, the science developed in the western world, Japan, India and China. However, since the 1980s, the field of agricultural meteorology has seen significant developments and modifications. Since the 1960s, the regions where it has been applied have increased, but water balances and evaporation in temperate climates became, and have remained, the most treated subjects. However, with increasing application in the developing world with its more abundant weather and climate disasters, the definition needed to be widened to include tropical agrometeorology.

A more inclusive definition of agricultural meteorology deals with water, heat, air and related biomass development, above and below ground, in the agricultural production environment, including the impact of pests and diseases that also depend on these factors.

Regarding water, this includes precipitation and what happens to it. For heat, it means radiation and how it is distributed. For air, we have to consider the atmosphere and its movement. For all three elements we may distinguish between consequences and use. "Agricultural production" is used in the widest sense, including forestry (and non-forest trees), livestock and fisheries, in line with the terms of reference of the Commission for Agricultural Meteorology (CAgM) of the World Meteorological Organization (WMO).

Examples of the consequences of water in the agricultural production environment are erosion, flooding and spreading diseases by splashing. Its use is exemplified in irrigation, crop growth and water-use efficiency aspects. Examples of the consequences of radiation as a source of heat are extreme temperatures and drought. For its use we can mention photosynthesis, evaporative cooling as well as heating and drying. Both consequences and uses are complicated by the existence of the radiation balance in which long-wave radiation also plays an important role.

Major consequences of air movement are wind damage, particle movement, and its role as a carrier, while the use of air movement in the production environment can be exemplified in the bringing of carbon dioxide, the bringing or taking away of heat, and in drying.

In relation to the definition above, one also needs to consider soil, biomass, and, in particular, social and economic aspects of the production environment.

Soil is not in itself a feature of agricultural meteorology, but water, heat, air and biomass, above and in the soil, are considered in agricultural meteorology (e.g. several aspects of irrigation, soil water use by crops, mulching, underground storage, tillage, protection from wind erosion and stored water in the soil).

Biomass is not an aspect of agricultural meteorology either, but water, radiation/heat and air in and around biomass are taken into account (e.g. phenology, growth, shelterbelts, drying, intercropping aspects, mulched horticulture and agriculture under cover and in glass houses).

The study of society and economics is not included in the field of agricultural meteorology but the consequences and use of water, radiation/heat and air in society and economics, as far as the agricultural production environment is concerned, are looked at within agricultural meteorology (e.g. socio-economic aspects of irrigation, storage,

agroforestry, floods, drought, desertification, frost, wind protection, artificial growth conditions, sustainable farming and related farmers' incomes). In short, socio-economic aspects of agrometeorological services, including preparedness for extreme events and environmental degradation, and their consequences for providers and users, are included.

From the above, it is clear that in the highly interdisciplinary applied field of agrometeorology knowledge may well come from overlapping disciplines, including soil science, plant science, animal science, climatology, phytopathology, aerobiology, hydrology and agricultural engineering, as well as basic science.

Science

Over its first 40 years, agrometeorology developed as a science as the possibilities for quantification of the physical aspects of the production environment evolved. The same applies to the biological aspects of the production environment.

Over time a valuable set of actual support systems, that helped the science of agrometeorology to grow, developed. In the summary and recommendations of the International Workshop on Agrometeorology for the 21st Century, which was held in February 1999 in Accra, four types of support systems were distinguished: data, research, education/training/extension and policies.

Data support systems have grown enormously in importance, particularly in applications in the industrialized world. Collection, management and analysis of atmospheric and surface data have evolved beyond the still highly valuable traditional data collection (often automated these days) into new techniques, including remote sensing and Geographical Information Systems (GISs), covering near ground to outer space. These techniques themselves need thorough scientific support.

GISs are computer-assisted systems for acquisition, storage, analysis and display of geographic data. GIS is an effective tool for the production of maps that require several databases. GIS technology is an extension of cartographic science, enhanced by computer technology, giving increased efficiency and analytical power over more traditional methodologies. Numerous thematic surveys in the form of soil survey reports for agriculture, agroclimatic maps, groundwater and soil moisture surveys, land evaluation and cartography exist. Integrated land and water resource information systems for agriculture, based on GIS technology, will play a major role in database management for agricultural decision making where good quality data exist.

GIS analyses, including the utilization of remote sensing data and rapid dissemination of near-real time data, are specialized areas that should be done by international, regional, national and, where possible, local specialized bureaus and organizations.

RAY DESJARDINS

RAY DESJARDINS

Methods of flux measurements over agricultural fields have changed over the years. In the 1960s, sampling assemblies were used to measure carbon dioxide and water vapour profiles in and above a cornfield (left). More recently, flux measurements of carbon dioxide, ozone and sensible and latent heat are taken by sophisticated sensors located on towers and aircraft (right).

Agrometeorological research as a support system needs ongoing regional, national and local prioritization. Priority aspects identified at the international workshop in Accra in February 1999 were:

- Agrometeorological aspects of the efficient use and management of resources in the full production environment, as defined in the introduction;

- Reduction of impacts on the resource base, yields and income from natural disasters, including pests and diseases, natural climate variability and increasing variability induced by climate change, and preparedness and prediction using agroclimatic information;

- Validations and applications of databases and models for well specified systems and users; and

- Ways to ensure that research results are adopted in farming.

These subjects also turn up as priorities in the new Open Programme Area Group (OPAG) structure, with its Expert Teams (ETs), discussed later in this brochure. The importance of policy issues and education/training/extension as support systems in agricultural meteorology is best illustrated in considering applications and services.

Applications and Services

If support systems are not used operationally for agrometeorological applications in agriculture, forestry, rangelands and fisheries, they do not serve any purpose. Examples of actual agrometeorological services from CAgM literature are:

- Agroclimatological characterization, using different methodologies;

- Advice on design rules on above and below ground microclimate management or manipulation, with respect to any appreciable microclimatic improvement: shading, wind protection, mulching, other surface modification, drying, storage, frost protection, etc.;

- Advice, based on the outcome of response farming exercises, from sowing window to harvesting time, using recent climatic variability data and statistics or simple on-line agrometeorological information;

- Establishing measures to reduce the impacts and to mitigate the consequences of weather and climate related natural disasters for agricultural production;

- Monitoring and early warning exercises directly connected to already established measures;

- Climate predictions and forecasts and meteorological forecasts for agriculture and related activities, on a variety of time scales, from years to seasons and weeks, and from a variety of sources;

- Development and validation of adaptation strategies to increasing climate variability and climate change and other changing conditions in the physical, social and economic environments of farmers;

- Specific weather forecasts for agriculture, including warnings of suitable conditions for pests and diseases and/or advice on mitigation measures, such as fire weather monitoring;

- Advice on measures to reduce the contributions of agricultural production to global warming and on keeping an optimum level of non-degraded land dedicated to agricultural production;

- Proposing means of direct agrometeorological assistance in the management of natural resources for the development of sustainable farming systems via technological advances with strong agrometeorological components.

A recent policy support paper for the Management Group (MG) of CAgM distinguishes two levels of increase in operational use of knowledge generated by the support systems. The first includes general agrometeorological action support systems for mitigating the impacts of disasters, e.g. monitoring, early warning, forecasting, focused quantitative analyses, general weather advisories, etc. It is helpful if the most suitable contemporary scientific knowledge is combined with local adaptive strategies (based on traditional knowledge). An appropriate policy environment, based on social concerns and environmental considerations, can help develop the right mix of strategies for preparedness and problem solving in practice.

