Report of Expert Team on Communication of Agrometeorological Products and Services for Sustainable Agriculture.

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Chapter One Introduction Peter Hayman, Leader ETCAPS

1.1 Background and overview of communication in the broader field of agrometeorology

This report from the Expert Team CAPS builds on the Working Group on the Communication of Agricultural Information, Perarnaud et al (2004) and other major reports such as the workshop on Improving Agrometeoroligical Bulletins held in Barbados 2001 (Sivakumar 2002) and the meeting of the CagM implementation coordination team on support systems for agrometeorolgical services held in New Dehli, India 26-28 February 2009.

An overview of the steady increase in an emphasis on communication of agrometeorolgical services is provided by the WMO (2006) document on the Commission of Agricultural Meteorolgoy – the first fifty years. At the risk of over simplification, the early years of the commission most of the emphasis was on the science and standardisation of measurement technology in the field of agrometeorology much of which were harnessing the advances in environmental physics.

The WMO (2006) outlines some of the key developments: CagM-VI held in 1974 responded to the World Food Conference (Rome, 1974) with an emphasis on food production in developing countries. The emphasis seems to have been primarily technical with a task force on Crop-Weather models. At the next CagM-VII 1979 there were a number of reports on training seminars and symposia. In the 1980s there was a call for *"effective methods for disseminating agrometeorological information, advice and warnings"*. By 1994 the president of CAgM stated that *"Users of agrometeorolgical information should be the focal point of all our work"* there was also a request for quantitative case studies on impacts and economic and social benefits of agrometeorology.

As summarised by Sivakumar (2001) the challenge for the 21st Century is clear. The urgent need to increase food production without degrading already fragile resources and with a variable and changing climate focuses attention on timely and effective agrometeorological information. He noted the need for *"reorientating and recasting meteorological information, fine-tuning of climatic analysis and presentation in forms suitable for agricultural decision making"*. He also noted the revolutionary changes in Information and Communication Technology, not only in developed countries, but particularly in developing countries.

The report from the Working Group on Communication of Agrometeorological information in 2004 recognised the plurality of providers of agrometeorolgical products and services such as NHMS, universities, public-private partnerships, private companies. They also drew attention to the many users of agrometeorolgical information from policy makers, industry, farm advisers and farmers. An interesting conclusion was that the same decision maker might want operational or tactical information one day and strategic information the next. The way the information is communicated matters and it is different for different decision making. For example operational decision making about spraying for a disease has to be immediate and is best suited to the internet whereas information on strategic response to climate change can come in the post Perarnaud et al (2004). As we will discuss in this report, developments such as WEB 2.0 emphasise the interactivity of the internet over the immediacy. This might make the internet a powerful tool for considering the impact of climate change but also to add meaning to short term forecasts.

For the purposes of this report we define communication as the reciprocal clarification of meaning between interacting people. We recognise the dramatic changes in information communication and technology, but in both developing and developed countries, these technologies are tools, communication still happens between people.

1.2 Terms of Reference

(a) To review the current means of communication of agrometeorological products and services to the farming sector in different regions, e.g. WAMIS;
(b) To identify the needs for improving the current systems of communication of agrometeorological products and services for promoting sustainable agriculture;
(c) To evaluate the feasibility of implementing new and/or appropriate tools for communication and dissemination of agrometeorological products and services and promote their application;
(d) To assess the socio-economic and environmental impacts of these new tools on agriculture in different regions; and
(e) To prepare reports in accordance with timetables established by the OPAG and/or MG.

The ETCAPS were able to meet in Toowoomba, Australia on 21 May 2009 following the International Workshop on the Content, Communication and Use of Weather and Climate Products and Services for Sustainable Agriculture 18-20 May 2009 at the University of Southern Queensland, Toowoomba. All members were able to attend; Almaz DEMESSIE RA I (Ethiopia); K.R. KIM RA II (Republic of Korea); Edgar IMAÑA RA III (Brazil); Harlan SHANNON RA IV (USA); Neal MOODIE RA V (Australia); Walter TRAMPF RA VI (Germany) and Peter HAYMAN RA V (Australia) as Leader.

1.3 Key sources of Information to address the terms of reference

Organisation of the report

This report consists of seven chapters. The first and last chapter are written by Peter Hayman who edited chapters two to six where team members took different but overall consistent approaches to addressing the terms of reference. Chapter seven is an attempt to bring the findings together and to conclude with some recommendations for the Commission of Agrometeorolgoy.

Past experience of Expert Team

As with all Expert Teams, the primary source of information was the expertise and experience of the team. We were fortunate to have a mix of members employed by National meteorological and hydrology services: IMAÑA, Servicio Nacional de Meteorolog¡a e Hidrologia, Bolivia; TRAMPF, Deutscher Wetterdienst; KIM, National Institute of Meteorology Research (NIMR)/KMA MOODIE, Australian Bureau of Meteorology and DEMESSIE National Meteorological Agency, Ethiopia. In addition we had two members employed by Agricultural agencies but with training in meteorology, SHANNON, US Department of Agriculture and a background in climate applications, HAYMAN Primary Industries and Resources of South Australia. All members had involvement with meteorological information and agricultural users of the information.

Formal and informal surveys of members of each WMO region

Expert Team members were able to draw on surveys from members of their regions but the response rate tends to be sporadic and low. In RA I, the communication

challenge is highlighted by the difficulty in collating activities despite considerable effort by Almaz Demessie. In some cases specific cases studies were used (eg Fiji and Samoa for RA V) and in other cases such as RA III, IV and V considerable additional information was gleaned from websites of relevant organisations.

Meeting of ET CAPS in Toowoomba 21 May 2009
As mentioned in the brief overview of the terms of reference, this team met in Toowoomba on 21 May 2009. The rapateur for the meeting was Dr. M.V.K. Sivakumar Chief, Agricultural Meteorology Division WMO who was able to translate from English to Spanish, provide guidance and contribute from his knowledge and interest in communication in developing and developed countries. We were also fortunate to have Dr L.S. Rathore, Vice-President of CAgM, and Head of Agrometeorology, India Meteorological Department.

International Conference on the Content, Communication and Use of Weather and Climate Products and Services for Sustainable Agriculture 18-20 May 2009 at the University of Southern Queensland, Toowoomba.
The workshop brought together members of two CAgM Expert Teams. The Communication of Agrometeorological Products and Services (ETCAPS-OPAG 2) and the Content and Use of Agrometeorological Products by Farmers and Extension Services (ETCUAP-OPAG 1) led by Professor Roger Stone from University of Southern Queensland. The workshop was also attended by Dr Sivakumar and Mr Stefanski from WMO, Dr Jim Salinger President of CAgM and Dr Rathore Vice President of CAgM along with a range of international experts on the production and communication of agrometeorological products and services and sustainable agriculture.

Each member of the team was able to present at the conference. The title of the presentations with their URLS are listed in the references. The presentations provided an opportunity for formal and informal feedback. In addition to the presentations by the two Expert teams (ETCAPS and ETCUAP) there were many relevant presentations from projects in Australia climate information for the sugar industry, the peanut industry and extensive grain and livestock farms. Projects addressing climate risk in small Pacific Island states, the use of climate information for policy decisions on rice importation to the Philippines and work with small holder farmers in the Philippines. There were also presentations on WAMIS and RANET as well as programs such as Water and the Land and the Managing Climate Variability program in Australia and a number of agrometeorological delivery projects in New Zealand.

The workshop concluded with a three working groups and a final plenary session. The working groups were as follows: WG 1 - Agrometeorological Products and their Applications for Farmers and Extension Services WG 2 - Effective Communication of Weather and Climate Products for Farmers and Extension Services and WG 3 - Enhancing Interactions between Weather and Climate Services and Farmers. We were specifically encouraged by Dr Jim Salinger to use the findings of the Toowoomba conference and the working groups recommendations in our report.

Literature on communication of agrometeorological information
This report is not a review of the substantial literature on communication of agrometeorolgical products and services – rather it should be read as a series of inventories (albeit an incomplete one) and a brief analysis of how well different approaches work and what could be done better. For the analysis we have drawn on some of the available literature.

Chapter Two. RA I Almaz Demessie (Ethiopia)

2.1 Introduction

A considerable effort was made to communicate to meteorological offices of RA-I to finalize this report , however with the exception of few countries like Sudan, Mozambique, Ethiopia and Tunisia, it was difficult to get respond on time from the rest of RA-I counties. However, agro meteorological practices are similar in most RA-I counties. With the exception of few RA-I countries, most of the meteorological services in Africa have independent agrometeorological services. The major role of Agro meteorological units is to provide agro meteorological products including routinely published bulletins in ten day, monthly and a seasonal basis for agricultural, water and environmental sectors of Governmental, Non Governmental and UN bodies, and other related concerns. Nevertheless, in some countries there is a high staff turnover due to unfavorable working environment, which result in well-experienced agro meteorological staffs and other meteorological scientists, leaving the meteorological offices to join other institutions.

Major stakeholder and customers of the services are government offices like ministry of agriculture, ministry of water resources, higher official, decision makers, agricultural research institutions, livestock and fisheries, Non Governmental Organization (NGOs), UN offices, Community Based Organizations(CBOs), farming communities, media, etc.

The frequency and severity of extreme weather events such as drought, floods, pest/disease out-breaks due to unfavorable weather has increased the demand for Agrometeorological information and services from the National Meteorological and Hydrological Services (NMHSs). The farming communities show an interest for agro meteorological information and services to cope with climate variability and minimize losses in agricultural production. Significant efforts have been made in the field of agro meteorology in terms of data collection, archiving and analysis and their transformation into information that can be benefit to the farming communities. However, use of this information in most parts of RA I countries remains minimal due to communication barriers. There needs to be greater interaction with the user communities in assessing the appropriate dissemination and communication procedures that can be enhance the value of the agro meteorological information and services.

As can be seen from WAMIS website (www.wamis.org) some countries of RA-I like Gambia, Burkina Faso, Mali, Niger and Senegal have Multidisciplinary Working Group (MWG) which provide written summaries on the meteorological situation, crop condition, crop pest/diseases, pasture conditions including water sources and animal movement and health, forestry, fishing, and agricultural markets. In most cases of NMHSs the Agro meteorological Services provides Weather Summary, Maps of Rainfall and Percent of Normal Rainfall, Weather Outlook, Vegetation Condition and Impact on Agriculture, and Expected Weather Impacts on Agriculture in ten days, monthly and seasonal basis. Some of them provide written summaries on the general meteorological and crop situation (summery of crop phenology report and NDVI), including graphs and tables which contains the summery of weather and agro meteorological analysis(values of ETo, moisture index, soil temperatures, wind, humidity, and solar radiation, extreme values of rainfall, maximum and minimum temperatures).

2.2 ToR a) Means of communication of agro meteorological products and services to the farming sector in RA-I region

Some countries like Ethiopia all types communication system is available such as website (WAMIS, RANET and others), e-mail, radio communication systems, TV, cellophane, wireless telephone, Fax, seasonal seminar to discus with users (stakeholders and costumers) about the seasonal meteorological and agro meteorological forecasts, etc. These days' farmers are keen to use weather information for their day-to-day activities in some areas. Mainly they are using radio programs transmitted through FM, SW and MW. Some farmers have TV and they can get weather information everyday to determine sowing dates, harvest decisions and early warning of extreme events like pest outbreak, flood, landslides and the like. Some farmers are using agro meteorological information through their respective extension agents, which have access to get information from website like WAMIS, RANET, NMA website and others. Some of extension agents are receiving agrometeorological bulletin through their respective organization so that they can transmit the information to the farmers, and can discus with the farmers in the area of their interest. There is also a radio programs providing advice to farmers.These stations use agrometeorological products including interviews transmitted from NMA agrometeorological section every time. In case of Mozambque their main means of communications are Internet (email, website), mass media; seminars, fax and RANET (Radio & Internet) for disseminating agro met information to rural communities. Besides, they have planned to use WAMIS in the near future because they believed that it is a good tool for communication of agro meteorological products and services. In Sudan, they are not providing agro meteorological products and services directly to the farmers. However, they are disseminating their products to governmental institutions such as Ministry of Agriculture and Forestry and some of agricultural centers. With regard to the conditions of Tunisia using website, SMS, Radio, TV and using mail for special bulletin according to a convention with the Regional Institution for agricultural development institution in the region of Nabeul Tunisia.

2.2 ToR b) The needs for improving current systems of communication of agro meteorological products and services for promoting sustainable agriculture.

- Capacity building in terms of human and material resources in order to improve the status of agro meteorological products, there by providing sound advisory services to the users.
- Promote and upgrade RANET communication system in terms of area coverage, because, the system could reach at grass root level i.e. in rural areas.
- Promote roving seminar to create awareness among users about the importance of agro meteorological products
- Improve net work of rain gauges in remote and sensitive rural areas.
- Facilities of meteorological stations at district level in terms of material resources like computers to disseminate information via SMS.

2.3 ToR c) The feasibility of implementing new and/or appropriate tools for communication or what are the challenges in implementing the new and emerging tools

- The main challenges in Ethiopia and Sudan is there is no multidisciplinary activities among institution so that there is no interface to understand each other i.e. interpretation of the products is the problem which exists in the user

side while there is no sufficient system to know the needs of the users is the challenge in NMA's side.

- In most RA-I countries poor and vulnerable farmers not have a means to use new tools particularly in rural areas due to poverty. Therefore, farmers exposed to different weather/climatic hazards in most cases.
- In most RA-I there is no sufficient decision support system to perform appropriate copping mechanisms at the time of occurrence of unfavorable weather/climatic situation and extreme events like drought, flood, land slide and the like
- In some counties of RA-I sometimes the media people transmit outdated agro meteorological information unknowingly due to awareness problem. There are also awareness problems to the systems among users in terms of understanding and interpreting agro meteorological information.
- In most RA-I countries less attention has been given for traditional knowledge, which could easily modified and practiced by farmers.
- In some counties no computers in the stations at district level e.g. Mozambique

2.4 ToR d) The socio-economic and environmental impacts of the new tools, and institutional arrangements on agriculture in different parts of RA-I countries

Some farmers in Ethiopia have a tendency to use agro meteorological information for their day-to-day activities. As they start to feel the impact of climate variability and change they are keen to use weather/climatic and agro meteorological products for their decision support system. In Mozambique improved access to agro meteorological products and services resulting in the improvement of crop production and /or yield, socio-economic level of living of population and reduction of impacts related to the effects of climate variability and change. As we informed by Sudan Agro meteorological Information System (SAMIS) using new tools of communication which will have a significant positive impact on past delivery of agricultural products and on the socio-economic livelihood of the farming community and the environment.

2.5 Activities of international organizations and NGOs in terms of Agro meteorological Communications

Agro meteorological information used for decision-making in day-to-day activities of farmers. Besides the information comprises other agro meteorological data which can be useful for scientific research. However, this information has value when they disseminated in a way that the end-users get the maximum benefit in applying its content. Although modern technology has improved agro meteorological information and increased the number of end-users, continued improvements are necessary to ensure that the content of the information is adequate to fulfill the requirements of the farming communities. Develop an African training program of communicators to get the best products to the end users. The target communicator includes journalists, meteorologists, agriculturalists, extension agents and NGOs. NGOs provide an increasingly amount of early warning and food security information at sub-national level. They are especially important in complex emergencies where government information services have collapsed. As indicated in FAO's Emergency Activities: Technical Handbook Series (2000 cited in http://www.fao.org), FAO's Global Information and Early warning System (GIEWS) monitors all aspects of food supply and demand and food security at global, regional/sub regional, national and sub-national levels. Its main objective is to provide early warning of imminent food crises to ensure timely interventions in countries or regions affected by natural or man made disasters. FAO plays a great role in providing products like satellite images and products derived from satellite data (NDVI pictures, RFE and WRSI products) which

are useful to enrich the quality of agro meteorological products particularly in areas where there is no sufficient ground information. Besides, FAO plays a great role in terms of capacity building in all aspects (training, provision of crop/weather model software and computers, etc to enhance the activities of agro meteorology in the region) in Africa. Moreover, other international organization like WFP, UNHCR, OCH, etc plays great role in providing information in terms of food security directly or indirectly.

2.6 Conclusion

Since agriculture is the powerful engine of African economy and it provides food and income to the vast majority of the people in African, using Agro meteorological information in the sector has supreme importance to establish sustainable food security in the Region. Moreover, using agro meteorological information has paramount importance in order to cope more effectively with climate variability and minimize losses in agricultural production. The ultimate goal of using all agro meteorological and agro climatological information is to improve and protect the livelihood of farmers in terms of increasing yield quality and quantity, there by establishing self sufficient economy in agricultural sector.

Chapter Three RA II Edgar Imana (Bolivia)

3.1 Introduction

South America has a long tradition of producing agrometeorological information as opposed to weather and climate information that is useful for agriculture. Different products reflect different organisations and different issues

3.2 Case studies for different regions

Argentina produces information on daily, 10 daily and monthly basis. On a daily basis it provides an outlook of weather information for agriculture and the risk of fire. Every 10 days an agroclimatological newsletter is produced along with a water balance and map of Standardized Vegetation Index. Every 15 days there are updates on the status of soil moisture and the development of the main crops. On a monthly basis a monthly agroclimatic bulletin and a newsletter with climate trends are produced.

In Bolivia a monthly newsletter has maps of meteorological elements, frequency of frost, agrometeorological indices, drought warning and the likelihood of flooding. In Brazil there is a considerable effort on water balance, including water balance for different cultural practices. A sequential water balance is updated using the method of Thornthwaite & Mather (1955). In addition to the water balance there is the estimated risk of damage to crops and thermal comfort index for livestock.This information is distributed by the internet and agroclimatological newsletters

In Colombia an agrometeorological bulletin has weekly forecast of each region with an emphasis on rainfall. In Chile there are wether forecasts for each agricultural region. In Equador an agrometeorological bulletin details rainfall and temperature trends and forecast for each region. In Peru a monthly newsletter covers agroclimatic information with an emphasis on drought monitoring. In Uruguay the agrometeorolgical bulletin focuses on precipitation but also covers precipitation and wind. In Venezuela the bulletin has estimates of monthly rainfall presented in maps that include agricultural regions.

3.3 Conclusions

There is an increasing demand from agro-meteorological information and products for farmers (both small holders and managers of large estates). The importance of this information is most evident when there are extraordinary phenomena as for example the presence of an El Niño event.

The information is supplied by electrical means in most countries. There is an increasing demand for data on a weekly or 10 day period rather than monthly.

The method most currently used to provide agrometeorological information is the Internet. However in many countries, this does not reach the farmer in more remote areas. The major means of wider dissemination for this sector is through radio and some sectors television. Direct distribution is done through print newsletters extension agents, agricultural and municipal agents. In recent times the focus of many groups has been on meteorological information with less emphasis on agrometeorology. There is a shortage of skill in this area. The WMO has an important role in improving this activity either through seminars and workshops and more continuous training including research.

Please note the examples included in this summary was extracted from some surveys but also from the Internet so if there was any omission I hope will be understood.

Chapter Four RA IV Harland Shannon (USA)

4.1 Introduction

This report examines the Terms of Reference relative to the Member countries of Regional Association IV (RA-IV). Numerous organizations within the Region provide agricultural weather information to the local farming communities. In countries where the government offers operational products and services, the National Meteorological and Hydrological Service (NMHS) or Ministry of Agriculture (MoA) typically provides this information. Other providers of agricultural weather products and services include academic-affiliated or government-related extension agencies, media outlets, and commercial vendors. The most successful communicators tend to be well-established organizations that serve agrometeorological information as part of their mission, but also have relatively stable funding and a well-educated, highly-trained staff. Deficiencies in one or more of these qualities tend to limit organizational success in communicating agrometeorological information to customers, sometimes significantly.

A diverse array of tools is used to communicate agrometeorological products and services to the farming community. The most commonly used tools, in no particular order, include television, radio, newspaper, telephone, email, and the Internet. Although the intended audience is often farmers and ranchers, customers of these products and services extend well beyond the farming community. Other customers include government marketing and regulatory agencies, natural resource managers, relief organizations, agricultural commodity traders, insurers, and the transportation industry. Following are specific examples describing how agrometeorological products and services are communicated in RA-IV and recommendations for improvement.

4.2 ToR a) How are Agrometeorological Products and Services Communicated in RA-IV?

In several RA-IV countries, the NMHS or MoA communicates agricultural weather information to the farming community via agrometeorological bulletins (Solano and Frutos, 2002). For example, the Meteorology Institute of the Republic of Cuba publishes a decadal agrometeorological bulletin which contains maps of rainfall, vegetation conditions, and agricultural drought; tables of weather data for select agrometeorological stations; and value-added text that highlights weather impacts on crop progress and conditions [1]. In El Salvador, the NMHS regularly prepares three agrometeorological bulletins each month [2]. These bulletins contain an abundance of agricultural weather information, including national maps of available soil moisture, time series of air temperature, soil temperature, and hours of sunlight for stations located in different agricultural zones, and text summaries describing the recent weather and observed crop development. In Guatemala, the National Meteorological Service and Ministry of Agriculture collaborate to periodically publish an agrometeorological bulletin [3]. A recent publication included a summary of the current weather patterns, a forecast of the onset of the rainy season, and recommendations regarding the best time to sow crops. In the United States, the Department of Agriculture (USDA) and National Oceanic and Atmospheric Administration (NOAA) jointly publish the *Weekly Weather and Crop Bulletin* (WWCB), a comprehensive collection of value-added text, tables, charts, and maps summarizing weather impacts on domestic and international crop production (Puterbaugh and Rippey, 2002) [4].

Agrometeorological bulletins are effective communication mechanisms because they package multiple, potentially beneficial products in customer-friendly formats for the

farming community. The Internet boosts the value of these bulletins by providing a convenient means for distribution (Stefanski and Sivakumar, 2007) [5]. Indeed, all of the bulletins highlighted in the previous paragraph are available on agency Internet sites. Significantly, the Internet also serves as an effective means for communicating individual agricultural weather products when a more comprehensive agrometeorological bulletin is not prepared. For example, the NMHS in Belize uses the Internet to communicate agricultural weather forecasts to farmers and livestock producers [6]. Similarly, the NMHS in Panama uses the Internet to disseminate rainfall, temperature, and potential evapotranspiration maps to help the agricultural sector monitor drought, manage irrigation supplies, and determine the optimal times to plant and harvest crops [7]. Finally, the USDA Natural Resources Conservation Service (NRCS) National Water and Climate Center (NWCC) uses the Internet to circulate water supply forecasts to local and regional water managers (Pagano et al., 2009) [8].

In most RA-IV countries, the NMHS or MoA is responsible for communicating operational agrometeorological products and services to the farming community, but some of these agencies also offer educational material to help farmers and ranchers better understand weather and climate impacts on agriculture. For example, the Costa Rica NMHS provides links on the Internet to several papers documenting the relationship between ENSO and agricultural production (e.g., Villalobos, 1998; Retana and Rosales, 2000) [9]. This information enables astute readers to use ENSO forecasts to better plan farm activities. Other organizations within RA-IV also provide agrometeorological products and services through extension efforts. The Caribbean Institute for Meteorology and Hydrology (CIMH) is a training and research organization that seeks to improve meteorological and hydrological services throughout the region [10]. The Caribbean Agrometeorology Network (CarAgMet), a component of the CIMH, provides information and advice to the farming community to help enhance agricultural productivity [11]. Many universities within RA-IV also offer agrometeorological products and services via their extension services. In the United States, example universities include North Dakota State University [12], Michigan State University [13], Washington State University [14], and the University of Missouri [15]. Successful extension agencies are staffed by well-educated individuals that work closely with farmers and ranchers to transition cutting-edge technology and knowledge into practical applications. Extension agents frequently use the Internet to promote agrometeorological products and services, but many of these individuals also communicate with individual farmers and ranchers via telephone, email, and in-person conversations. These dynamic interactions are very beneficial to both the extension and farming communities because these exchanges provide an opportunity to discuss user requirements and to evaluate the effectiveness of existing agrometeorological products and services. Although these products and services may be considered operational, extension efforts are inherently associated with academic and other research-oriented institutions. As a result, fluctuating funding levels and incomplete product and service development sometimes hinder the effectiveness of these efforts.

In RA-IV, media outlets regularly communicate weather information to the farming community through television and radio broadcasts and daily newspaper publications. Many of these outlets also use the Internet to simulcast and archive their broadcasts and to post their print articles. Media outlets are successful in communicating weather information because television and radio broadcasts can be broadcast over long distances and newspapers can be widely distributed. Furthermore, these broadcasts and distributions often follow fixed schedules, enabling farmers and ranchers to incorporate these communications into their daily routines. One drawback associated with fixed broadcast schedules is the limited

amount of time media outlets can devote to weather segments. Similarly, space in newspapers if often limited. Additionally, those individuals who prepare and present weather information often have little training in agrometeorology. These weaknesses together frequently result in media outlets communicating relatively generic weather information, such as basic weather observations and forecasts, instead of more helpful products which are tailored specifically to the needs of the farming community. Extension-affiliated radio and television programs can be very effective in communicating agrometeorological-specific information to a far-reaching farming community. In the United States, Oklahoma State University (OSU) produces "SUNUP", a weekly television program that is dedicated to state agricultural issues, including agricultural weather [16]. In a recent broadcast, the agricultural weather segment discussed soil moisture and temperatures for farmers preparing to plant wheat. The OSU broadcast provides an excellent demonstration of how expert knowledge and custom products can be combined with broadcast technologies to significantly enhance the communication of agrometeorological information to the farming community.

Some commercial weather vendors also offer agrometeorological products and services in RA-IV. Select companies in Canada and the United States include Agro Climatic Consulting [17], the Weather Network [18], Freese-Notis Weather [19], and Agricultural Weather Information Service, Inc. [20]. Because these and other companies typically charge for their services, it is critical that they provide products and services that satisfy very specific user requirements. In general, commercial weather vendors must provide information in a format that customers can understand and apply and the information must be available when customers need it. As a result, company representatives often work closely with their clients to tailor agrometeorological products to end user needs and to ensure that company services continue to meet customer expectations. Significantly, the competition for clients among commercial weather vendors has likely spurred technological advances in communicating agrometeorological products and services to the farming community. Many of these companies not only fax, email, and post their products on Internet sites, but also have developed products that take advantage of newly developed mobile and networking technologies. Although commercial weather vendors can be very successful at communicating agrometeorological information, the availability of these services is limited to those individuals and groups that can afford them. This limitation is likely the primary reason why commercial agrometeorological product and service providers were only found in North America when examining RA-IV. Although agrometeorological information could benefit the farming community in Central America and the Caribbean, the provision of such services may not be profitable for commercial weather vendors. Nevertheless, the efforts of the private sector provide some insight on how to improve the communication of agrometeorological products and services.

Some of the information contained within this report was obtained through personal communications (e.g., email, in-person conversations), but much of the information was gleaned from the Internet (e.g., agency web sites, conference proceedings, peer-reviewed publications). The availability of information varies significantly among countries; some countries offer a relatively thorough description of their operational agrometeorological activities, while other countries provide little, if any, details. Although some countries provide little information because their agrometeorological activities are minimal, other countries appear to offer relatively robust products and services but provide little supporting documentation. As a result, it is possible, if not likely, that the agrometeorological programs in any one country are more active than reported here. Finally, the examples presented in this report are intended to provide some insight into how agrometeorological products and services are communicated

in RA-IV. These examples do not necessarily represent the full capabilities of each country.

4.3 ToR c) How Can We Improve Communications in RA-IV?

Similar to the other Regions around the world, some countries and organizations within RA-IV are more successful than others at communicating agrometeorological products and services to the farming community. Regardless of current or past levels of success, arguably all providers of agricultural weather information in RA-IV can improve their means of communication. Following are several recommendations to help improve communications in RA-IV:

1. Develop more agrometeorological products and services that satisfy specific farming community needs. Although many farmers and ranchers in the region have access to weather information, few of these products and services address the specific needs of the farming community. The agricultural and meteorological communities should combine their resources and knowledge to develop additional agrometeorological-specific products and services, thereby improving how weather information is communicated to farmers and ranchers.

2. Provide agrometeorological products and services in formats that farmers can understand and apply. Agrometeorological products and services are potentially very beneficial to the farming community, but the value of this information diminishes greatly if it is not provided in a form that users can understand and apply. Thus, agrometeorological product and service providers should strive to communicate this information in user-friendly formats, taking into consideration their audience's education and training, as well as their specific information and data requirements.

3. Educate the farming community on product usage, including strengths and weaknesses. Many existing agrometeorological products are accompanied by insufficient documentation to inform farmers and ranchers how to use the products properly. This shortcoming often results in products being misinterpreted or ignored. Agricultural weather experts can overcome this obstacle through extension efforts, such as providing training seminars, preparing and distributing instructional brochures, developing Internet content, and engaging individuals one-on-one.

4. Solicit feedback from the farming community on product and service requirements and effectiveness. Given the significant role that user requirements play in the development of any agrometeorological product or service, the agrometeorological community should make it a priority to obtain feedback from the farming community to ensure that their products and services satisfy user needs. The benefits of feedback reinforce the need for extension services because extension efforts are often characterized by dynamic, two-way interactions between the agrometeorological and farming communities, providing an ideal opportunity to solicit user input.