The second level of increase in operational use of knowledge relates to agrometeorological services supporting the decisions and actions of producers.

The relatively scant actual use of agrometeorological services in agriculture, particularly but not only in developing countries, can be attributed to:

- Insufficient education and training of user communities, including the farm advisory services, that provide specific agricultural advice (the services) from more general but focused agrometeorological information (the knowledge mix);

- Lack of cooperation between the institutions providing information and relevant advisories (operational use of knowledge) and those responsible for their transfer to the farming community (on the ground direction and decision-making).

In general, when the level of education and skills of farmers is insufficient to cope with new or aggravating agrometeorological problems, which can be anywhere in the world, there may be a need for intermediaries, trained and equipped to provide services, to assist in solving these problems. This can be the solution to the above constraints on effective use of services. These intermediaries may belong to public as well as private institutions and an economy of such services will always have to be developed.

In developing countries, there remain risks that very few high-level agrometeorological personnel and limited resources are geared towards modern specializations. This situation is accentuated by low quality data and the limited absorption capacity of agricultural decision makers for agrometeorological products.

First, priority problems/needs and priority agrometeorological services have to be identified through a participatory approach with farmers. Methodologies come second but are essential. The methodologies need to be applied with detailed consideration of the specific data and ecoregional conditions.

THE COMMISSION FOR AGRICULTURAL METEOROLOGY THROUGH THE YEARS

The Birth of WMO and CAgM

The birth of CAgM is linked to the establishment of WMO in 1950 as one of the youngest specialized agencies of the United Nations. However, WMO inherited from its predecessor, the International Meteorological Organization (IMO), nearly 75 years of practical experience with international cooperation in meteorology and its application to human activities, including agricultural meteorology.

CAgM was one of the eight technical commissions created by the first WMO Congress held in Paris in 1951. The terms of reference laid down by the Congress were as follows:

- Keeping abreast of and promoting meteorological developments, both in the scientific and practical fields;
- Standardizing methods and procedures, and the techniques for their application;
- Collaborating with other commissions; and
- Proposing to the organization the adoption of resolutions relating to:
  - Weather and climate in relation to animals and plants;
  - Requirements of weather forecasts in relation to agriculture;
  - Meteorological aspects of phenology;
  - Artificial influences on weather conditions in relation to agriculture;
  - Weather and climate in relation to use, formation and conservation of soils and vegetation.

Subsequent congresses reviewed the terms of reference of the CAgM and made necessary amendments and also gave guidance to priorities. WMO was mandated to collaborate with other international organizations and some of these were of special interest to CAgM. In the beginning, these included the United Nations itself, the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), and in time more international organizations and regional associations were contacted by WMO/CAgM for possible collaboration.

Highlights of CAgM Sessions I to III and Intersessional Activities

The first session of CAgM (CAgM-I) was held in Paris in November 1953, and the second session in Warsaw in September/October 1958. J. J. Burgos was the president of the Commission at these two sessions. He was responsible for a great deal of the planning and organizing which led to the founding of CAgM and to the success of the first two sessions.

The deliberations of CAgM-I centred around organizational and policy matters as well as basic technical matters. One of the first policy matters to be considered was the place of agricultural meteorology in WMO. There were disturbing discussions in both Congress and the Commission for Climatology (CCl) that agrometeorology was part of climatology and that the two commissions, CCl and CAgM, should merge. CAgM countered that the terms of reference of CCl had no bearing on the biological aspects of agricultural meteorology, forecasting for agriculture, artificial control of weather (microclimate) and some aspects of hydrology, all of which are essential features of agricultural meteorology. Thus it was argued that CAgM should be retained as a separate commission in WMO. Similar merger proposals were proposed in subsequent years but were always strongly rejected, especially by Congress delegates from developing countries.

The early history of CAgM shows a remarkable evolution from a discipline attempting to relate meteorology to agriculture into a well recognized and integrated constituent body of WMO. This was due to the efforts of a small group of individuals dedicated to the benefits of agricultural meteorology at the global, regional and national level, and to the support received by the WMO Congress and the WMO Secretariat.

Early sessions of CAgM

At CAgM-I the president submitted a document on the Commission's terms of reference. The new terms were substantially different from those laid down by Congress, and an attempt was made to avoid overlapping between the fields of competency of CAgM and those of the other WMO technical commissions. The new terms of reference were spelled out in the recommendation to Congress: "Proposed revised terms of reference for the Commission for Agricultural Meteorology".

These terms of reference formed the guidelines for the Commission for the next four sessions. They were, however, revised and updated by the Advisory Working Group prior to the sixth session of CAgM in 1974 and were included in the revised *Guide to Agricultural Meteorological Practices* (GAMP, WMO–No. 134). The terms of reference for all the WMO Commissions were once again revised and approved by the Tenth Congress (*Basic Documents*, 1987 edition).

From the very beginning CAgM recognized the importance of inter-agency cooperation, realizing that agrometeorology was an applied science and that there must be strong interaction with user groups. On invitation, eight international agencies sent representatives to CAgM-I. These included FAO, UNESCO, the Biometric Society, the International Association for Meteorology, the International Association for Hydrology, the International Federation of Agricultural Producers, the International Geophysical Union and the International Society of Soil Science.

Participants in the first session of CAgM held in Paris in November 1953

Table 1. CAgM sessions, abridged final reports, number of working groups and rapporteurs established

CAgM session	Year	Venue	Abridged final report (WMO-No.)	Working groups	Rapporteurs
I	1953	Paris	27	5	-
II	1958	Warsaw	83	11	-
III	1962	Toronto	125	10	-
IV	1967	Quezon City	221	7	13
V	1971	Geneva	318	8	18
VI	1974	Washington	402	8	17
VII	1979	Sofia	546	9	9
VIII	1983	Geneva	612	7	18
IX	1986	Madrid	677	5	19
X	1991	Florence	775	5	13
XI	1995	Havana	825	6	11
XII	1999	Accra	900	6	11
XIII	2002	Ljubljana	951	12*	-

* Implementation/Coordination Teams and Expert Teams

Table 2. CAgM president, vice-president, WMO Agricultural Meteorology Division officials at different CAgM sessions

CAgM session	Year	President	Vice-president	WMO Agricultural Meteorology Division officials
I	1953	J. J. Burgos (Argentina)	H. Geslin (France)	J. M. Rubiato
II	1958	J. J. Burgos (Argentina)	H. Geslin (France)	O. M. Ashford, M. A. Alaka
III	1962	P. M. A. Bourke (Ireland)	M. S. Malik (USSR)	K. Langlo, B. Thorslund
IV	1967	L. P. Smith (UK)	J. J. Tecson (Philippines)	O. M. Ashford, M. L. Blanc
V	1971	L. P. Smith (UK)	J. van Eimern (Germany)	C. C. Wallen, C. M. Taylor
VI	1974	W. Baier (Canada)	J. Lomas (Israel)	C. C. Wallen, M. J. Maunder, V.Krishnamurthy
VII	1979	W. Baier (Canada)	Did not attend	R. Schneider, M. J. Connaughton, E. G. Davy, V. Krishnamurthy
VIII	1983	N. Gerbier (France)	J. J. Burgos (Argentina)	D. Rijks, V. Krishnamurthy, N. A. Gbeckor-Kove
IX	1986	A. Kassar (Tunisia)	C. J. Stigter (Netherlands)	D. Rijks, V. Krishnamurthy
X	1991	A. Kassar (Tunisia)	C. J. Stigter (Netherlands)	N. A. Gbeckor-Kove, V. Krishnamurthy
XI	1995	C. J. Stigter (Netherlands)	J. Salinger (New Zealand)	N. A. Gbeckor-Kove, V. Krishnamurthy A. Yeves-Ruiz
XII	1999	C. J. Stigter (Netherlands)	J. Salinger (New Zealand)	M. V. K. Sivakumar, A. Yeves-Ruiz
XIII	2002	R. Motha (USA)	L. Akeh (Nigeria)	M. V. K. Sivakumar, M. Saho, R. Stefanski

Collaboration between meteorology and agriculture at the national level was recognized as a very important matter by the participants at CAgM-I. A recommendation was adopted encouraging members "to consider the establishment of national coordinating committees composed of representatives of meteorology, agriculture, animal husbandry, forestry and soil science agencies or, alternatively, the establishment of satisfactory direct liaison, in view of the fact that such collaboration is of immediate practical importance in the fields of pathology and soil conservation".