5. Establish agricultural weather information hubs within remote and economically-challenged regions. Physical and economical barriers hamper the provision of agrometeorological products and services in portions of RA-IV, denying access to the more isolated and less wealthy areas. One approach to overcoming these obstacles is to establish agricultural weather information hubs within these remote and economically-challenged regions, providing individuals with access to previously unattainable information. Efforts are likely to be most successful in areas where well-equipped and forward-thinking individuals can be enlisted in each community to coordinate product dissemination locally.

6. Identify and adopt new and emerging technologies to broaden communication efforts. A continuing stream of new and emerging technologies is rapidly changing the face of global communications, presenting even more opportunities for the agrometeorological community to broaden and enhance communication efforts. The agrometeorological community should continue to investigate the potential benefits of

these new and emerging technologies and seek avenues to incorporate the most promising technologies into future communication efforts.

As implied in the ETCAPS Terms of Reference, a primary objective of this report is to evaluate the feasibility of implementing new and appropriate tools for communicating agrometeorological products and services. This objective will be addressed by examining how new and emerging technologies could be used to enhance communication efforts in Mexico and the United States. It is important to note, however, that technological advances alone can not eliminate all of the obstacles that hinder communications between the agrometeorological and farming communities. The other issues raised here are equally as important, and all of these issues should be addressed in concert to develop more effective and complete means for communicating agrometeorological information to the farming community.

4.4 ToR d) What New Tools Can We Use to Improve Communications?

The telecommunication markets within the United States and Canada are among the most progressive in the world. Elsewhere in RA-IV, however, the availability of reliable telecommunication systems is more limited (e.g., Noguera, 1997; Raventos, 1998). For example, in Mexico, Central America, and the Caribbean, fixed-line communication systems (e.g., phone, cable television, broadband) are generally more robust and better maintained in urban centers than in rural areas [21]. One factor that has contributed to these inequities is the existence of local monopolies which are under little pressure to reduce prices or expand infrastructure [22]. Additionally, potential customers in urban areas are often more wealthy than their rural counterparts. Because of the difficulties associated with fixed-line communication systems and providers, many RA-IV countries are actively supporting the development of mobile networks to expand and improve their telecommunication capabilities [21, 23, 24]. These efforts are encouraging competition among multiple service providers, thereby reducing customer costs, while helping to broaden the spatial extent of services across the Region.

Mobile telecommunication tools, such as cell phones and mobile Internet devices, can be used for a variety of purposes, including voice communications, sending and receiving text messages, browsing the Internet, and running applications. The agrometeorological and farming communities could use all of these capabilities to improve the communication of agricultural weather products and services throughout RA-IV. For example, cell phones may enable farmers to call extension agents and obtain agrometeorological information that was previously inaccessible because of inadequate land line communication services in their area. Mobile text messaging could be used to provide farmers written weather information, including surface weather observations, local forecasts, and severe weather warnings while they are at home, in a field, or in town. A basic agrometeorological text message may include weather information and a recommended agricultural action, such as:

- NW WNDS 15-30 MPH – DO NOT SPRAY (surface weather observation)
- 10-25 MM RAIN TONITE, DRY TMRRW – CONDS FVR WHEAT PLNTNG (local forecast)
- SVR TSTRMS APPRCHNG – TAKE SHLTR IMMDTLY (severe weather warning)

Web-enabled mobile devices could also be used to communicate more descriptive versions of these written products, as well as an entire suite of products that can not be disseminated via text message. Products in the latter category may include soil moisture maps, satellite imagery, radar data, and hurricane charts. Indeed, the United States National Weather Service and various North American commercial weather vendors have already begun developing Internet content specifically for display on mobile devices. Some of these groups have also developed applications

that can be installed on mobile devices, enabling customers to access weather data and products without launching a mobile web browser. Although the number of agrometeorological-specific products currently available via mobile web browsers and applications remains limited, these advances in mobile telecommunications are laying a solid foundation upon which future agrometeorological services could reach a much broader audience.

All of the mobile communication methods described above could help improve the communication of agrometeorological information, but not all methods are widely accessible or easily affordable, especially for farmers and ranchers located in the more economically-challenged and infrastructure-poor regions of RA-IV. For example, web-enabled mobile devices and application-laden cell phones are often more expensive than basic cell phones. Similarly, the monthly service plans that accompany the higher-priced tools are typically more expensive than the service plans associated with less expensive equipment. Given that these price differentials likely exclude poorer farmers and ranchers from using web-enabled and application-laden mobile devices, a more all-inclusive solution for improving the dissemination of agrometeorological information is to implement text messaging services within RA-IV. These services likely have the most potential for success because mobile networks are rapidly expanding across the Region and text messaging can be accomplished using relatively inexpensive cell phones and related service plans. Thus, it is strongly recommended that the NMHS or MoA in each country incorporate text messaging as a primary means for disseminating agrometeorological information. Despite the higher cost of web-enabled cell phones and other mobile devices, it is also recommended that the agrometeorological community further develop Internet content and applications specifically for these devices. Given the already extensive use of the Internet for communicating agricultural weather information, product and application development for mobile devices should continue in anticipation that web-enabled cell phones and other mobile devices, like many other technologies, will become less expensive and more widely available over time.

4.5 What are the Potential Impacts of Implementing these Improvements?

A case study examination of existing and proposed methods for communicating agrometeorological products and services illuminates the potential benefits of using mobile devices to disseminate agricultural weather information. In Mexico, the National Meteorological Service (SMN) publishes a daily agrometeorological bulletin that summarizes recent weather observations, crop progress, and crop conditions and contains weather forecasts for major agricultural areas across the country. This agrometeorological bulletin, like many others in RA-IV, is posted on the Internet to facilitate distribution [25]. Although the Internet is relatively well established in Mexico's urban centers, the Internet is not as accessible in rural areas, suggesting that a subset of the farming community can not obtain the SMN bulletin via these means [26]. Several countries in Central America and the Caribbean have similar Internet issues, likely restricting farming community access to agrometeorological information.

Mobile networks are expanding rapidly throughout RA-IV, improving telecommunications in rural areas. One solution for improving the dissemination of agricultural weather information is to use cell phone text messaging to disseminate agricultural weather information to the farming community. A notable strength of the SMN agrometeorological bulletin is that it successfully consolidates a variety of weather and crop information into one-concise product. Consequently, this information-rich publication could serve as an effective starting point for developing an agrometeorological information text messaging service in Mexico. Text messages must be short, limiting the amount of information that can be sent via these means.

The layout of the SMN bulletin favors the extraction of short text messages because the weather and crop information is presented by agricultural region. Individual text messages describing crop progress, crop conditions, surface weather observations, or weather forecasts can be prepared using bulletin content. These text messages could be then sent to those groups and individuals that have agricultural interests within each region. Because the SMN bulletin contains agricultural weather information for all of Mexico, text messages targeting very specific audiences could help minimize provider and customer costs by reducing the flow of potentially extraneous information. In summary, the implementation of agrometeorological information text messaging services in Mexico would benefit the farming community by (1) offering an alternative means for obtaining agricultural weather information, (2) providing focused information based on regional needs, and (3) expanding the communication of agrometeorological information into rural areas that were previously inaccessible using other telecommunication methods.

The introduction of agrometeorological text messaging services could benefit farmers and ranchers in other parts of RA-IV as well, especially those parts of Central America and the Caribbean where inadequate telecommunication systems have previously hindered the dissemination of agricultural weather information. These text messaging services have proven successful in parts of RA-IV already, as evidenced by commercial weather vendors offering such services in the United States and Canada. Although text messaging can be an effective tool for communicating agrometeorological information, continuing advancements in mobile Internet communications are increasing the popularity of web-enabled mobile devices. Such devices could further improve the communication of agricultural weather information by making even more robust agrometeorological products and services available to the farming community.

In the United States, the National Integrated Drought Information System (NIDIS) team created the U.S. Drought Portal, an interactive system that provides an early warning about emerging and anticipated droughts [27]. Other functions of the Portal include assimilating and quality controlling drought data, providing information about drought risks, explaining how to plan for and manage drought impacts, and providing a forum for different stakeholders to discuss drought-related issues. The Drought Portal provides access to numerous products, including static maps that depict the spatial extent and intensity of drought across the country, dynamic maps that enable users to zoom in on a specific location of interest, charts and tables that quantify the percent of a region impacted by drought, and text summaries that describe drought impacts on agriculture. Although text messaging could be used to communicate some Drought Portal information to the farming community, text messaging can not replicate the full functionality of the Drought Portal service. In contrast, web-enabled mobile devices can provide users with full access to Drought Portal capabilities, enabling farmers and ranchers to better manage drought impacts on agriculture. Furthermore, these devices can potentially provide access to drought information in regions where other communication systems may not be available. As noted previously, such devices may be too expensive for many farmers and ranchers, especially those individuals located in poorer countries. Nevertheless, these devices are likely to become more affordable over time, making even more agrometeorological products and services available to the farming community.

4.6 Summary

Agrometeorological products and services are potentially very beneficial to the farming community, but the effectiveness of these products and services often hinges on how well this information is communicated to end users. While some countries and organizations within RA-IV have had considerable success communicating

agricultural weather information to farmers and ranchers, others have struggled to overcome an assortment of obstacles, including social, political, educational, economical, and technological barriers. Based upon these findings, agrometeorological product and service providers are encouraged to pursue the following initiatives to improve communications with the farming community:

- Develop more agrometeorological products and services that satisfy specific farming community needs,
- Provide agrometeorological products and services in formats that farmers can understand and apply,
- Educate the farming community on product usage, including strengths and weaknesses,
- Solicit feedback from the farming community on product and service requirements and effectiveness,
- Establish agricultural weather information hubs within remote and economically-challenged regions, and
- Identify and adopt new and emerging technologies to broaden communication efforts.

Agricultural weather information is disseminated to the farming community through a variety of means, including in-person conversations, television and radio broadcasts, newspapers, telephone, email, fax, and the Internet. One of the primary objectives of this report was to address the final recommendation above and evaluate the feasibility of implementing new and appropriate tools to improve communications.

Rapidly evolving mobile communication networks are steadily improving telecommunications in RA-IV by enhancing service in areas where communication networks are already established and expanding service into areas where communication networks are non-existent. These networks are likely to benefit the agrometeorological and farming communities by creating additional, more expansive avenues for disseminating agricultural weather information in rural areas. In addition to broadening the geographic coverage of communications, the wireless communication devices that access these networks often have a variety of features that make these devices well suited for communicating agrometeorological products and services. For example, cell phone text messaging services can potentially be used to disseminate agrometeorological observations, forecasts, and advisories to the farming community. Text messages must be short, limiting the amount of information that can be conveyed using this method, but this form of wireless communication can be relatively inexpensive, helping make this solution more affordable than others. Additionally, mobile Internet devices could potentially be used to communicate more robust agrometeorological products and services in areas where land line communication services are poor or not available. Such devices and related service plans are typically more expensive than cell phone text messaging services, likely limiting the number of potential customers. Despite current limitations, the agrometeorological community is encouraged to pursue the development of agrometeorological products and services for mobile Internet devices in anticipation that this technology will become cheaper and more widely available over time.

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Chapter Five RA V Neal Moodie (Australia)

In the RA V report, case studies from Fiji and Samoa are used to address the key terms of reference before considering the

5.1 Fiji case study

5.1.1 ToR a) What are the current means of communication

- The Fiji Met service provided a seasonal rainfall forecast on its website, newspapers and is faxed to specific farmer groups.
- Feedback from farmers was that the forecasts were confusing, didn't fit the farming cycle, and weren't compatible with local knowledge.

5.1.2. ToR b) What improvements to means of communication. Ie. New and emerging tools and institutional arrangements.

- The Fiji Met service has setup a regular forum for heads of industry to participate in a discussion forum about the seasonal rainfall forecasts. Industry bodies can interact with staff from the Fiji Met Service and discuss aspects of the forecast that may impact their operations. Staff are able to add value to the forecast by explaining how the forecasts may be used throughout the growing cycle.
- A monthly South Pacific forum has been implemented where staff from South Pacific met services and the Australian Bureau of Meteorology can discuss the latest climate information and forecasts. This has enabled a greater sense of ownership in the seasonal forecasts and has strengthened the relationships between staff from each met service.
- Regular workshops are conducted by the Fiji Met service to raise awareness and help educate farmers about the climate forecasts, and how to apply them practically in their operations.

5.1.3. ToR c) What are the challenges in implementing the new and emerging tools and institutional arrangements?

- A major challenge with implementing the new arrangements is trying to incorporate the communication into the farmers working cycle. Some farmers have expressed that they do not see the value in taking time away from their activities to examine the impact of the latest forecast on their operations.
- Integrating the communication tool into existing practices, or trying to activate a change in practice is a major challenge that needs a good strategy to overcome. The strategy needs to be flexible and may consist of numerous phases and activities that build towards the ultimate goal. Partnerships with local champions may need to be incorporated as a central part of the strategy in order for farmers to adapt their practices based on peer influence.
- Local knowledge is very important, not only on local climate but what local users require. Climate forecasts may be too broad for users to relate to their local farm or operation. Fiji met service staff understand local language and customs, and are better at conveying the information to the users. A regular review of feedback from farmers will identify any gaps in the communication requirements between the two parties.
- Raising awareness amongst potential users requires a sustained effort utilising a number of strategies. The Fiji Met service has distributed a number of educational brochures to key farming groups to raise awareness and understanding amongst their members. Workshops have been conducted with advertising targeting farmers who haven't been utilising forecast information prior.
- Another challenge is organising a regular national climate forum where producers and other users can discuss the seasonal forecast and interact directly with the Director of Meteorology and staff of the Fiji Met service.

- Educating the media is also important to ensure that the Climate forecasts are conveyed to the public accurately. Fiji Met service has endeavoured to invite media organizations to the monthly climate forums and educational workshops. By developing a closer relationship, Fiji Met service can utilise the media for disseminating key climate forecast messages.

5.1.4. ToR d) What are the potential impacts of implementing the new and emerging tools and institutional arrangements?

- The Fiji Met service is upskilling its staff through participation in the Monthly Climate forum where Climate scientists can share information about their latest research and knowledge of the Climate system. This in turn improves the reputation of the Fiji Met service amongst the community, and builds trust in the services that are provided to farmer groups.
- Interaction between the water managers and FMS is becoming more regular. Examples of close relationships between Fiji Met service and industry bodies are the Sugar industry and forestry. For example, Fiji Pine has held workshops on each of the two main islands in the Fiji Group. FMS staff were available to explain to Fiji Pine managers and field officers about the potential effects of El Niño patterns on Fiji rainfall, and provided advice about the impacts to the organizations plantations. Similar workshops would be of great benefit to the water resources community.
- Pacific Island Countries can share experiences and examples of successfully applying each communication tool. Through the monthly climate forums, an opportunity exists to develop best practice benchmarks and report back on the outcomes of new initiatives. Positive production gains in each country through more effective use of climate forecasts would provide improved economic and social benefits for the collective countries in the South Pacific.