The second session of the Commission (CAgM-II) discussed the topic of collaboration with agriculture and made specific suggestions as to how close collaboration might be achieved at the national level. In this context, the organization and strengthening of national agrometeorological services was also discussed. A number of national reports on existing organizations were considered. A document by the president contained a broad review of the world situation and recommendations aimed at strengthening agrometeorological services. These recommendations were later used in GAMP.

CAgM-II took place in Warsaw from 29 September to 17 October 1958.
Left to right: H. Geslin (France), retiring vice-president of CAgM; P.M.A. Bourke (Ireland), newly elected president of CAgM; J.J. Burgos (Argentina), retiring president of CAgM;
M.S. Sulik (USSR), new vice-president of CAgM),
W. Okotowicz (Director of the Institute of Hydrology and Meteorology and Permanent Representative of Poland)

CAgM-II also discussed the importance of hydrology to agriculture: agriculture in arid and semi-arid areas of the world was entirely dependent on water supplies and it was, therefore, essential for the agrometeorologist to be able to compute with sufficient accuracy the various terms of the hydrological cycle. CAgM-II looked to the future and realized that the water balance concept was rapidly becoming of global importance.

This session paid great attention to the content and preparation of GAMP. It was felt that early completion and publication of this work would be a valuable contribution by WMO to agrometeorology and a working group on GAMP was appointed. A provisional list of contents was prepared as guidance material (WMO-No. 83, Annex I and Annex II).

P. M. A. Bourke (Ireland) was elected the second president of the Commission at the third session of the Commission (CAgM-III), which was held in Toronto in 1962. Major contributions were in connection with the formation of CAgM and Mr Bourke's role in presenting to Congress arguments for the continuation of CAgM as a separate technical commission of WMO.

CAgM-III recognized that forestry meteorology had received little consideration to date and agreed that attention should be given to the role of forestry in future amendments to GAMP. Tropical agrometeorology also received some attention at this session.

The FAO/UNESCO/WMO Inter-agency Project on Agroclimatology had submitted to the Secretary-General its first report on "A Study of the Agroclimatology in Semi-arid and Arid Zones of the Near East", which was then recommended for publication.

Participants in the CAgM-II session held in Warsaw from 29 September to 17 October 1958

The Commission considered this type of study to be very valuable and useful, not only to the countries studied but also to experts and consultants who worked in those regions. They recommended that the Inter-Agency Group undertake a similar study in the southern fringe of the semi-arid part of West Africa and recommended to Congress that adequate funds be provided in the budget of WMO for its participation in the project.

For the next three sessions and intersessional periods, the themes of the Commission shifted rapidly from emphasis on data and information-gathering to such topics as: data interpretation in connection with the solution of urgent operational problems in agriculture; the role of meteorology in the protection of natural resources and the environment; agrometeorology in aid of world food production; and technology transfer, particularly to developing countries.

Highlights of CAgM Sessions IV to VII and Intersessional Activities

L. P. Smith (UK) was elected president at CAgM-IV and re-elected at CAgM-V; he presided over two sessions. He brought to the presidency a wealth of experience in both meteorology and agriculture. He was associated with the international journal *Agricultural Meteorology* (Elsevier) from its inception and was for many years a regional editor. For over 20 years he

Lionel P. Smith (United Kingdom), third president of CAgM

Meeting of the CAgM Working Group on the Guide to Agricultural Meteorological Practices, *held in Geneva from 19 to 28 March 1962; left to right: B. Thorslund, WMO Secretariat; T. L. Noffsinger (U.S.A.); L. J. L. Deij, Chairman (Netherlands); L. P. Smith (U.K.); P.M.A. Bourke (Ireland), president of CAgM* compiled an extensive list of recently published papers for each issue of the journal – a valuable source of reference material for research workers in many disciplines around the world.

The fourth session of the Commission (CAgM-IV), held in Quezon City in 1967, assigned to working groups a diversified programme including meteorological factors affecting quantity and quality of crop yields as well as methods of forecasting micrometeorology, agroclimatology, locust meteorology and drought.

An inter-agency coordinating group on an Agrometeorological Programme in Aid of World Food Production was established by a resolution of Congress prior to CAgM-IV. The group consisted of representatives from WMO, FAO, UNESCO and the United Nations Development Programme (UNDP). This probably was one of the most important programmes supported by CAgM and it continued through several sessions. It was involved with other activities of the Commission, such as the agricultural use of World Weather Watch (WWW) data; collaboration with FAO, UNESCO and UNDP; the arid-zone research programme; drought and agriculture; and food production in developing countries, as well as with many topics being considered by rapporteurs and working groups.

The fifth session of the Commission (CAgM-V), held in Geneva in 1971, considered the Agrometeorological Programme in Aid of World Food Production and noted that considerable progress had been made. Two regional training seminars had been held; the FAO/UNESCO/WMO Inter-agency Coordinating Group on Agricultural Biometeorology had been active since its inception in 1968, particularly with regard to the undertaking of regional agroclimatic surveys. Over the years, the group has carried out six agroclimatological surveys of regions – the Near East, south of the Sahara, East Africa, the Andean zone, Southeast Asia, and the lowlands of South America.

The shortcomings in the current application of meteorology to food production were reviewed by the fifth session. These included such factors as: shortage of trained staff; lack of facilities for intensified research on

Agrometeorological observing systems have progressed from manually recording observations from a thermohydrograph in the late 1950s (left) to a fully automated weather station in use today (right).

practical aspects of agrometeorology; lack of coordination at the national level between meteorological services and agricultural institutions; and lack of coordination in the exchange of agriculturally significant weather data at the international level.

A comprehensive WMO agrometeorological programme at the national level was proposed by CAgM-V. This programme aimed to find ways and means to assist members to keep abreast of the anticipated consequences of the variability of weather and climate on food production. Working groups were established to address agrometeorological factors concerning crop yields as well as crop diseases, animal diseases, soil deterioration, aerobiology, agroclimatology, and, for the first time in the history of the Commission, international experiments in the acquisition of crop-weather data.

W. Baier (Canada) was elected the fourth president at the sixth session of the Commission (CAgM-VI), was re-elected at the seventh session (CAgM-VII) and hence presided over two intersessional periods.

During his presidency the Commission introduced several new topics into its work programme and addressed problems in the light of a worsening world food situation. Increased efforts in training in agrometeorology and stronger involvement of developing countries in the work of the Commission received special attention.

CAgM-VI, held in Washington in 1974, considered, again, the problem of the Agrometeorological Programme in Aid of Food Production. The Commission noted with particular appreciation the participation of WMO in the preparatory meetings of the World Food Conference and the action of the Executive Committee in recommending full participation of WMO in all consultations and preparations for the conference.

Following much discussion, the Commission finally decided to establish a total of eight working groups: four dealing with meteorological aspects of animal diseases, soil degradation, land use and forestry; two on international crop-weather experiments; one on forecasting crop development; and one looking at weather and climate in relation to world food production. This last working group was to act as an advisory body for the development of the Agricultural Meteorology Programme (AgMP) but was also expected to engage actively in the evaluation of techniques used in the components of the programme dealing with the assessment of crop conditions based on meteorological information provided by World Weather Watch.

Wolfgang Baier (Canada), fourth president of CAgM

The Commission also stressed that research was needed into the use of models, developed for local and regional use, for global monitoring purposes and incorporating satellite data. Special training programmes were required to prepare agrometeorologists in the use of crop-weather models and in the interpretation of information derived from them for crop production assessment, land-use planning, crop selection and crop- and soil-management practices.

CAgM-VI will be remembered in the history of the Commission because of the Congress decision to strengthen WMO activities in aid of food production and to allocate, for the first time in the history of WMO, significant funds to be used exclusively for this purpose. This decision was in response to the World Food Conference (Rome, 1974) and the detailed background work provided by the Commission at CAgM-VI. The WMO Executive Council (EC-XXVII) requested the Secretary-General to take appropriate action. One of these steps was the establishment of the Task Force on Crop-Weather Models in 1977. Crop-weather modelling was a topic of great interest at this time and four reports on the subject were prepared by rapporteurs and published in 1983.

CAgM-VII (Sofia, 1979) established a work programme covering both traditional and emerging topics carried out by nine working groups and nine rapporteurs: analysis of data and knowledge regarding agrometeorological aspects of crop yields and development; land management; desertification; the role of forests in global balances of carbon dioxide, water and energy; agrometeorological services; animal health; and meteorological aspects of agriculture in humid and sub-humid tropical areas. For the first time, a working group was established on the interaction between climate variability and agricultural activities. Other topics which received new or renewed attention included forest meteorology, remote sensing techniques in agrometeorology, and the role of CAgM in the World Climate Programme (WCP).

The president of CAgM reported to the seventh session that a large number of short-term missions to developing countries had been carried out with considerable success. The Commission felt that because of these missions a comprehensive manual for use by developing countries on the structure and organization of agrometeorological services should be prepared, and established a working group for this

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Weather and climate information is crucial for operational decisions such as timely planting of crops and for ensuring food security.

purpose. The Commission also emphasised the usefulness of seminars and symposia restricted to single topics and recommended to the Secretary-General topics for symposia and training seminars.

Many of these CAgM activities only achieved their full benefit to member countries well after CAgM-VII and are part and parcel of the history of the Commission in the 1980s and 1990s.

The Early Years – Conclusions

The achievements of the Commission from CAgM-I to CAgM-VII are reflected in an impressive number of WMO technical notes, CAgM reports, symposia/seminars/technical conferences, consultancies and roving seminars, and expert meetings.

The activities of the Commission, addressed by working groups, ranged from specific topics, such as developing instructions for observations and experiments, including GAMP, in the early period, to broader topics, such as meteorological aspects of crop and animal production and protection, forecasting yields, soil and land use, and world food production, later on.

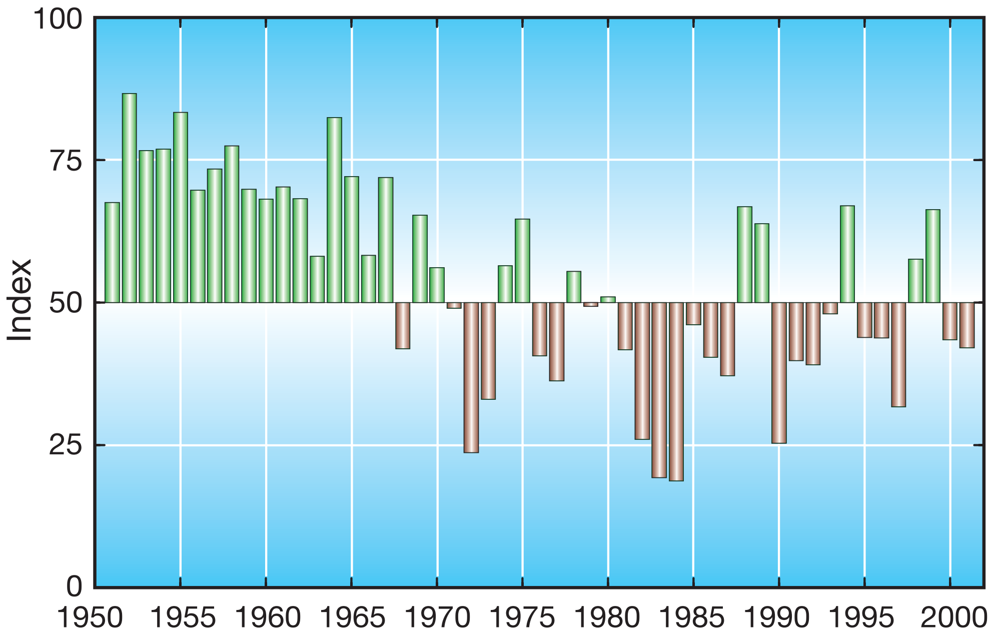
Crop production, protection and storage were addressed by 21 working groups. Five working groups dealt with agrometeorological forecasts, animal production and protection, and soil and land-use problems; four addressed observations and data management, and training and education, including GAMP. In the later part of this period, the Commission broadened its programmes to include climate change and variability, including forestry. In total, 58 working groups were established and their findings were made available to national meteorological and hydrological services (NMHSs) and other users of this information.

The WMO Congress and the Executive Council frequently expressed their satisfaction with the transfer of new knowledge and information to end users at the global, regional and national levels; this was especially important in developing countries.

Recent History – CAgM in the 1980s and 1990s

The 1980s

The recent history of CAgM is considered thematically. The gradual change in agricultural meteorology that continued in and through CAgM in the 1980s is represented in the reports of CAgM-VIII (Geneva, 1983), CAgM-IX (Madrid, 1986) and CAgM-X (Florence, 1991). It is again best assessed by the changes in its terms of reference, as



Rainfall variability, as illustrated by the June to September (rainy season) precipitation index for the Sahel (CPC, NOAA), is a major factor limiting agricultural productivity.

published in GAMP. As discussed, these changes had been started and prepared in the 1970s. It is very instructive to compare the terms of reference in GAMP of 1981 with those of GAMP Supplement No. 3 of 1993, which were approved at CAgM-X.

Immediately evident is a loss of formality, in line with the political and social changes occurring worldwide at the time. CAgM is no longer there mainly for informing "constituent bodies", "standardizing", dealing with "technical regulations" and "studying" meteorological aspects and developments of importance to agricultural meteorology.

No longer does the fourth term of reference have to be reached to find "soils, plants and animals and their enemies". They are replaced, directly in the first term of reference, by "cropping systems, forestry and agricultural land use and livestock management". Not only do meteorological developments in scientific and practical fields have to be followed, but also agricultural developments. The main practical issues are now to be found in the second, not the seventh term of reference, and CAgM's sole task of "providing advice" significantly has become "development of agricultural meteorological services of members and providing advice".