5.2 Samoa case study

5.2.1. ToR a)What are the current means of communication

- Providing seasonal forecasts and faxing them to key stakeholders. The forecasts are also placed on the Samoan Met service website. Occasionally, there is opportunity for face to face briefings with specific user groups and local farmers.

5.2.2. ToR b) What improvements to means of communication. Ie. New and emerging tools and institutional arrangements.

- The Samoan government has engaged the services of NIWA in New Zealand to develop a Climate early warning system for Samoa. This initiative is an ambitious programme aimed to increase the understanding of weather and climate related risks facing Samoa, and to develop appropriate mitigation and adaptation strategies to protect the well-being of the Samoan population and its production capability.
- The programme aims to provide quarterly reports of climate information to key users.
- Conduct systematic workshops and consultation within the agricultural and health sectors, focusing on specific climate risks in each sector and capacity building in local communities.
- Providing map based risk information on the Climate in GIS format so that the information can be integrated into sophisticated decision support tools for the agricultural sector.
- Developing information on the Samoan Met service website about Climate related risks on agricultural production. An opportunity exists for the Met

service to partner with agricultural departments to provide a range of information and become the authoritative source for agricultural information.
- Use of extension officers to work amongst the local farming community to assist farmers to practically utilise Climate forecasts. Extension officers will be able to transfer the latest climate information and agricultural techniques to the farmer in a simple language.
- Conduct a regular forum for policy debate on resilient agricultural production to encourage sharing of ideas, and provide opportunities for policy makers to understand the needs of the agricultural community.

5.2.3. ToR c) What are the challenges in implementing the new and emerging tools and institutional arrangements?

- Systematising the monthly climate forums with key stakeholders to ensure that the forums are relevant to user needs and are held in locations that are accessible to local farming groups.
- Developing the background climate information sources as the foundation for the climate forecast products. The climate information for many locations across Samoa may not be available in digital format, or have complete records resulting in difficulties in analysing the data.
- Maintaining funding for extension work will require demonstration of cost benefits to senior management or government officials. The challenge will be managing expectations of these officials while designing targets that are meaningful and easy to understand for senior managers.
- Developing alternative dissemination techniques other than via the internet to reach local communities who either don't have internet capabilities or have traditionally used other communication means. The key to a successful communication strategy is flexibility and offering a range of delivery mechanisms to cater for the broad needs of the community.
- Training staff and lack of expertise in Samoa may require the importation of expertise from other countries and further costs in order to raise the skill base of local staff.
- Incorporating the institutional, legislative and policy frameworks into a sustainable application of government programmes that can be leveraged into other areas of Samoa.
- Tailoring information mechanisms and building adaptive capacities in local communities to fully utilise and understand the climate forecast products.

5.2.4. ToR d) What are the potential impacts of implementing the new and emerging tools and institutional arrangements?

- A Climate Early Warning System will enable agricultural and health sectors to prepare themselves against the threats posed by any anomalous changes in the climate system through more timely and accurate reports. The agricultural sector will be able to implement strategies to maintain production by investing in drought resistant crops, and mitigating against flooding. The benefits of sustainable agricultural production on the community will be to stabilise costs of goods during adverse events, and maintaining the traditional diet of the community. The health sector will be able to activate mitigation strategies against vector-borne diseases during wet periods.
- The new tools will contribute to improved management of village plantations and commercial farms through effective planning strategies against climate risks. Food security and price stability will be managed more effectively resulting in greater investment confidence.
- A coordinated approach to dealing with Climate related risks to agricultural production will assist the development of policies and programmes aimed at

local farmers and government owned industries to reduce and manage these risks.

5.3 Services provided in the region (addressing ToR a)

5.3.1 Australia

At the Federal level, the Bureau of Meteorology provides weather and climate services to the broad agricultural sector via the Agricultural section of its website. The Agricultural website provides a range of information, observations and forecasts for relevant agricultural weather elements such as rainfall, wind, frost, sunshine and evaporation. Over the next five years, a new forecasting system is being implemented that will allow the Australian community to access 7 day forecasts for their local area, via an interactive map display on the Bureau's website. The Bureau of Meteorology provides its data and maps in a number of formats that can be utilised by popular software systems. The Bureau of Meteorology interacts with the Agricultural community by having a presence at field days, providing an opportunity for farmers to gain some one on one advice on the latest services and science that might apply to them.

The Bureau of Rural Science is another federal department that provides services to the agricultural sector. Their main role is to monitor drought levels and investigate claims for assistance through its Exceptional Circumstances relief program. Services are displayed on its website and they work closely with State departments to facilitate the dissemination of the information in their regular newsletters to farming groups.
At the State level, Government Agricultural departments operate extension services to local farming groups. This involves regular face to face visits from extension officers with the aim of educating farmers on how to utilise the best techniques and information available to them. To reach a broader audience, the Agricultural departments produce a regular newsletter that relates the recent weather and climate information to farming and market conditions. For example, the Victorian Department of Primary Industries produces a newsletter titled "The Break", providing information about recent agricultural production across the State, and linkages between anticipated production and techniques with Climate information for the coming season. The newsletters are distributed mainly by email, but are delivered by post as a secondary option if needed. The newsletters are posted on noticeboards in local shopping precincts to reach other sectors of the community who may not be directly involved in farming production. The agricultural departments also provide a range of software that can be used to analyse climate and environmental data.
At the Community level, a number of co-operatives exist where groups of farmers have joined together to share resources and information for the betterment of the whole group of farmers. The cooperatives establish partnerships with other cooperatives, or State and Federal government departments to develop services that benefit the farming community. A number of examples exist including a frost warning service for a susceptible grape growing area that required detailed temperature information of the following morning. This service was developed by the Bureau of Meteorology as a registered user service and presented in a graphical format on a website. Statistical correlations allowed members to relate information to their farm. An email was sent to members when temperatures were forecast to exceed the temperature threshold.

At the academic level, there are a number of research bodies funded by the University or government sector. The activities of the research bodies are primarily focused on improving yields through better use of information, and adapting farming practices and cropping decisions to the local environment and climate. The research bodies work closely with farming groups to conduct pilot studies with the aim of commercialising or scaling up the outcomes. The research bodies have the

capability and resources to introduce new techniques for communicating and utilising information within the farmers decision making processes. Examples include using wireless internet technology to deliver real-time information to farmers from the field, using mobile phone technology to present relevant information to farmers whilst they are out in the field, using the internet to customise and tailor information for reporting and decision making purposes, and providing discussion forums for farmers to learn about new techniques from their peers or researchers.

5.3.2 Fiji

The Climate Section in the Fiji Met Service provides 3 month Rainfall Outlooks for the Sugar Industry on a quarterly basis. The farmers are interested in soil moisture, temperatures and rainfall information. The rainfall outlooks are based on 30/40/50 year averages. For example, for the western division, 40 years of data is needed for a reliable rainfall outlook. There is high demand for short term climate forecasts from the broad agricultural sector.

The information is disseminated to the Fiji Sugar Corporation who utilise their Extension Officers to communicate the information face to face with farmers. A proportion of Sugar cane farmers face communication problems because they do not understand the meteorological terms used. A potential weakness in this system is that the farmers may not receive the full context of the information provided by the Fiji Met Service. Fiji Met Service does not have the capacity to provide a more regular service.

Feedback is received though workshops where farmers and the Fiji Sugar Industry meet with Fiji Met service to discuss the products and service. A recent initiative by the AUSAID Climate Prediction Project has yielded greater feedback and improvements to the service through workshops between local farmers and the Fiji Met Service climate section.

Up until recently the Fiji Met Service climate section provided a 1 and 3 month rainfall outlook to the Fiji Pine sector, however the pine sector has reduced significantly and the service is no longer required. Demand for weather and climate information from local farmers is driven by the presence or impending arrival of adverse climate conditions caused by drought, El Nino and La Nina episodes. This places demands on the Fiji Met Service to provide additional services that may be outside their scientific and operational capabilities. Farmers expectations may be unreasonable during these periods as the impacts of the conditions affect their ability to produce income and places pressures on their family livelihood.

5.3.3 Samoa

Samoa issues seasonal climate outlooks covering rainfall and temperature. These outlook products were developed in close collaboration with the Ministry of Agriculture and Fisheries (MAF) and members of the Samoa Farmers Association. The specific SCO will also be available and translated into the Samoan dialect to reach rural farmers who are not familiar with some of the scientific concepts that are presented in the English language. Further improvements to the service include a specific seasonal forecasts to cater for the health sector.

The major difficulty the Samoan Met service faces with the distribution of these services is the lack of resources and coordination between the Samoan Met service, the MAF and farmers. Education on utilising the service remains an ongoing challenge, and there are very few farmers that really understand the importance of SCO and meteorology services. Access to the outlook service is challenging for many farmers. Not all farmers use the internet and emails, so the Samoan Met

Service has to devote additional resources into alternative dissemination mechanisms. The Samoa Met service uses radio talk-back programs as another means to reach rural farmers. There is also a need for the Samoa Met Service, in partnership with MAF, to go out to rural farming villages to discuss the needs of each farmer and design appropriate strategies to address these. Local Farmer Association's also play a minor part with relaying of weather and climate data to interested farmers. The most interested sectors are the semi-commercial and commercial farmers, while the traditional farmers rely on their experience. Samoan farmers are generally concerned about rainfall during the drier months.

Further efforts into developing awareness raising programs of meteorology services need to be established. Samoan farmers do not fully understand the relationship of weather and climate information in maximising their production and profits. More efforts are required to educate farmers about weather resilient crop choice based around the seasons of the year, and using weather information to organise their cropping calendar to maximise market dynamics for their products.

Assessing the needs of farmers in relation to weather and climate services has been conducted on an ad-hoc basis due to budgetary constraints. With increasing number of diseases and pests posing risks to their crops, farmers are starting to ask for solutions rather than trying to understand the role that weather & climate patterns play in it.

5.3.4 New Zealand

At the federal level, the Ministry of Agriculture and Forestry provides monitoring and forecasts reports for various agricultural sectors. These reports are provided on their website. The National Institute for Water and Atmospheric Research provides climate information suitable for agriculture in a number of formats ranging from data and reports to sophisticated mapping applications. Most of the services are available on the NIWA website. They work closely with Agricultural government departments to advance the science by conducting demonstrations with local farming groups. This involves face to face consultation and regular review and feedback cycles to assist the farming groups through the demonstration exercise. NIWA also provides a range of software that can be used to analyse climate and environmental data. NIWA conducts a number of training workshops covering topics that are applicable to specific agricultural sectors.

Chapter Six RA VI Walter Trampf (Germany)

6.1 Introduction

ETCAPS agreed to distribute a questionnaire to the NMHSs (National Meteorological and Hydrological Services) of the different regions of WMO. So the following questions were sent by e-mail to the 50 NMHSs of the RA VI region:
1. Current means of communication of agrometeorological products and services to the farming sector in the RA VI region
2. A remark about improvements to the means of communication (new tools, e.g. SMS)
3. A remark about challenges of the implements (e.g. fees and prices)
4. and the impact (e.g. increase of agricultural production); if there is a publication, please indicate the name and title.

Out of the 50 NMHSs contacted, 16 (32%) replied to the questionnaire:
Armenia, Austria, Belgium, Bosnia and Herzegovina, Croatia, Denmark, France, Germany, Greece, Israel, Latvia, Luxembourg, Moldova, Poland, the Russian Federation and the UK.

At their meeting at Toowoomba, the expert team had already expected the reply rate to be weak, for which reason the members agreed that it would be necessary to carry out own investigations about the communication of agrometeorological products and services. A detailed study of all web pages published by the NMHSs in the RA VI region gave much useful information. There is quite a number of web pages which are provided by the NMHSs, by other public organisations (mostly regional organisations depending on the political structure of the country; e.g. centralised or decentralised) or by private companies using NMHS data or information. Private companies which only use data and forecasts from private networks and not from a NMHS are not mentioned. Table 6.1 of the appendix 2 gives an overview of the agrometeorological information available in 33 countries of RA VI.

6.2. ToR a) Current means of communication of agrometeorological products and services to the farming sector in the RA VI region

Table 6.1 in appendix 2 shows that agrometeorological information is available for most of the 50 RA VI countries. Such information is mainly produced by the NMHSs or other public organisations. Some NMHSs do not operate agrometeorological units, as their agrometeorological information system is exclusively in the hands of private companies. Some of the countries have only a nominal agricultural activity, with no need for agricultural information.

The web addresses listed in table 6.1 give direct access to the agrometeorological information system offered by the NMHSs or public or private organisations. From these home pages, the user can access to detailed information about the content and the means of communication. Many of the web pages are available in English although unfortunately some of the reports and bulletins or text descriptions in the maps are only in the national languages.

6.2.1. Products offered by NMHSs

Agrometeorological information is offered by the NMHSs of the following countries: Albania, Armenia, Austria, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, France, Germany, Greece, Ireland, Israel, Kazakhstan, Lithuania, Latvia, Moldova, Montenegro, Poland, Portugal, Romania, the Russian Federation, Serbia, Spain, Sweden, Switzerland, UK and the Ukraine.

Range and quantity of products provided through the web sites vary widely. Some NMHSs (e.g. Germany) provide a large number of agrometeorological web pages and other products for farmers or organisations engaged in agriculture whereas others have a smaller range of products. Austria (ZAMG), for example, offers only a phone information service, Spain (AEM) some maps on water balance, Albania a bulletin with agrometeorological information. In these countries, the advice systems are mainly organised by private companies.

In Belgium, the agrometeorological advisory system is in the hands of regional public services, in Luxembourg of the agricultural administration and in Italy of the Ministry of Agricultural Food and Forestry Policies. The NMHS of the Netherlands (KMNI) does not provide any agrometeorological information as this is the business of private companies.

The investigation gave no information about agrometeorological activities in Azerbaijan, Cyprus, Estonia, Georgia, Hungary, Iceland, Jordan, Macedonia, Malta, Monaco, Norway, Lebanon, Slovakia, Slovenia, Syria and Turkey. Most of these NMHSs publish web pages with meteorological but not agrometeorological information.

6.2.2. Products offered by public organisations

In some countries, public universities or institutes provide farmers with agrometeorological information (e.g. Armenia, Israel). In Belgium, the Walloon Agricultural Research Centre and the Flemish Institute of Technological Research produce bulletins that are communicated by web or e-mail. In Luxembourg, it is the agricultural administration who offers these services to the farmers. In Croatia, advice on plant protection is published by the HZPSS institute.