Other indicative changes are the use of "land management" instead of "land utilization", introducing "intensification of crop production" next to "increase in the area of agricultural production", adding to improved varieties of plants and breeds of animals that they should be "better adapted to the climatological conditions and their variability" and bringing into focus for action "the interactions between air pollution and vegetation and soil".

Prominent additions are "forestry and rangeland operators" as clients, "agrometeorological forecasts and warning", "meteorological aspects of desertification", "food aspects of fisheries", "methods, procedures and techniques for the provision of meteorological services to agriculture", "formulation of data requirements for agricultural purposes" and "introduction of effective methods for disseminating agrometeorological information, advice and warnings".

CAgM in the 1980s, with N. Gerbier (France) as president (1979–1985, when he died in office) and A. Kassar (Tunisia) as his successor (1986–1991), is characterized by further intensive development of this wider and more practical approach. While in the 1990s, with C.J. Stigter (Netherlands) as president (1991–1999), effort was devoted to providing more actual content in the "transfer of knowledge and methodology", looking at the dynamic realities of agricultural production, and on increasing participation of developing countries.

In line with the above it was in the early 1990s that GAMP included significant chapters on "Applications of Meteorology to Forestry", "Aerobiology", "Agrometeorological Aspects of Desertification" as well as "Weather and

Norbert Gerbier (France), fifth president of CAgM

Climate and Animal Production" that had been prepared in the previous few years.

Near the end of the 1980s "operational agrometeorology" and "economic benefits of agrometeorology" became main topics and "practical application of agrometeorology to demonstrate its importance in agricultural production" became a main goal. The Commission agreed that all activities under the Agricultural Meteorology Programme of WMO should contribute towards this objective. CAgM provides scientific and technical support for the implementation of AgMP.

The increasing participation of developing countries in the 1990s followed earlier developments of the Regional Training Centre for Agrometeorology and Operational Hydrology and their Applications (Niamey, Niger) (AGRHYMET); the Mali pilot project (for which expansion is still sought within Mali and outside); the introduction of roving seminars (from 1981 onwards); and the establishment of the Working Group on Microclimate Management and Manipulation in Traditional Farming and subsequent related rapporteurs (1983–1991). This culminated in 1986 when CAgM's president was appointed from a developing country.

In the second WMO Long-term Plan (LTP), for the period 1988 to 1997, six specific objectives were formulated in AgMP projects. The CAgM working groups and rapporteurs and the working groups on agrometeorology in the six regional associations were nominated to focus on the following objectives:

- Develop data for operational agrometeorology;
- Formulate relationships between climate/weather and agricultural production;
- Provide agrometeorological information to users for planning and operations in agriculture;
- Promote agrometeorology in drought- and desert-prone areas;
- Transfer knowledge of practical agrometeorological techniques;
- Promote interdisciplinary agrometeorological research.

A. Kassar (Tunisia), sixth president of CAgM

Participants in the ninth session of CAgM held in Madrid in November 1986

The 1990s

The third LTP (1992 to 2001), after CAgM-X (1991), placed the objectives outlined above within the context of a newly formulated challenge: "to be of service to sustainable agricultural production in the framework of sustainable development". This includes the protection of the environmental resource base itself, where it is used for agricultural production.

This additional priority was initiated by the realities of agricultural production; endangered by land degradation of various kinds, water waste and water pollution, air pollution, increasing climate variability and the possibilities of climate change. The president of CAgM in 1994 emphasized that "users of agrometeorological information should be the focal point of all our work".

This led to the following formulation of the main long-term objectives of AgMP in the fourth LTP (1996 to 2005) for the period after the eleventh session of the Commission (CAgM-XI) held in Havana in 1995:

- To promote economically viable and high quality production so that it can be sustainable and environment-friendly by strengthening members' indigenous capabilities to provide relevant meteorological services to agriculture and other related sectors;

- To foster a better understanding by farmers and other end-users in the agricultural, forestry and related sectors of the value and use of meteorological (including climatological and hydrological) information in planning and operational activities.

These objectives have to be continuously refined in the light of the realities of agricultural production occurring in the face of environmental degradation and social and environmental policies that frequently work against farmers.

In Geneva meetings of the presidents of the technical commissions in the 1990s, the then president of CAgM argued for the collection of quantitative case studies on impacts, economic benefits and social consequences of the different branches of meteorology addressed by the different technical commissions, to illustrate the importance of their fields of work. For agricultural meteorology such case studies have been collected, but not without enormous difficulties. They are fewer in number than might be expected, mainly because the methodologies for economic evaluation of agrometeorological services have been insufficiently developed.

The situation facing CAgM and agrometeorology in general in the mid-1990s could be split into two. In the industrialized world and in some parts of the newly industrializing world, intensive agriculture, in some cases including animal husbandry, had an accumulating deteriorative effect on the production environment and on soil, air and water quality. In addition, the issue of industrial output and waste, in various forms, effected some agricultural activities. Programmes started to be developed in the industrialized world to diminish inputs into agriculture and to reduce the damage from inputs used as well as from outside hazards.

In the developing world growing environmental hazards posed challenges with agrometeorological components: low external input agricultural production systems; increased climate variability; deforestation; wind erosion and desert encroachment; water erosion; more agricultural use of sloping lands; migration, due to environmental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Wind erosion on light soils can provoke severe land degradation (left) and sand deposits can affect crop establishment (right).

degradation or population increase, into areas of low agricultural potential and/or with a delicate equilibrium between population and land use; labour scarcity at crucial moments in the growing season and new insect pests. CAgM, through the science of agrometeorology and its applications, would have to guide the development of operational knowledge to cope with these new hazards and their consequences.

In the late 1990s at a WMO Executive Council (EC) meeting, the president of CAgM indicated that results on sustainable yield increases were already being shown via two main methods of management:

(a) The first was agroclimatological in nature – using microclimate management and manipulation for crop and soil protection at the small scale; and regional climate forecasting for the diversification of cropping and farming systems at the large scale;

(b) The second adopted an agrometeorological approach – on-line advice on sowing time within the ongoing rainy season on a country-wide basis; and irrigation scheduling from soil moisture data obtained from a combination of soil and crop water balances in a seasonal book-keeping process for particular crop fields.

At the middle or regional scale, these strategies encompass efforts such as sprinkling orchards to prevent flowers freezing when late nightfrost is forecasted and spraying locust breeding grounds when remotely sensed information indicates suitable vegetation growth for breeding.

At another EC meeting, the president reported that in the Western world the term "precision farming" had become established. This refers to reducing waste by better gearing inputs to actual conditions in the root zone. Some see this trend simply as a return to the old wisdom of knowing the land. In the developing world, in a parallel development, indigenous knowledge from agricultural fields and home gardens and their yield potential and exploitation was slowly getting the attention it had often been denied by conventional scientific thinking in agricultural research.

A reported consequence of this shift is that, in addition to multiple cropping with annuals, agrometeorology is paying more attention to tree crops (e.g., home gardens, traditional agroforestry, and new forms of cropping with shrubs/bushes and trees). Whereas thus far woody plants had been studied for productive purposes predominantly, the focus has started to shift to understanding their protective and supportive functions.

This trend has been initiated by non-governmental organizations, and has been picked up by groups of young scientists, some in developing countries, and sometimes with external support. This has consequences for CAgM and agrometeorology, considering the limiting factors in low and medium external input sustainable agricultural production in tropical and arid climates.

Kees Stigter (Netherlands), seventh president of CAgM, speaking during the twelfth session of CAgM in Accra

The definition of the role of CAgM, as a "Statement of Need" in a CAgM vision document of 1999, remained "to promote agrometeorology and agrometeorological applications for efficient, sustainable food, fodder and fibre production for an increasing world population in fastly changing environments". CAgM continues to motivate its members to supply all necessary agrometeorological services, such as agrometeorological advisories and relevant forecasts to agricultural communities, for improved planning and operational activities.

The developments in CAgM in the 1990s continued to require creative thinking and methodological and scientific support in the way described in the introduction. The current situation was reviewed at an international workshop held in Accra, Ghana, in 1999 (preceding the twelfth session of CAgM) – the findings were summarized in the introduction. The workshop showed that new technologies may be expected to continue to support and strengthen diagnosis potential, but that cures must come from human interventions that have to be organized with the support of agrometeorological services. To provide this organization, support and education were the challenges facing CAgM at the beginning of the twenty-first century.

It became clear that GAMP should reflect the agrometeorology developments and priorities generated in the 1990s. At the twelfth session, the Commission endorsed publication of a completely revised third edition. The revised terms of reference of CAgM, however, remained unchanged from their establishment in the 1980s.

Participants at the twelfth session of CAgM held in Accra in February 1999

The issues that confront CAgM are exceedingly complex by virtue of the diversity of disciplines (meteorology, agronomy, crop physiology, information technology) involved in the field of agricultural meteorology. The technical information that is produced by scientists must be appropriately channelled to extension personnel or directly to the farming community to achieve the desired results. The information must be disseminated well to ensure that the knowledge and expertise are utilized appropriately. The Commission must also be responsive to this diversity and recognize the need for evaluation and change in adapting to a rapidly evolving world. This brochure concludes with how it meets that challenge.

THE COMMISSION IN THE TWENTY-FIRST CENTURY

2000–2003

AgMP implemented six projects, the scope of which correspond to the terms of reference of the Commission, during 2000–2003: (a) agrometeorological applications; (b) use of climate forecasts in operational agriculture; (c) agrometeorological data management; (d) communication of agro-meteorological information; (e) agrometeorology of extreme events; and (f) agrometeorological adaptation strategies to climate variability and climate change.

Ray Motha (USA), eighth president of CAgM.

Since 1999, with R. Motha (USA) as president, CAgM has accomplished the goals set forth by the Commission at its twelfth session towards the implementation of the six projects. Five working groups and 11 joint rapporteurs completed their final reports. With additional co-sponsorship from national, regional and international sources, active involvement of member experts, and strong team leadership, CAgM provided scientific and technical support for additional activities that focused on the promotion of user applications of agrometeorological information. CAgM sponsored roving seminars and training courses. International workshops, conferences and expert group meetings were organized by CAgM and other co-sponsors. From these activities, publications, including technical notes, CAgM reports, an AGM report, training manuals, brochures, and proceedings were produced. Further, publication of two CD-ROMs, distributed to all CAgM members, has vastly enhanced the accessibility of information. The first set of CD-ROMs is a complete list of all the WMO agricultural meteorology publications. The second is a list of readily available public domain software for applications in agricultural meteorology. In a special issue of *Agricultural and Forest Meteorology* (Vol. 10, Nos 1–2, 2000), the proceedings of the international workshop held in Accra were published. A well-balanced agenda for the thirteenth session of CAgM was developed by the CAgM Management Group, and organized by the Secretariat, recognizing key issues of weather and climate as they relate to agriculture, forestry and fisheries that needed to be addressed during the following intersessional period. The thirteenth session of CAgM was held in Ljubljana, in 2002.

Prior to this session, the International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change was held, the proceedings of which appeared in 2005 in Volume 70 of *Climatic Change.*

The Commission's New Working Structure – Open Programme Area Groups

CAgM has responded well for 50 years to a broad range of tasks in agricultural meteorology through its structure of working groups and (joint) rapporteurs. In recent years, WMO began to scrutinize its technical

Participants attending the workshop on User Requirements for Agrometeorological Services in Pune, India, visit a greenhouse experiment.

Participants at the thirteenth session of CAgM held in Ljubljana in October 2002

PROJECTS IMPLEMENTED BY THE AGRICULTURAL METEOROLOGY PROGRAMME FROM 2004

1. Agrometeorological Services for Agricultural Production

This project envisages provision of assistance to members in improving their agrometeorological services, including services for agricultural production. Members are provided with guidance and advice, particularly through CAgM, on the improvement of early warning and monitoring systems, short- and medium-range weather forecasts for agriculture and agrometeorological aspects of land and water management in agriculture. Emphasis is placed on promoting the more active use of seasonal to inter-annual climate forecasts in agricultural planning and operations in active collaboration with the Climate Information and Prediction Services (CLIPS) Programme.

Expert emphasis in the guidance provided by CAgM is placed on issues such as strengthening relevant observation and information networks and dissemination of information through advisories and warnings. Case studies for developing policy support systems are encouraged and assisted as appropriate. Recommendations on strategies to adapt to climate variability and climate change, and to achieve improved water management and protection and use of tropical forests, are provided. Emphasis is placed on the provision of training, education and extension support systems for the provision of improved agrometeorological services through technological transfer, better methods, procedures and techniques for disseminating agrometeorological information and awareness and training for disaster mitigation and climate disaster prediction. One of the major activities in this project is on weather, climate and farmers, where a bottom-up approach to the full involvement of farmers is envisaged to ensure that the agrometeorological methods and procedures developed and used will adequately respond to the needs of farmers.

2. Support Systems for Agrometeorological Services

Under this project, guidance is provided, with the active participation of CAgM, on the development by members of support systems for agrometeorological services, including the use of GIS and remote sensing for sustainable land management and agroclimatic zoning.

Expert group meetings and the organization of training activities on applications of GIS, agroecological zoning and crop modelling are envisaged. Guidance and advice is provided to members on the validation and application of crop simulation models and other research results at the national and regional level.

3. Climate Change/Variability and Natural Disasters

This project envisages promotion of, and assistance in, evaluation studies by members of the impacts of climate change/variability and natural disasters on agriculture. Relevant guidance and recommendations are provided, together with guidance and recommendations on measures to help reduce the contributions of agriculture to global warming and measures for the prevention and mitigation of the effects of droughts, floods and other extreme events in agriculture and forestry. Meetings of expert groups and regional workshops on agrometeorological impacts and other related topics are organized by the Secretariat, together with roving seminars to disseminate the results of these workshops.

commissions to determine if there were more efficient ways of organizing the working structure. The basic premise was that the fixed working group structure was no longer the most appropriate. There was a need for a more effective, flexible and responsive structure that could focus on well-defined tasks identified by the commissions. The new dynamic and proactive structure is called Open Programme Area Groups (OPAGs).

At its thirteenth session, CAgM adopted the new structure, establishing three focal OPAG areas, each with operational and research accountability. These OPAG areas are:

(a) Agrometeorological Services for Agricultural Production;

(b) Support Systems for Agrometeorological Services; and

(c) Climate Change/Variability and Natural Disasters in Agriculture.

Within each OPAG are Expert Teams (ETs) and an Implementation Coordination Team (ICT). The ETs are convened for developing proposed solutions to scientific/technical problems and for studying issues for which specific expert knowledge is needed.