The Federal Republic of Germany operates a NMHS (DWD) which offers a large range of agrometeorological products. Furthermore, many of the 16 Federal states (Länder), which are responsible for the provision of agricultural advice and plant protection, operate a special agrometeorological network and thus have special web sites of their own where they publish regional data and information. The plant protection services of the Länder are pooled in the ISIP co-operation which receives its data from DWD.

Farmers in Israel have access to agrometeorological advice provided by their NMHS and the Israelian Ministry of Agriculture. In Italy, the NMHS is a branch of the Aeronautica Militare under the Ministry of Defence with no agrometeorological activity. The agrometeorological web pages for Italy are therefore run by the Ministry of Agricultural Food and Forestry Policies. Furthermore, there are many public organisations at the regional level which supply the farmers with information about the agrometeorological situation in the specific territory.
In Poland, the Institute of Plant Protection offers special advice services.

6.2.3. Products offered by private organisations

Agrometeorological information in Denmark is mostly distributed by agricultural advice companies which receive their data from the NMHS. In Germany, too, there are web sites run by private providers making products of the NMHS (DWD) available. They are allowed to present or set links to the web pages of DWD that are free of charge. There are two kinds of private providers, agricultural or chemical industry companies (e.g. Bayer CropScience, BASF) and private web portals (e.g. Proplanta) with a large range of information for farmers. Public-private institutions such as farmers' associations provide farmers with agrometeorological information of

DWD by fax (or the web). The ProPlant information and decision support system for farmers and agricultural advice offers products that rely on data from the DWD.

In Luxembourg, an agricultural service company distributes one of the DWD's agrometeorological weather faxes. UK Met Office, the NMHS of the United Kingdom, offers a monthly review. Most services for the agriculture, however, are provided by public or private companies.

6.2.4. Communication and users

The increasing popularity of the internet has made it the most important channel to communicate agrometeorological information. Nearly every NMHS now offers web pages for farmers, companies or organisations engaged in agriculture and most pages are free of charge, only special information and forecasts often are fee-based.

Besides being provided through web sites, agrometeorological data and forecasts are also communicated by fax, phone or e-mail. In some countries farmers can receive information by SMS. These media are mostly fee-based. The comparison of the various communication channels shows a clear disadvantage of the classic media, which is mainly due to the limited space for the information to be communicated (e.g. one page in case of the fax service or very short messages/text in the case of telephone information or SMS services).

Some NMHSs, such as Bosnia and Herzegovina, Moldova and Croatia, use communication by radio or TV. Agrometeorological bulletins are distributed by mail in Albania and Israel, for example.

Table 6.1 in appendix 2 shows that most users are farmers (including vine and fruit growers) and private or public organisations engaged in agriculture. Other users are public administrations, public or private advisory companies, plant protection organisations, public and private scientific organisations, insurance and agricultural industry companies.

6.3 Improvements to the means of communication

The development of the means of communication clearly shows a significant change from the classic media such as phone or fax to the web. The numerous web sites listed in table 6.1 underline that the web has become the most important means of communication in nearly all RA VI countries.

Agricultural holdings benefit from the global expansion of new information technology and the web services. During the past years, every full-time German farm has obtained access to the internet. This shows that the importance of this communication channel is still increasing.

The results of the latest investigations carried out by the Agrometeorology Department of DWD into the number of phone calls, fax subscribers and page views during the period 2004 to 2007 are published in Figures 6.1 and 6.2 of appendix 2. The two figures show a decrease in the calls to telephone information services and the number of fax subscribers. During the same time, the number of page views to the agrometeorological web sites has increased considerably.

Another improvement is the use of SMS as a means of distributing agrometeorological information in a rapid and easy way. SMS services are operated in many countries, such as Armenia (planned), Croatia, Denmark, Finland, France and the UK.

In Germany, however, this way of communication to farmers failed. In 2006, the Agrometeorology Department of the DWD started to distribute special SMS (Agrarwetter-SMS) to farmers. The message consisted of a table with 8 agrometeorological parameters forecast for the next 3 days (maximum temperature, wind speed, sunshine duration, precipitation amount, probability of more than 1 mm and 5 mm of precipitation, number of rain hours, minimum temperature at 5 cm height, snow depth, soil temperature at 5 cm depth, potential evapotranspiration and soil moisture under grass). This service was fee-based with a price of 15€/month. In the end, however, this new means of communication did not obtain sufficient acceptance due to the relatively high fee and the limited amount of information provided. Consequently, the service was ceased at the end of 2006. DWD, though, continues to operate a SMS service especially for local weather warnings.

With the continuous advancements in technology, sophisticated mobile phones (e.g. with touch screen) also allow access to the internet and farmers can receive all agrometeorological information available on the web even on their fields.

In Poland, the Institute of Meteorology and Water Management, the Institute of Plant Protection, the University of Life Sciences, the Advisory Service (for agriculture), the Wielkopolska Agricultural Center (Wielkopolska Izba Rolnicza) and the Regional Forest Administration are currently creating a consortium whose main objective is to offer a common agrometeorological service for the protection of agricultural production (plant diseases, pest protection, drought etc.). The service will be based on the widest range of tools possible some of which will have to be subject to fees.

6.4 Challenges of the implementation of new communication tools

Farmers have a permanent need for better and long-term or even seasonal forecasts. They also need highly detailed and local information. These demands are challenges to which the scientific teams of the NMHSs must respond by developing new agrometeorological models and better forecasts. This requires a considerable quantity and quality of manpower and technology that also needs financing. For this reason, the various ministries of finance insist that parts of the expenses are to be covered by the customers, e.g. by paying fees for receiving the information.

The difficult economic situation resulting from the low crop prices, however, does not encourage farmers to spend money on fee-based products. This is why preference is given to private services from the agricultural industry or private web portals with agrometeorological information and forecasts provided free of charge. The private agrometeoroogical service providers have therefore become major competitors to the NMHSs as they finance their information services by companies' marketing budgets or by publishing advertisement on the web sites. Incorrect forecasts of agrometeorological parameters are considered less negative when they are free of charge. It is more and more difficult for the NMHSs to convince farmers of the benefit of fee-based products.

Figure 6.1 of appendix 2 documents that the demand in agrometeorological information has increased during the last years in Germany. The page view numbers show considerable growth rates every year. The graphic, though, proves that farmers mostly use web pages that are free of charge. The increase in the page view numbers relating to fee-based pages is not so significant.

Poland's main challenge is finding sponsors and funding from the private or public sector. So far, the agrometeo service has been provided only for the central-western part of Poland, i.e. the Wielkopolska region, and this as a pilot project. There is little

interest on the part of the Ministry of Agriculture to find or provide funds for extending the project to all agricultural areas in Poland.

Another challenge is the continuous decrease in the number of agricultural holdings in the European Union and other RA VI countries. Table 6.2 (and Figure 6.3) appendix 2 shows the situation in Germany from 1999 to 2007. The number of farms with an arable area less than 75 ha has been decreasing whereas the number of holdings with more than 75 ha has increased. Altogether the number of potential customers for agrometeorological advice is decreasing. Farmers with important holdings are very interested in agrometeorological information but they expect a high quality and local forecasts for their farm region. They are the main clientele of private advisory companies which exclusively take care of the successful and big farms. On the contrary, NMHSs and other public organisations have the general task to offer agrometeorological information and advice for all types of agricultural holdings.

Table 6.3 of appendix 2 illustrates that most of the member states of the European Union experience the same situation as in Germany. From 2003 to 2007 the number of agricultural holdings has decreased considerably, e.g. in France by -14.1%, Germany -10.1%, Italy -14.5%, Spain -8.5%, Netherlands -10.2%, Denmark -8.2% and Belgium -12.6%. The largest decrease, however, occurred in Eastern Europe, e.g. in Bulgaria by -23.4%, Hungary -19%, Estonia -36.7% and Portugal -23.4%. An increase was only observed in UK, Sweden, Poland and Greece. This proves that the number of potential customers of agrometeorological information is diminishing in most parts of Europe.

The analysis of the questionnaires and interviews which the Agrometeorology Department of DWD carried out with farmers and other users of agrometeorological products at agricultural fairs revealed a ranking of agrometeorological parameters. This ranking is presented in table 6.4 of the appendix. The most important parameter is precipitation as a steering element for many agricultural activities such as ploughing, sowing and harvesting. To plan their activities farmers need a reliable forecast of the amount, time and probability of precipitation. Other important values are temperature, wind speed, relative humidity and evapotranspiration. It seems strange that the other parameters calculated by the agrometeorological models (e.g. ammonium losses, meteorological condition for pests) do not find much appreciation. But farmers often have a conservative opinion and therefore their own methods to make decisions concerning their agricultural business.

6.5 Socio-economic and environmental impacts of the new communication tools.

To point out the socio-economic and environmental impacts, a comparison must be made between agricultural holdings using new agrometeorological tools and farms that do not. In Germany, agricultural organisations often compare the economic situation of farms. The results of these investigations show that there are groups of holdings that are making sufficient profits whereas the profits of others are insufficient. The reasons for the economic situation of a farm, however, are manifold and make it impossible to point out only the agrometeorological part.

The comments supplied by Israel show that according to the Central Bureau of Statistics of Israel (the Agriculture Statistics quarterly) the "online" exposure to meteorological information is only one part of the hi-tech technology used in agriculture. Therefore, it is difficult to point out the impact of it although it is without doubt that communication data contribute to the success of agricultural products.

The questionnaires gave few results concerning the socio-economic and environmental impacts. Administration in Armenia intends to increase agricultural production, improve the planning of the activities, increase crop protection and ensure optimal irrigation scheduling. Climate change makes irrigation in agriculture increasingly important in many countries of the RA VI region and thus the need for irrigation management on the basis of agrometeorological information. It is possible to estimate the economic benefits of irrigation advice by comparing the amount of water used for farmland on the basis of an advice given with the amount used without such information.

In Poland, some research has been done by the Institute of Plant Protection (IOR) into the impact of NegFry and SimPhyt systems (internet decision support systems) on potato production. The publication can be found at:
www.ior.poznan.pl/index.php?strona=93 (in Polish).
The systems helped to increase the potato yield and to decrease the costs of plant protection. Both Internet systems proved to be useful.
Another publication deals with the changes in some agrometeorological indices in western Poland: www.cost734.eu/working-group-2/reports-andpresentations.

A lot of publications have been published in the Russian Federation but all of them only in the Russian language.

6.6 Conclusions
The long list of agrometeorological web pages and products provided in the RA VI counties shows that the interest in agrometeorological information is increasing. There is a need for better and also long-term, even seasonal forecasts as well as more detailed and local information.

But the list shows that most of the detailed information is fee-based. This fact reduces the acceptance of the products. A possible solution could be to improve the relevance of environmental aspects in agrometeorological information. Agrometeorological advice should be considered as an important part of environmental protection, e.g. the cost-free irrigation advice system is necessary to save water and not to subsidise agricultural holdings. Sustainable agriculture can also do much to avoid environmental problems, e.g. application of pesticides, manure problems or erosion. For this reason, in Germany the range of agrometeorological information which is classified as basic information or advice of environmental impact (e.g. soil frost, forest fire index) is provided free of charge. The Agrometeorology Department of the DWD undertakes many efforts to increase the range agrometeorological information that is supplied free of charge.

Acknowledgements The author expresses his warm thanks to all colleagues of the NMHSs of the RA VI region who helped to produce this paper by answering the questionnaire. Thanks to their kind co-operation it was possible to produce this summary in a short timeframe. The author would like to express his thanks to WMO for the possibility to participate in the International Workshop on the Content, Communication and Use of Weather and Climate Products and Services for Sustainable Agriculture in Toowoomba (Australia).

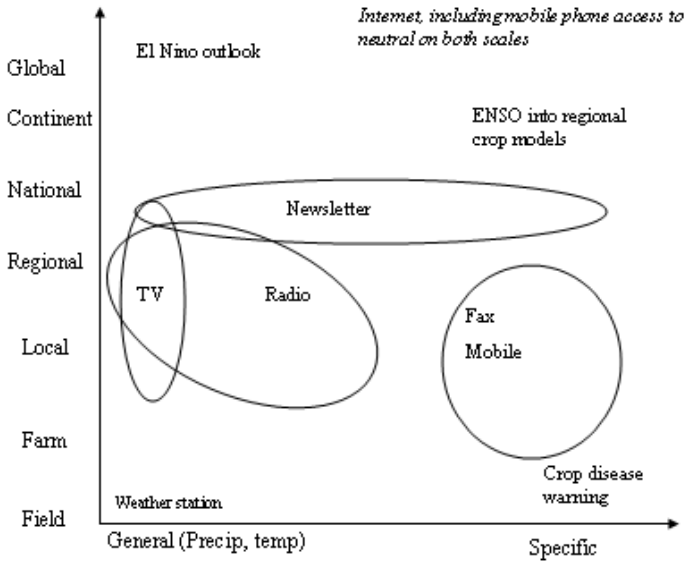
Chapter 7 Discussion and conclusion Peter Hayman (Australia)

7.1 Discussion of ToR a) on current means of communication of agrometeorological products and services

The different chapters of this report strike a balance between recognising the good work that is being done across the regions and calling for improvements. It is important to observe that every day there is an enormous level of thoughtful activity communicating agrometeorological products and services to farmers and agricultural decision makers. Reports from RA VI and RA IV come close to a comprehensive inventory; however, even these authors note that there are likely to be many activities that they have missed. Rather than an inventory, this report is best read as a mosaic of activity. We agree with the recommendation of Working Group 2 of the Toowoomba workshop that not all methods of communicating agrometeorological products are applicable everywhere. Indeed, it would be conceivably possible to have all forecasts for anywhere on the globe issued by a single centralised agency, but the development and communication of agrometeorolgical products and services must involve local expertise.

Although there are differences between regions, there is also substantial overlap. The meeting of the Expert Team in Toowoomba agreed on Figure 7.1 as a representation of different forms of communication. The Y axis is spatial scale from farm level to regional, national, continent and global. The X axis is from general meteorological information through to very specific agrometeorolgical advice. Television and radio tend to be local, however there is an increasing amount of 'narrow casting' whereby more local and specific information can be made available. The content needs to match the form of communication, for example specific disease information has to be at a scale appropriate to weather conditions for major crops in the region. The advantage of the internet is that it is possible to have global information on El Nino and be able to 'drill down' to action at a field level.

Figure 7.1 Communication methods plotted against information and spatial scale



7.2 Discussion on ToR b) identifying needs for improving the current systems of communication.

At the Toowoomba workshop there was considerable discussion on the need for improvement. In the plenary session, Working Group 2 - Effective Communication of Weather and Climate Products for Farmers and Extension Services succinctly stated the challenge as *"Communication has to be relevant, timely, targeted, reliable, and match the needs of the country cultures and users".* This statement refers to both technology and people.