OPAG 1 (Services) focuses on operational and research activities that promote (services to) agricultural production. OPAG 2 (Support Systems) concentrates on all service support systems including network observations, data and information management, and technical support needed to advance the science of agrometeorology. OPAG 3 (Impacts) deals with priority issues affecting agriculture such as climate change, climate variability and natural disasters. For OPAG 1, ETs include: "Weather, Climate and Farmers", "Strengthening Information and Dissemination Networks, Including Monitoring and Early Warning Systems" and "Management of Natural and Environmental Resources for Sustainable Agricultural Development". For OPAG 2, ETs include: "Techniques for Agroclimatic Characterization and Sustainable Land Management", "Database Management", "Validation and Application of Models" and "Research Methods at the Ecoregional Level". For OPAG 3, ETs were convened for: "Impact of Climate Change/Variability on Medium- to Long-Range Predictions for Agriculture", "Reduction of the Impact of Natural Disasters and Mitigation of Extreme Events in Agriculture, Forestry and Fisheries" and "Contribution of Agriculture to the State of Climate".

The ICT is comprised of membership from all WMO regions with additional members invited to provide a source of expertise on major technical issues. The ICT is familiar with implementation issues at the regional level and coordinates specific results of the ETs, including capacity-building measures. Oversight of the OPAG activities comes under the Management Group that has a strong, active and pivotal role in guiding CAgM's activities between sessions. It is responsible for ensuring the integration of the programme areas, for strategic planning issues, for the evaluation of the progress achieved in the agreed work programme and for related necessary adjustments to the working structure in the intersessional period.

M. V. K. SIVAKUMAR

Land degradation is a major threat to sustainable agriculture around the world.

PRIORITY AREAS OF THE COMMISSION FOR AGRICULTURAL METEOROLOGY

There are some basic mission goals and objectives that form a permanent mandate of the Commission for Agricultural Meteorology. Ultimately, the Commission is committed to promoting a substantial role for operational agrometeorology in an effort to sustain and increase agricultural development and food production, especially in the developing world. It is important to ensure that the benefits of agrometeorological services reach as many potential agricultural users of operational information in the farming communities as possible, not only by improving the extension systems but also the scientific resources and information transfer systems in the developing world. To achieve this goal there are several requirements.

The role of early warning and advance planning for natural disaster management and the mitigation of extreme weather/climate events is crucial not only for agriculture but also for human well-being. The application of weather and climate information to improve the effectiveness and efficiency of emergency preparedness and response activities is essential. There is a need to monitor critical thresholds that should trigger early warnings. It is essential to survey the status of trends in land degradation and to report on appropriate criteria to conserve and manage material and environmental resources for the benefit of agriculture, forestry and fisheries. The objective is to establish practical guidelines, from the agrometeorological perspective, for the conservation of natural and environmental resources in harmony with agricultural production systems.

Improved methods, procedures and techniques for the dissemination of agrometeorological information need to be utilized operationally. Rapid advances in information technology need to be rapidly transferred to operational applications to more effectively disseminate agrometeorological information to the user community. There needs to be full involvement of all users of the information as well as the providers of the information to ensure that the right information is delivered to the right user at the right time for operational agriculture. Thus the objective is to identify the information gaps and establish guidelines and procedures to improve the flow of timely and accurate information to farmers, including both monitoring and early warning systems.

There is clearly a need to improve and strengthen agrometeorological observation networks to support data collection for operational applications and applied research in agricultural meteorology. Many established networks are falling into disrepair due to lack of sustained funding for their maintenance and operation. Moreover, shifts in cropping patterns and emphasis on vulnerable regions necessitate the deployment and operation of modern equipment, including automated weather network technology, for data collection and transmission. Here, the objective is to develop recommendations for more effective communication, dialogue for training and demonstration between agrometeorological services and farmers in the proper use of information for crop, livestock, forestry and fisheries management. In developing countries these are most often public services but in the industrialized world commercial undertakings play an increasing role in information collection and delivery.

Technological advances in remote sensing (hand-held and space based) such as soil moisture detection and evapotranspiration

estimations constitute new sources of data for many agrometeorological applications. These not only complement ground observations but also offer new types of data, provide greater global coverage and improve aerial averaging. Regional and global cooperation can help countries that lack the financial and technical resources to acquire such data. As indicated earlier, recent technological advances in GIS offer significant improvements in spatial analyses of meteorological and agricultural databases. Agroecological zoning offers the potential for developing strategies for efficient and sustainable natural resource management, including sustainable management of farming systems, forestry and livestock.

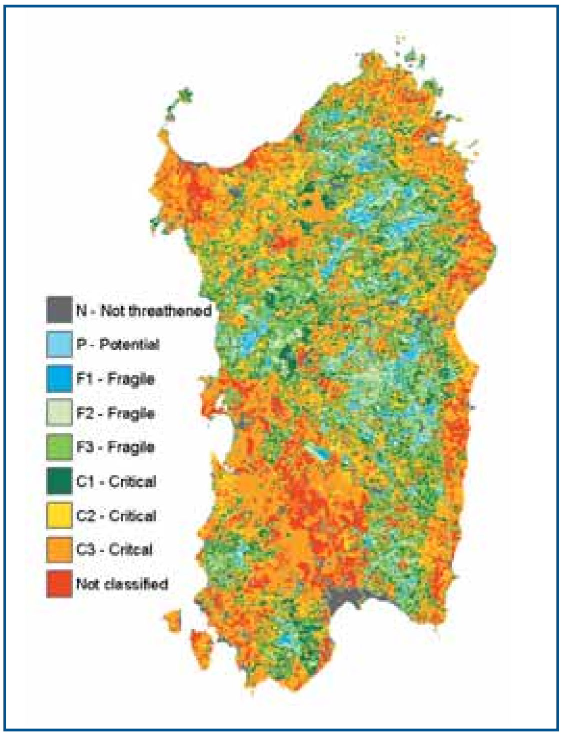
Substantial research and development has occurred in the application of crop models ranging from the field level to country level and even larger scale modelling. Various modelling techniques range from statistics-based regression analysis to more complex process-oriented approaches. Models are also used in global changes impact studies. Recommendations are needed on how to develop an integrated information management system with computer technology and standardized analytical techniques that can be applied operationally for validation of selected models in agriculture, rangelands, forestry and fisheries at the ecoregional level.

There is a need in many agricultural areas around the world to enhance the understanding of climate variability in order to be able to assess the impact of and the distinction between causal factors, both natural and human, for climate change, drought and desertification. A better understanding of the climate of the major ecosystems of the world where biological diversity is at risk could help develop effective in situ conservation strategies. There also needs to be a thorough understanding of the effects of changes in regional climate on deforestation and their impacts on biological diversity.

One of the persistent demands of agriculturists is for reliable forecasts of seasonal climate information to make appropriate decisions as to which crops and cropping patterns to choose well ahead of the growing season in order to avoid undue risks.

Agrometeorologists need accurate and reliable climate forecasts to assist the agricultural community in planning and operations. The Commission must keep its members appraised of current capabilities in the analysis of climate change/ variability and long-range prediction studies as they specifically relate to agriculture, rangeland, forestry and fisheries at the national and regional levels for appropriate applications.

Climate change and other changes in all sectors of agricultural production necessitate the adoption of measures that must be economically feasible. Such measures could improve resilience of agricultural production systems to weather variability but do not necessarily reduce emissions from the agricultural sector. To serve the agricultural sector, the Commission needs to thoroughly review the interactions between greenhouse gas emissions and agricultural activities. The Commission needs to document both positive and negative influences of agriculture on weather and climate systems; and develop guidelines for increasing awareness within the farming communities of the related adaptation/



Geographical Information Systems (GISs) can integrate diverse datasets to make agroclimatic maps such as this one depicting areas sensitive to desertification in Sardinia (Montroni and Canu, 2005).

mitigation strategies to address climate change and poverty issues.