As an Expert Team we broke the need for improvement down into three questions

a) what is being communicated (this is primarily for ETCAPS)
b) how the information is being communicated (technology)
c) who is involved in the communication (institutional arrangements and feedback from users of information).

Improving the content of what is being communicated

It is not easy to separate the need to improve the *content* of agrometeorolgical products and services from *communication* of the products and services. The focus of ETCAPS is on the communication rather than the content. However the first point is that in all regions there is a need to improve the content and this makes communication an easier task. Poor communication can reduce the potential value of projections of climate change or a forecast of EL Nino in the coming season or rain in the coming week. At the same time with enhanced technology, misleading or out of date content can be effectively and widely communicated.

Working Group 3 of the May 2009 Toowoomba workshop; - Enhancing Interactions between Weather and Climate Services and Farmers made the following conclusions *Despite the advances made in improving weather and climate forecasts, the application of these products at the field level has not been 'up to the mark' because of the lack of effective contact between the service providers and user communities.*

Hence there is a very important role in providing feedback from end users to the providers of information. This raises the interesting role of WEB 2.0

Improving the means of communication

All team members reported a move towards digital forms of communication especially the internet and mobile telephones. This does not mean that older forms of communication are automatically replaced. In some cases newsletters are only electronic but in most situations paper copies are printed and circulated. The radio and television remain dominant in many regions. As discussed in more detail later, a common message is that communication remains a human process and despite the many technological improvements, there is an increasing need for skilled human communicators.

Nowhere is the change in technology more dramatic than in developing countries. Presentations at the Toowoomba Workshop on the public private partnership that the Indian Meteorological Service has developed with mobile phone companies illustrate the opportunities for dissemination that was beyond imagination in recent times. Figure 7.2 shows the dramatic increase in connectivity for Africa in the near future. This presents opportunities for communication of agrometeorolgical information.

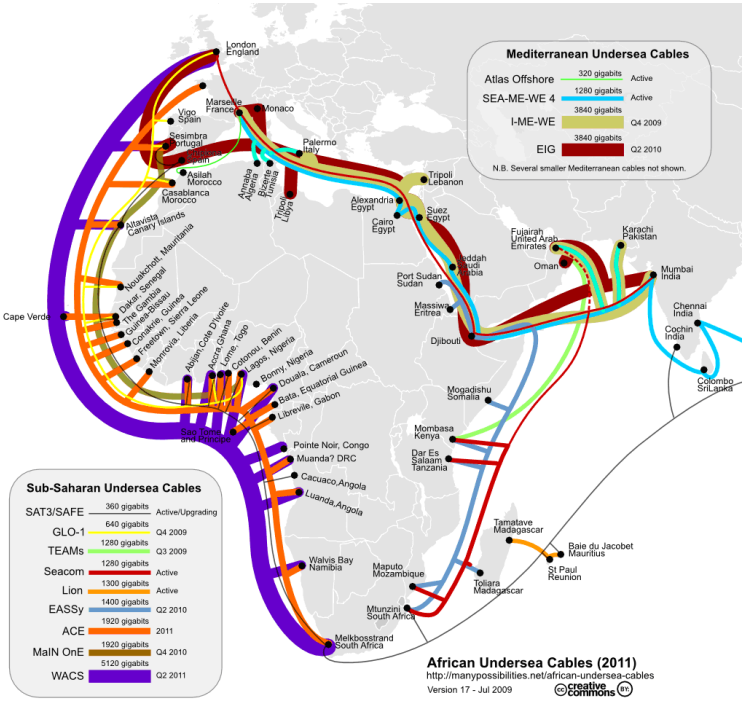


Figure 7.2 Diagram of undersea cables operating and planned in near future

The lessons from India and elsewhere challenge simple notions of the 'digital divide'. Although by no means a panacea for poverty, ICT has a recognised role in development work and agrometeorology is one of the examples were this had been thoughtfully applied.

Although it is easy to fall into simplistic views on the digital divide, there are real challenges. As reported from Africa, Pacific Islands and southern and central America there are many users who cannot access information due to lack of resources and many local providers who are limited in what they can communicate due to limited ITC infrastructure and resources.

A clear message is to watch the developments of mobile phones. The developing world accounts for two-thirds of total mobile phone subscriptions, and Africa has the world's fastest growing mobile phone market.[1] Although the number of people who own personal computers will increase, a personal computer is not ideal outside of the farm office. It is certainly not ideal in dusty environments or in monsoonal environments. In contrast, the mobile phone is an ideal technology. As reported from RA IV and RA VI text messages have many advantages. They do however have limits in terms of the amount of information that can be made available on the screen. The chapter from RA IV usefully contrasted SMS messages with the layers of detail and interactivity in the US drought report. The chapter from RA VI details an interesting case where German farmers did not adopt the use of SMS service because they did not judge the advantages outweighed the costs.

[1] http://ictupdate.cta.int/en/Regulars/Editorial/Editorial-A-chronicle-of-ICTs-in-agriculture

Improving institutional arrangements

A clear message from all reports was that technology was not going to solve the communication challenge. This was echoed by all Working Groups at the Toowoomba Conference.

WG 1 *The need to better understand the reasons why products are either used or not used by a wide range of decision makers (e.g., Government officials, farmers, etc) and to study the needs for new products… Employ an interdisciplinary approach and teams including sociologists, economists, and users in the development of AgroMet products.*

WG 2 *Experts do not consult users enough about their requirements for products and services*

WG 3 *In general, in the past two decades, there has been a steady decline in both the number of personnel and technical competences of many extension services related to delivery of agrometeorological products.*
• Despite the need for greater interaction with the farming community to meet the need for increased farming productivity, in general, the NMHS have not been allocating the resources needed to make this commitment.

The chapter from RA 1 made a plea for more skilled workers in the area of agrometeorology and there are calls from most regions for better training in media skills and communication for agrometeorologists and more background in agrometeorology for the communication media. As noted from RA 1 and RA III the lack of understanding from media people in agrometeorology leads to misinformation. The RA IV report details an approach from Okalahoma Sate University which has a dedicated weekly television program that includes weather information. Although the Internet is a source of immediate information, increasingly it can also be a source of training material and discussion papers on issues such as drought and El Nino and the use of probabilistic climate forecasts.

The task of communication is influenced by organisational arrangements, as noted in RA I, closer collaboration between meteorological and agricultural agencies is urgently needed. The reports of the discussion held by Fiji met service with agriculturalists in general and Fiji Pine and Fiji Sugar companies provides a good example. The Roving Seminars on Weather, Climate and Farming held in West Africa, Ethiopia and India provide an opportunity for farmers to learn about local weather and farming and for NMHS to learn more about the needs of farmers. http://www.wmo.int/pages/prog/wcp/agm/roving_seminars/index_en.html

7.3. Discussion on ToR c) feasibility of implementing new and/or appropriate tools for communication and dissemination

Collaboration such as that between the Samoan weather service and New Zealand Met Service and the detail at the Toowoomba workshop of NOAA involvement in RANET and the Australian Bureau of Meteorology with Pacific Islands are all examples where local intermediaries have been essential for communication.

There are interesting details on the complex public-private partnerships in reports from RA IV, V and VI. In many cases the products are developed by government and university agencies and then passed onto private firms. It is important to recognise the role that these private firms have in disseminating information through television, sponsored web sites, grower networks (eg grape growers in Australia) or through

mobile telephone in India. Not only does this reach a wider audience, a commercial operation has a high incentive to understand what their clients need and are willing to pay for. At the same time it is possible for government funded R&D to be quarantined for a select group of end users who are able to pay for it, or for priorities of public R&D organisations to be dominated by commercial incentives.

A consistent finding is that there is significant knowledge in farming communities about agriculture, meteorology and the application of meteorology to agriculture. The chapter from RA I urged for more involvement of indigenous knowledge.

The Farmer Field School approach as outlined by Gomes et al 2010 and Stigter et al 2010 follows a strongly client centred approach. Gomes et al 2010 summarise the principles as follows:

- Farmers are experts: farmers learn by carrying out for themselves the field studies/comparisons related to the particular farming practice, they are interested in "learning by doing";
- Field based education: real live examples in the field (farmer domain) is the primary learning material. Farmers interact in small sub-groups (10-15 farmers) to collect and analyse data and perform action. Farmer driven research should be responsive to field needs as part of the research network and supporting educational programs;
- Decisions based on farmer analyses and shared with others in the group for further discussion, questioning, and refinement;
- Extension workers are facilitators, not teachers: extension workers only offer guidance to farmer projects (mainly principles but no packages nor atomised messages);
- Problem posing/problem solving: problems/challenges confronted in the field along the season are tackled in real-time using numerous analytical methods within farmer groups;
- Holistic approach integrating all technical, ecological, socio-economic and educative aspects;
- Group dynamics within farmer teams for skill building in communication, problem solving, leadership towards higher quality of farmers, farm management skills.

The notion of extension workers as facilitators not teachers offering principles but not atomised messages is challenging but an aspect of the sociology of knowledge and deliberate management of power politics that are part of the approach. Central to this approach is the notion that communication between farmers is of the greatest importance.

One of the most interesting developments is how new technology that was once a form of communication from *one* to *many* can now be used for communication from *many* to *many*. Some of these developments have been summarised as Web 2.0 captured by a shift of publishing encyclopaedia Britannica on-line to the participatory approach involving 'radical trust' in users associated with Wikopedia. In this environment many applications are in 'perpetual beta' mode and the end use of applications emerges rather than being pre-determined. Table 7.1 lists some of the opportunities and challenges for these developments for NHMS

Utilising Web 2.0 tools – challenges and opportunities Neal Moodie RA-V
Web 2.0 is defined as web applications that promote two way collaboratively shared

information over the internet. Governments across the world are actively investigating how to harness these tools to more effectively engage and interact with their communities. As the internet becomes more pervasive, and these applications mature and their popularity grows, the potential for cost effective interactions directly with all corners of the community becomes a reality. NMHS need to monitor these developments and actively investigate strategies to utilise them to promote the use and understanding of their products and services. The opportunities and challenges relating to Web 2.0 are outlined below.

Opportunities	Challenges
• Provides an opportunity to transform the communication relationship from one to many, to one to many to many. Gives the community a chance to self-regulate and educate within the community, thus reducing the resources required for a NMHS to produce similar results (positive cost benefit ratio). • NMHS have the benefit of creating a more meaningful relationship with its community by providing an opportunity for members to belong to a trusted organisation where they have access to expertise that otherwise might not have been available to them. • NMHS can use blogs as a way of reflecting on past events and creating an opportunity for the community to share and learn from others experiences. NMHS should aim to provide background meteorological information and examples of services provided by NMHS at the time as a way to promote the use and understanding of their products. The community can review the performance of the services for themselves, which in turn will strengthen the trust they have in NMHS services. • A combined strategy of using the various strengths of each Web 2.0 application will provide additional avenues to communicate with internet users who may not be aware of internet services provided by NMHS. For example, Twitter can be used to create a group of followers who are interested in staying updated with aspects of NMHS services or information releases. NMHS can create content on their own websites, and alert Web 2.0 users directly to that content. • Some Web 2.0 applications, such as Facebook, Twitter, enable NMHS to create a resource where interested	▪ Ability of the NMHS to resource the Web 2.0 initiative. A NMHS may need to consider re-prioritising its resources and structuring activities to fully capture the potential of Web 2.0 communities. Due to the relative immaturity of Web 2.0 strategies and lack of tangible evidence highlighting successful campaigns over traditional communication methods, it can be difficult to convince management about the benefits and potential of Web 2.0 as an alternative communication strategy. It might pay for NMHS to conduct pilot test cases and review the success of each pilot before re-focusing resources towards a multi-pronged Web 2.0 communication plan. ▪ Regulation of mis-information may be challenging as community members have equal opportunity to provide explanations to the community, as does the NMHS. This may create tension between the goals of the NMHS and the goals of the members in the community. In some circumstances, moderating the content posted by users or imposing a set of guidelines for members to follow may be successful in achieving NMHS goals but may alienate some members into non-participation. The key for NMHS is to drive the conversations through active participation. ▪ Another challenge is maintaining ownership and currency of the information and focus of the Web 2.0 community that the NMHS is hosting. Experience shows that activity and interest levels about key issues facing a community ebb and flow over time, and NMHS must be responsive to these phases. A tactic used in blogs is to invite comments about an issue or service for a short period and then remove the opportunity for comments. NMHS

members can share their local weather information or experiences with each other. This type of resource can become a valuable non-official climate resource to complement the official quality controlled climate databases. The reliability and perceived accuracy of these observations and reports can be assessed on an individual basis, or the other members of the community can rate the performance of each other's information. This creates a peer-regulated environment where members share a similar vision and work together for the benefit of the group. • NMHS can utilise Web 2.0 applications such as Flickr or Youtube, that allow users to upload photos or videos on the internet, to create a learning resource whereby members can contribute imagery of their experiences during weather related events, such as drought, crop disease, storm damage. Members can provide metadata with the photos and for some catastrophic events, these images can be overlayed on a map to show the extent and severity of the damage to a region. This type of resource enables communities to visually learn from past experiences, and to capture this kind of experience for future generations.	can then analyse the feedback and develop an appropriate response strategy before responding to the community. ▪ There are issues around the copyright of content provided on Web 2.0 applications. NMHS may not be able to control how their content is presented, or if inappropriate advertising or content is associated with NMHS content and ultimately detracts from the intent of the NMHS message. Some Web 2.0 applications only allow content to be published under Creative Commons, an alternative form of copyright, which is less restrictive and more conducive to sharing across internet platforms. This may present a barrier to NMHS providing content with limited copyright protection, and NMHS should investigate their legal risks before committing to Web 2.0.

7.4 Discussion on ToR d) assessing the socio-economic and environmental impacts of these new tools

All regions found that hard evidence on the impacts of improved communication is difficult to identify. At the Toowoomba workshop, Stephen Lellyett Deputy Regional Director NSW Australian Bureau of Meteorology presented an analysis of the use of information in Australia. He noted the importance of this sort of analysis and the difficulties in conducting the analysis, he suggested economic choice modelling.

As noted by Pielke and Carbone (2002) it is difficult to work out the true cost of weather and climate related events and even harder to work out the value of information about these events. The analyst's choice of temporal and spatial scale will can lead to different, but internally valid, estimates. A local community might suffer loss from a hail storm, but a neighbouring community may benefit from higher prices. The time period matters as well, for example the impact of an El Nino event may be on the availability of seed for the coming year. The further challenge of valuing information about the likelihood of a coming event is even more complex, especially if the cost of false warning are included whereby action is taken and the event doesn't occur, or the damage is less than anticipated.