Issues that are of direct relevance to agrometeorologists include improved and more efficient fertilizer use, water conservation, crop water management related to more efficient use of water, crop adaptation to rainfall variability, growing of alternative crops and improved ruminant feeding. These issues have to be balanced against the traditional production issues in each region.

There are a number of common issues. Automated weather station technology, data management, natural disaster prevention and mitigation, the impact of climate variability and climate change and revision of guides are issues common to a number of technical commissions. CAgM is addressing each of these issues either in expert group meetings or workshops. In response to the importance of natural disaster reduction, there is a pilot project for a Joint Programme to Contribute to Natural Disaster Reduction in Coastal Lowlands. Natural disaster reduction affects all scientific and technical activity. With the importance of agriculture along coastal lowlands in many countries, CAgM is aware of and involved in this issue. The Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) and CAgM are exploring possibilities of an expert team focusing on this topic.

The revision of GAMP is of utmost importance. A new expert team has been convened to organize and coordinate the revision of current chapters and the preparation of new draft chapters. Quality management issues are being evaluated by the Inter-Commission Task Group on WMO Quality Management Framework (QMF). The president of CAgM is a member of this task group. This important issue of quality management will also be addressed in GAMP.

THE FUTURE OF THE COMMISSION

Key to future activities of the Commission for Agricultural Meteorology will be how to take advantage of the rapid innovations in technology for the benefit of agriculture, rangeland, forestry and fisheries, especially at the local operational level. Farmers urgently need timely and accurate weather and climate information for operational decisions. The application of meteorological knowledge, ranging from assessments and advisories to long-range forecasts, greatly assists the agricultural community to develop and operate sustainable agricultural systems and to increase agricultural production in an environmentally sustainable manner. At a time when there are growing concerns for achieving greater efficiency in natural resource use while conserving the environment, there is also a greater emphasis placed on understanding and exploiting climate resources for the benefit of agriculture and forestry.

The diverse user community ranges from farmers to national and international planning agencies. The demand for information by user communities has increased dramatically owing to the recognition of the importance of agroclimatic information for decision-making, to increased economic pressures, natural resource conservation and environmental concerns, and to greater availability of technological resources. The agroclimatic information base is not only needed at the farm level for daily tactical decisions on planting, weeding, integrated pest management, disease control by efficient spraying and harvesting, but also for long-term strategic decisions at the national and international levels concerning poverty alleviation, marketing, global variability and risk management.

CAgM has already undertaken steps to expedite the utilization of information and communication technologies for the benefit

WAMIS – WORLD AGROMETEOROLOGICAL INFORMATION SERVICE WWW.WAMIS.ORG

Disseminating agrometeorological information is part of a process that begins with scientific knowledge and understanding and ends with the evaluation of the information. But, in order for this information to be useful, it must be accurate, timely, and cost-effective. The Internet can accomplish this since vast amounts of timely information can found with one click of a mouse button. Additionally, the Internet can play a vital role in the training of agrometeorologists by providing useful knowledge to a large number of people in a cost-effective manner.

During an Inter-Regional Workshop on Improving Agrometeorological Bulletins organized by the World Meteorological Organization (WMO) in Bridgetown, Barbados in October 2001, participants developed the concept of a dedicated web server for agrometeorological products. As a follow up to this recommendation, the Commission for Agricultural Meteorology (CAgM) organized an Expert Group Meeting on Internet Applications for Agrometeorological Products held in Washington, D.C. during May 2002. Following these meetings, the World AgroMeteorological Information Service (WAMIS) was created and was operational in December 2003.

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 can be in the form of a web page or PDF. Provision of a central location for agrometeorological information can help the users quickly and easily evaluate the various bulletins and gain insight into improving their own bulletins. Also, WAMIS provides tools and resources that were compiled from different sources or developed specifically for WAMIS which includes links to useful available software, guides, web portals, training resources, and tutorials.

of its members. One recent initiative is the World Agrometeorological Information Service (WAMIS).

It is important to recognize that there is a wide range of needs for agrometeorological information and products and great variation between regions. New and effective communication procedures that are currently coming on stream can respond to the varying requirements and capabilities of farmers across different countries and regions. There is clear recognition of the importance of feedback mechanisms between the producers and users of agrometeorological information.

The focus of future efforts in agrometeorology is likely to be centred around the following aspects:

(a) In relation to Internet information technology in the provision of agrometeorological information for field applications, there is a need for a multi-disciplinary approach, keeping in mind the user requirements and region-specific needs. Training and capacity-building programmes must be an integral part of this development.

(b) There is a need to reinforce training in the fields of agrometeorology, remote sensing, specialized software and GIS, especially regarding the new and rapidly developing information technology for agrometeorology.

(c) As in the past, there will be a continuous need and challenge to promote the collection and collation of high quality, long-term continuous data sets and to ensure that data are complete and free from systematic or random errors. There is a continuing need to overcome spatial gaps in data, especially in regard to natural disaster monitoring and early warning systems.

(d) Enhancement of the communication channels for the improved dissemination of agricultural meteorological information should take into account the literacy levels of users, socio-economic conditions, level of technological development and accessibility to improved technology and farming systems.

(e) Strategies for strengthening information and dissemination networks for developed and developing countries must take into account the differences that exist in their resources and skills. Existing systems for the dissemination of agrometeorological information in the developed world, such as facsimile, e-mail and the Internet, should take advantage of broadband channels for high speed and integrated dissemination of information. Mobile phones and wireless access offer the greatest potential for rapid dissemination of early warning alerts and operational decision-making at the farm level.

(f) In the developing world, lack of resources and skills are the basic limitation to enhanced web-based dissemination of information. Hence, all efforts should be made to employ the most feasible and cost-effective technologies, especially rural radios, to bring monitoring and early warning networks to rural communities. Considering that more than 90 per cent of rural communities have access to radios, it is recommended that regular and systematic use should be made of this communication channel to disseminate information and early warning alerts. Empowering rural communities to decide on the content and the frequency of information bulletins and alerts on the radio, e.g. RANET, could help maintain sustained interest in obtaining and using agrometeorological information.

(g) Innovative strategies for the dissemination of agrometeorological information and early warning should be developed to take advantage of the increased use of mobile phones by rural communities. New and exciting prospects of wireless technologies for meteorological sensor output should be combined with this communication channel to rapidly deliver not only agrometeorological information, but, more importantly, early warning alerts.

(h) Operational agrometeorological information in the form of bulletins and advisories, transmitted and archived on the WAMIS web servers, will be seamlessly available to all members. Training modules will be also available on the host servers for operational applications. For effective linking of national products through WAMIS to end-users, advantage should be taken of new middleware tools such as “MetBroker”.

(i) In view of the rapid pace of development of information and communication technologies and their applications in agrometeorology, it is recommended that seminars and workshops be conducted in selected regions, especially in the developing world, to enhance the capacity of NMHSs to rapidly deploy, in a way adapted to their conditions and target groups, new technologies for strengthening their information and dissemination networks.

(j) Affiliated organizations, such as FAO and the International Society for Agricultural Meteorology (INSAM), will play an important role in jointly promoting the above developments in agrometeorology.

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