One approach is that used in an Australian Centre for International Research (ACIAR) which examined the value on a project that improved the communication of seasonal climate forecasts in North-Eastern Australia. The analysis was undertaken on the basis of the following assumptions:

- Area of cropping in the case study region - 3.6 million hectares
- Estimate of the value of SCF of $3.50/hectare[2]
- Sustainable max adoption rate[3] (with & without) remains the same at 45%
- Influence of the project on adoption of SCF speeds up adoption by 3 years (see below).
- Costs of the project $763,078

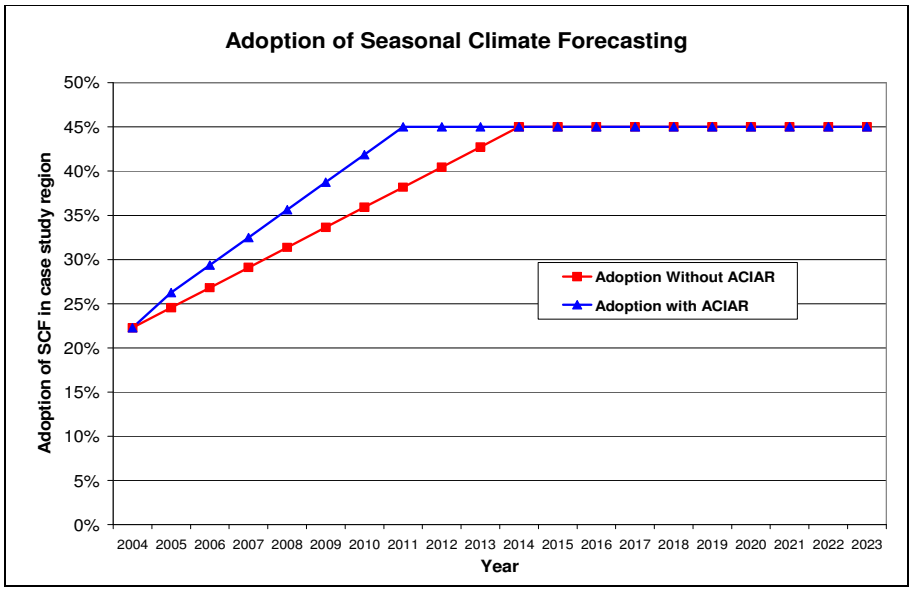


Figure 7.3 Simple with and without analysis of an Australian Centre for International Agricultural Research (ACIAR) that increased the rate of adoption of seasonal climate forecasts.

Using the above assumptions, the project $0.8 million project was found to have a net present value of $2.9 million and a benefit cost ratio of 5.2.

An interesting aspect of the RA VI report was the decline in the economic fortunes of many farmers and the dramatic decline in the number of farm holdings. This has implications for the market of agrometeorological information. However it is likely that the fewer farms will be larger enterprises and more willing to pay and use information.

[2] A value of $3.50 /ha is thought to be a conservative estimate of the value of SCF and is provided by Marshall, Parton and Hammer (1996), 'Risk attitude, planting conditions and the value of seasonal forecasts to a dryland wheat grower', AJARE, Vol. 40, No.3.

[3] While there are estimates currently of around 40-45% of farmers in Australia using seasonal climate forecasts, it is likely that the real (or significant) sustainable adoption rate is considerably lower. We have assumed that the current real rate of adoption is half of this reported rate.

7.5 Concluding remarks with special reference to CAgM

There is much in this report that applies to the many organisations involved in communicating agrometeorological products and services. There are specific recommendations and conclusions from the working groups at the Toowoomba conference and within each chapter of this report.

Pielke and Carbone (2002) compared the weather and climate prediction and information enterprise in the US as a complex system with different participants that had different and sometimes conflicting perspectives and values. They concluded that it was similar to the health care system in its complexity and the difficulty of finding a place to get a perspective of the whole system. Different roles and views from public and private advisers and roles of NGOs and governments all add to the complexity. Any perspective is partial, and from that incomplete perspective the following conclusions are made

1. CAgM needs to continue to monitor and report on technological and sociological aspects of the rapid changes in Information and Communication Technology in both developed and developing countries.
Evaluation is undertaken to 'prove' and 'improve'; there is a need to 'prove' to both meteorological services and to agricultural organisations that resources spent on agrometeorology lead to improvements in sustainable agriculture. At the same time it is vital that we all learn from success and failure of rapidly changing ITC so that scarce resources are well spent. The reporting of the failure of SMS services in Germany from RA VI report must be commended as there is a culture of only reporting success and this inhibits the learning process.

2. Recognising that communication relies on skilled people, CAgM encourage training courses on media and communication for agrometeorologists and on agricultural applications for meteorologists and communication personnel.
The report from RA I made a specific plea for training. As outlined in the report from RA IV one of the lessons of the US drought monitor is that drought is a complex, contested issue and needs to be thoughtfully communicated. Hayman and Cox 2007 drew attention to deep misunderstanding in the concept of drought between the lived experience of rural communities, a meteorologist and a policy economist. Gomes et al 2010 note that warning systems have to be communicated wisely and carefully or they can end up doing more damage than good.

3. Special attention is paid by CAgM to developments associated with Web 2.0 as it presents and opportunity for feedback and end user interactivity but also challenges the quality of information available for decision makers
We started this report with reference to the early years of Agricultural Meteorology as a discipline and CAgM that was originally focussing on standardising the measurement of advances in environmental physics (Steiner and Hatfield 2008, WMO 2008). One of the leaders in the environmental physics John Monteith at a WMO conference posed the question "How can the skills developed in operational, experimental and theoretical aspects of agricultural meteorology be more effectively integrated and deployed to make production in systems of agriculture and forestry more reliable, more efficient and above all more equitable in the world at large". (Monteith 1993). This report suggests that one of the ways is through appropriate communication. Just as CAgM played an authoritative role in coordinating experts in standardising measurements, there is a need for leadership in how agrometeorological information is made useful in the Web 2.0 environment

References – to be completed

Appendix 1

Talking about the weather with farmers by Neal Moodie RA IV, http://www.wamis.org/agm/meetings/wocaps09/S3-Moodie.pdf

The importance of computing Length of Growing Periods (LGP) in a given locality to investigate the extent of climate change and to design appropriate decision support systems and strategies accordingly by Almaz Demessie, RA I http://www.wamis.org/agm/meetings/wocaps09/S6-Demessie.pdf

Agrometeorological Information in South America by Mr Edgar Imana, http://www.wamis.org/agm/meetings/wocaps09/S6-Imana.pdf

Communicating Agrometeorological Infomraiton in RA-IV: Experiences with the U.S. Drought Monitor and Similar Products by Harlan Shannon http://www.wamis.org/agm/meetings/wocaps09/S6-Shannon.pdf

Overview of Agrometeorological Products and Services in Germany by Walter Trampf, http://www.wamis.org/agm/meetings/wocaps09/S6-Trampf.pdf

Risky communication: uncertain climate information and imperfect decision makers by Peter Hayman, http://www.wamis.org/agm/meetings/wocaps09/S3-Hayman.pdf

Appendix 2 (to be read with Chapter 6 by Walter Trampf)

Table 6.1
Current means of communication of agrometeorological products and services
to the farming sector in different regions (RA VI)

Products	Communication	Users
Albania		
Hydrometeorological Institute Dept. Agrometeorology http://www.wamis.org/countries/albania/POSTER_2004.pdf Agrometeteorological Bulletins	Mail	Farmers
Armenia		
Armstatehydromet www.meteo.am	Phone (free of charge), fax, mail, e-mail (free of charge to the governmental bodies, fee-based in case of contracts), web	Governmental bodies (Ministry of Agriculture, Ministry of Nature protection, Ministry of Emergency situations, etc)
Extension Department of the Armenian State Agrarian University	Phone, fax (distribution by farmers' associations, agricultural support regional (marz) centers)	Farmers
Austria		
ZAMG (Zentralanstalt für Meteorologie und Geodynamik) Agrarwetter http://www.zamg.ac.at/produkte/branche/landwirtschaft/ forecasts	Phone (fee-based)	Farmers
Belarus		
Department of Hydrometeorology http://www.pogoda.by/315/agr.html reports	Web (free of charge)	Farmers
Belgium		
Agrometeorologische Berichten van België – Bulletin Agrométéorologique de la Belgique (published 3 times during the growing season) Description of meteorological conditions, crop growth and development and yield forecasts (maps, tables)	e-mail & websites (free of charge):	Flemish & Walloon authorities, EC, farmers' organisations, insurance sector

French & Dutch version project website: http://bcgms.cra.wallonie.be/en/Agrometeorological_Bulletins/Bulletins_FR.aspx (Dutch version) http://bcgms.cra.wallonie.be/en/Agrometeorological_Bulletins/Bulletins_NL.aspx (French version) -link at WAMIS website: http://www.wamis.org/countries/belgium.php -link at NIS website: http://www.statbel.fgov.be/port/agr_nl.asp		scientific users, etc.
Bosnia and Herzegovina		
Republic hydrometeorological service Banja Luka Agrometeorology www.meteo-rs.com/agroizvjestaji Decadal agrometeorological survey Seven–day agrometeorological forecasts Tables, figures, maps, analysis	Web, phone (free of charge)	Farmers; public agricultural advisory
Federal Hydrometeorological institute(FHMI) www.fhmzbih.gov.ba/latinica/agrometeorologija Agrometeorology Ten - day agrometeorological analyses, Seven–day agrometeorological forecasts Tables, figures, maps,	Web, phone, media (radio and TV (free of charge)	Farmers; public agricultural advisory
Bulgaria		
NIMH-BAS (National Institute of Meteorology and Hydrology) Dept. Agrometeorology http://www.meteo.bg/meteorology/agro_e.htm maps	Web	Farmers
Croatia		
Meteorological and Hydrological Service of Croatia (DHMZ) http://meteo.hr Agrometeorological Bulletin twice a week Tables, graphs, maps, forecasts	Web (free of charge)	Farmers; public agricultural advisory; private agricultural advisory
Meteorological and Hydrological Service of Croatia (DHMZ) http://meteo.hr Protection of forest fire Table, forecasts every day	Web (free of charge)	Firemen, Ministry of Interior State Directory for Protection and Rescuing (links to DHMZ

		pages)
Meteorological and Hydrological Service of Croatia (DHMZ) Agrometeorological forecasts three times a week	Croatian TV (HTV) (free of charge)	All users
Meteorological and Hydrological Service of Croatia (DHMZ) Agrometeorological forecast once a week	Croatian radio (HR) (free of charge)	All users
Meteorological and Hydrological Service of Croatia (DHMZ) Agrometeorological forecasts twice a week	Newspapers Vjesnik (free of charge)	All users
Meteorological and Hydrological Service of Croatia (DHMZ) Agrometeorological advice and forecasts (2–3 calls for day)	Telephone (free of charge)	All users
Meteorological and Hydrological Service of Croatia (DHMZ) Agrometeorological forecasts twice a week	SMS (Fee-based)	Clients of Podravska Banka
Croatian Agricultural Extension Institute (HZPSS) http://www.hzpss.hr Agricultural advice for plant protection	Web (free of charge)	Farmers
Czech Republic		
Czech Hydrometeorological Institute Climatological section, Dept. of biometeorological applications http://www.chmi.cz/meteo/ok/obae.html#pvsai Tables, maps, graphics, forecasts Phytopathology	Web fax, e-mail, phone	Farmers' organizations and companies engaged in agriculture
Denmark		
Danmarks Meteorologiske Institut (DMI) www.dmi.dk Climate, maps, tables, forecasts, radar and satellite pictures	Web (free of charge). Phone (fee-based)	Public in genera including farmer
Dansk Jordbrugsforskning and Dansk Landbrugrådgivning www.planteinfo.dk/ Weather information provided by DMI. Forecast for 7 days, radar, observations, climate, forecasts for specific location, tables, potential evaporation	Web (fee-based)	Farmers and vine and fruit-growers
Dansk Landbrug, Dansk LandbrugsMedier & Dansk Landbrugsrådgivning	Web, Phone (fee-based)	Farmers

http://landmand.dk/ Weather information provided by DMI. Forecast and radar. Links to www.planteinfo.dk/		
Finland		
Finnish Meteorological Institute http://www.fmi.fi/tuotteet/maatalous.html#2 Tables, maps, forecasts SMS by Weather Proof SMS Matalous	Web phone SMS (fee-based)	Farmers' organisations and companies engaged in agriculture
France		
Météo-France (MF) http://france.meteofrance.com/ General forecasts, observed data table, water resources assessment (monthly time step)	Web (free of charge)	Farmers, public agricultural advisory
Météo-France (MF) https://agro.meteofrance.com/agriculture/accueil High resolution data (observed and forecast), rainfall radar data, climate update	Web (fee-based)	Farmers (incl. vine and fruit-growers), farmers' associations, technical institutes, suppliers of materials, seed firms, insurance, farmers, public agricultural advisory, private agricultural advisory
Météo-France (MF) Forecasts, warnings, nowcasting	Phone, fax, SMS (fee-based)	Farmers (incl. vine and fruit-growers) or farmers' associations
Farmers Weather information, climatological tools, specific information for crop management (treatment, irrigation, harvesting…)	Extranet	Mainly farmers' associations, or big farms (vine producers, for instance)
Germany		
Deutscher Wetterdienst (DWD) www.dwd.de/agrowetter Agrarwetter (Agro-weather) Tables, maps, graphics, forecasts	Web (free of charge)	Farmers, public agricultural advisory, private

Forest fire danger risk Phenology Agroclimatology		agricultural advisory (links to DWD pages)
Deutscher Wetterdienst (DWD) www.dwd.de/agrowetter Agrowetter(c): Tables, maps, graphics, forecasts Irrigation advice	Web (fee-based)	Farmers (incl. vine and fruit-growers)
Deutscher Wetterdienst (DWD) www.dwd.de/agrowetter Service und Beratung (Service) Wetter und Wetterfax für die Landwirtschaft Agrarwetterberichte (Reports) Tables, forecasts	Phone, fax (distribution by farmers' associations or public agricultural advisory) (fee-based)	Farmers (incl. vine and fruit-growers)
BBV GmbH (Company of the Bavarian farmers association) www.landwetter.de Tables, forecasts from DWD	Fax, Web (fee-based)	Farmers
MAIS www.mais.de Tables, forecasts from DWD	Fax, Web (fee-based)	Farmers
Landvolk Niedersachsen Landesbauernverband (Farmers association of Lower Saxony) http://www.landvolk.net/Mitgliederservice/Wetterfax/index.php Tables, forecasts from DWD	Fax (fee-based)	Farmers
Agrardienst Baden GmbH http://www.agrardienst-baden.de/wetterfax/index.html Tables, forecasts from DWD	Fax (fee-based)	Farmers
Landwirtschaftskammer Nordrhein-Westfalen (Chamber for agriculture of North Rhine-Westphalia) http://www.landwirtschaftskammer.de/landwirtschaft/infodienst/index.htm Tables, forecasts from DWD (Rhineland)	Fax, e-mail (fee-based)	Farmers
LLH Landesbetrieb Landwirtschaft Hessen (public service of the Land Hessen) http://www.llh-hessen.de/landwirtschaft/pflanzenbau/wetterfax/wetterfax.htm Tables, forecasts from DWD	Fax (fee-based)	Farmers
BAYERCROPSCIENCE Agricultural web pages of the BAYERCROPSCIENCE corporation www.bayercropscience.de tables, maps, forecasts (maps partly from DWD)	Web (free of charge)	Farmers' organisations and companies engaged in agriculture
BASF Agricultural web pages of the BASF corporation	Web (free of charge)	Farmers' organisations

www.agrar.basf.de tables, maps, forecasts (also for plant diseases and pests) (data partly from DWD)		and companies engaged in agriculture
ISIP (information system of public plant protection services of the Länder) www.isip.de tables, maps, forecasts (esp. for plant diseases and pests) (data from DWD and Länder)	Web (Mostly fee-based)	Farmers, plant protection services, agricultural advice
Internetwetter (private Internet Service) Agrarwetter http://www.internetwetter.de/home/agrarwetter.htm maps from DWD	Web (free of charge)	Farmers' organisations and companies engaged in agriculture
Informationszentrum für die Landwirtschaft (Web portal for the agriculture) www.proplanta.de/Agrar-Wetter/ Tables and maps from DWD or esp. forecasts from private company (free of charge)	Web (free of charge)	Farmers' organisations and companies engaged in agriculture
Proplant GmbH (Information and decision support system for farmers and agricultural advice) Company with public and private partners www.proplant.de data and forecasts partly from DWD	Web (fee-based)	Farmers' organisations and companies engaged in agriculture and crop protection
Bayrische Landesanstalt für Landwirtschaft (Bavarian Institute of Agriculture) with agrometeorological weather stations (public institution) http://www.lfl.bayern.de/agm/start.php data, graphics, monitoring of plant diseases and pests	Web (free of charge)	Farmers' organisations and companies engaged in agriculture and crop protection
AInfo Thüringer Landesanstalt für Landwirtschaft (Thuringian Institute of Agriculture) with agrometeorological weather stations (public institution) http://www.tll.de/wetter/wet_idx.htm data, tables	Web (free of charge)	Farmers' organizations and companies engaged in agriculture and crop protection
Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (Saxon Institute of Environment, Agriculture and Geology) with agrometeorological weather stations (public institution) http://www.landwirtschaft.sachsen.de/Wetter08/asp/inhalt.asp?seite=uebersicht	Web (free of charge)	Farmers' organizations and companies engaged in agriculture and crop protection

data, tables		
Dienstleistungszentren Ländlicher Raum Rheinland-Pfalz (Public services for the agriculture of the Land Rhineland-Palatinate) with agrometeorological weather stations http://www.dlr-rnh.rlp.de tables, maps, forecasts (partly from DWD)	Web (free of charge) Fax (fee-based)	Farmers
BOLAP GmbH (agricultural services) http://bolap.de/ tables, forecasts from DWD	Fax (fee-based)	Farmers' organizations and companies engaged in agriculture
Grand-Duchy of Luxembourg		
Administration des Services Techniques de l'Agriculture (ASTA) www.asta.etat.lu Meteorology Climatological data	Web (free of charge)	Farmers' organizations and companies engaged in agriculture
Maschinenbauring Luxemburg http://www.mbr.lu/ Tables, forecasts from DWD	Fax (fee-based)	Farmers
Greece		
Hellenic National Meteorological Service (HNMS) www.hnms.gr weather forecast up to 6 days Tables, maps, forecasts	Web, TV, phone (free of charge)	Farmers' agricultural co-operatives, Peripheral Centers of Ministry of Agriculture for plant protection, Agriculture Insurance Organisation
Hellenic National Meteorological Service (HNMS) www.hnms.gr in co-operation with Ministry of Agriculture www.minagric.gr Weather bulletin for farmers (forecasts, specified information regarding different cultivations)	Web, TV (free of charge)	Farmers' agricultural co-operatives
Hellenic National Meteorological Service (HNMS) www.hnms.gr/greek/agriculture 10-days Agrometeorological Bulletin Tables, diagrams *(available by the end of 2009)*	Web,e-mail (free of charge)	Farmers' agricultural co-operatives, Peripheral Centres of Ministry of Agriculture for

		plant protection, Agriculture Insurance Organization, Agricultural Universities, National Agriculture Research Foundation
Ireland		
Met Eireann http://www.ie/agri-environment/agri_agri.asp Tables, maps, forecasts	Web (free of charge) Weatherdial (fax and phone) (fee-based)	Farmers
Israel		
Israel Meteorological Service (IMS) www.ims.gov.il 0bservation,forecast Maps, tables, hourly data, Averages, forecast, warnings Contact us *	Web (free of charge)	Farmers, agricultural advisory, insurance companies
Israel Meteorological Service (IMS) www.ims.gov.il Agrometeorology Evapotranspiration Chilling portions (winter) Data, tables, averages	Web (fee-based)	Farmers, irrigation – consumers, gardeners
Ministry of Agriculture www.moag.gov.il Agrometeorology Frost forecast, warnings, tables	Web (fee-based)	Farmers, agricultural advisory, insurance companies
Israel Meteorological Service 10 Days (Decade) Agrometeorological Bulletin Tables, averages, daily data	Mail	Farmers, diverse consumers, libraries, agricultural advisory, insurance companies
Regional Research Institute www.Mop-zafon.org.il www.Mop-darom.org.il	Web (fee-based)	Local farmers, agricultural advisories

Tables, maps, daily data		
Italy		
Hydrographisches Amt Autonome Provinz Bozen Hydrological department of the Autonomous Province of Bolzano http://www.provinz.bz.it/hydro/wetter_landwirtschaft_d.htm bulletin for the agriculture in the region of Bolzano tables, forecasts	Web (free of charge)	Farmers' organisations and companies engaged in agriculture
Arpa Servicio Idro-Meteo-Clima Northern Italy (province of Emilia-Romagna) http://www.arpa.emr.it/sim/?agrometeo Tables, maps, forecasts Reviews (monthly and weekly)	Web (free of charge)	Farmers' organisations and companies engaged in agriculture
Istituto Agrario di San Michele al Adige (Fondazione E. Mach) Autonomous Province of Trento http://meteo.iasma.it/meteo/index.php Tables, maps, forecasts for the province of Trento Irrigation advice	Web (free of charge)	Farmers' organisations and companies engaged in agriculture
Agricoltura Italiana (Ministry of Agricultural Food and Forestry Policies) National agrometeorological network http://en.agricolturaitalianaonline.gov.it/servizi/meteo Tables, maps, forecasts Bulletins	Web (free of charge)	Farmers' organisations and companies engaged in agriculture
La Rete agrometeorologica del Piemonte (RAM) Province of Piemont http://www.regione.piemonte.it/agri/set_fitosanit/agrometeo/climatologia/ram.htm Tables, maps, forecasts	Web (partly free of charge)	Farmers' organisations and companies engaged in agriculture
Arpa Veneto Dipartimento Regionale per la Sicurezza del Territorio Centro Meteo di Teolo (Province of Veneto) UNITA' OPERATIVA AGRO-BIOMETEOROLOGICA http://www.arpa.veneto.it/agrometeo.htm Tables, maps, forecasts	Web	Farmers' organisations and companies engaged in agriculture
ARSSA Centro agrometeorologico regionale Scerni Regione Abruzzo http://www.arssa.abruzzo.it/car/ Tables, reports, maps, forecasts Irrigation service	Web e-mail	Farmers' organisations and companies engaged in agriculture
Regione Campania, Assessorato all` agricoltora	Web	Farmers'

http://www.sito.regione.campania.it/agricoltura/meteo/agrometeo.htm Tables, reports, maps, forecasts		organisations and companies engaged in agriculture
Arsia Regione Toscana http://agrometeo.arsia.toscana.it/ Tables, reports, maps, forecasts	Web	Farmers' organisations and companies engaged in agriculture
SIAS Regione Sicilia http://www.sias.regione.sicilia.it/ Tables, reports, maps, forecasts	Web	Farmers' organisations and companies engaged in agriculture
Sardegna Arpa http://www.sar.sardegna.it/ Tables, reports, maps, forecasts Irrigation service	Web	Farmers' organisations and companies engaged in agriculture
Kazakhstan		
Kazihydromet http://www.meteo.kz/page.php?page_id=350&lang=2 Agrometeorological informations	Web	Farmers' organisations and companies engaged in agriculture
Lithuania		
Lithuanian Hydrometeorological Service http://www.meteo.lt/english/services.php data	Fax, e-mail	Farmers' organisations and companies engaged in agriculture
Latvia		
Latvian Environment, Geology and Meteorology Agency www.meteo.lv General meteorological forecasts, meteorological observation data	Web (free of charge)	All users incl. farmers
Latvian Environment, Geology and Meteorology Agency www.meteo.lv Agrometeorological and meteorological data, maps, forecasts	Web, phone, fax, mail (information on request) (fee-based)	All users incl. farmers
Moldova		
State Hydrometeorological Service (SHS) www.meteo.md Tables, forecasts, press releases, brochures	Phone, fax, Web, mass-media (free of charge)	Public agricultural advisory, private agricultural advisory,

		farmers (specia forecasts for farmers are not provided, so tha they are using those addressec to mass-media)
Montenegro		
Hydrological and Meteorological Service of Montenegro http://www.meteo.cg.yu/misc.php?text=8&sektor=1 Maps, tables, graphics, reports	Web (free of charge)	Farmers' organisations and companies engaged in agriculture
Poland		
Institute of Meteorology and Water Management www.imgw.pl/index.php? options=com_wrapper&view =wrapper&Itemid=236 Tables, graph, forecasts, comment and advice for farmers	Web free of charge	Farmers, agricultural advisory; public administration
Institute of Plant Protection www.ior.poznan.pl/monitoring_zmiemniaka.php	Web free of charge	Farmers (esp. potato producers); advisory service
Portugal		
Instituto di Meteorologia http://www.meteo.pt/pt/agrometeorologia/mapas/ maps, tables, graphics, reports	Web	Farmers
Romania		
Meteo Romania (Nat. Meteorological Administration) http://www.meteoromania.ro/index.php?id=368 http://www.meteoromania.ro/index.php?id=368&lang=en (English) agrometeorological diagnoses at country, agricultural region, county and locality level; - agrometeorological forecasts at country and agricultural region level. Reports, tables, maps, forecasts	Web	Farmers' organisations and companies engaged in agriculture
Russian Federation		
Hydrometeorological Center of Russia (responsible for the country) http://hmc.hydromet.ru http://meteoinfo.ru	free of charge As a rule HMC has an agreement with end-users.	Ministries, Federal agricultural organizations, insurance companies
Weather forecasts with different advance time	The same	The same

Agrometeorological forecasts (wintering conditions, availability of water and heat, productivity and total yield for principal crops – the country and 7 big federal districts)	The same	The same
Agrometeorological survey for the last decade	The same	The same
Note on some hazard weather and climate phenomenon (drought, frost, hail, flood, tornado, etc.)	The same	The same
Information about other agro-meteorological events	The same	The same
A territorial body of Rosgidromet (included several regions, responsible for these regions, there are 24 bodies within the country). Web-site of the NHS http://www.meteorf.ru contains the addresses of regional body (UGMS) web-sites	Free of charge or fee-based depending on products	Local agricultura organisations, farmers, regional bodies
Local weather forecasts with different advance time	The same	The same
Local agrometeorological forecasts (wintering conditions, availability of water and heat, productivity and total yield for principal crops – the regions)	The same	The same
Local agrometeorological survey for the last decade	The same	The same
Local agro-meteorological bulletin, including information for some hazard weather and climate phenomenon (drought, frost, hail, flood, tornado, etc.)	The same	The same
National Institute on agricultural meteorology (responsible for the country) http://cxm.obnisk.org Only in Russian		
Agrometeorological forecasts for some crops with significant advance time	Free of charge	Pass to HMC
Estimates of crop state and productivity	Free of charge	Pass to territoria bodies of Rosgidromet
Detection of drought and its severity	Free of charge	Pass to HMC and some national HMS
Agro-meteorological information and some advice http://www.agromet.ru Only in Russian	Web system, experimental exploitation	Farmers' and agricultural enterprises
Expert conclusion for some hazard weather and climate phenomenon	Fee-based	Insurance companies
Meteorological agency (responsible for the country, provides meteorological services as some commercial product http://www.meteoagency.ru Only in Russian	Fee-based	Requested organisations
Non standard territory	The same	The same
Non standard aggregation	The same	The same
Non standard processing	The same	The same
National Institute on Meteorological information http://www.meteo.ru	Fee-based	Requested organisations

Agro-climate products		
Serbia		
Hydrometeorological Service of Serbia http://www.hidmet.gov.rs/eng/meteorologija/agro.php Bulletins, reviews	Web (free of charge)	Farmers' organisations and companies engaged in agriculture
Spain		
AEMet (Agencia Estatal de Meteorologia) http://www.aemet.es/es/eltiempo/observacion/balancehidrico Maps of the water balance	Web (free of charge)	Farmers' organisations and companies engaged in agriculture
Sweden		
SMHI Weather for agriculture (Lantbruksväder) http://www.smhi.se/cmp/jsp/polopoly.jsp?d=5873&a=15289&l=sv Tables, maps, forecasts http://www.smhi.se/cmp/jsp/polopoly.jsp?d=5873&a=19854&l=sv Irrigation advice	Web (distribution by organization LRF) (fee-based)	Farmers
Switzerland		
MéteoSwiss (Federal Office of Meteorology and Climatology) http://www.meteoschweiz.admin.ch/web/de/services/landwirtschaft/profi_landwirtschaft.html Tables, maps, forecasts	Web (fee-based)	Farmers' organisations and companies engaged in agriculture
United Kingdom		
Metoffice UK http://www.metoffice.gov.uk/agriculture/index.html General monthly summery		Farmers' organisations and companies engaged in agriculture
Met Office Rural Environment Team		
Potato Late Blight Warnings - BlightWatch http://www.blightwatch.co.uk/content/bw-Home.asp	Web, e-mail & SMS; corporate sponsorship (free to users)	Potato growers agricultural advisors, agronomists
Raspberry Cane Midge – Spray Timing Alerts	e-mail	Fruit growers
Soil Moisture Balance – MORECS	various	Water resource planners, wate supply

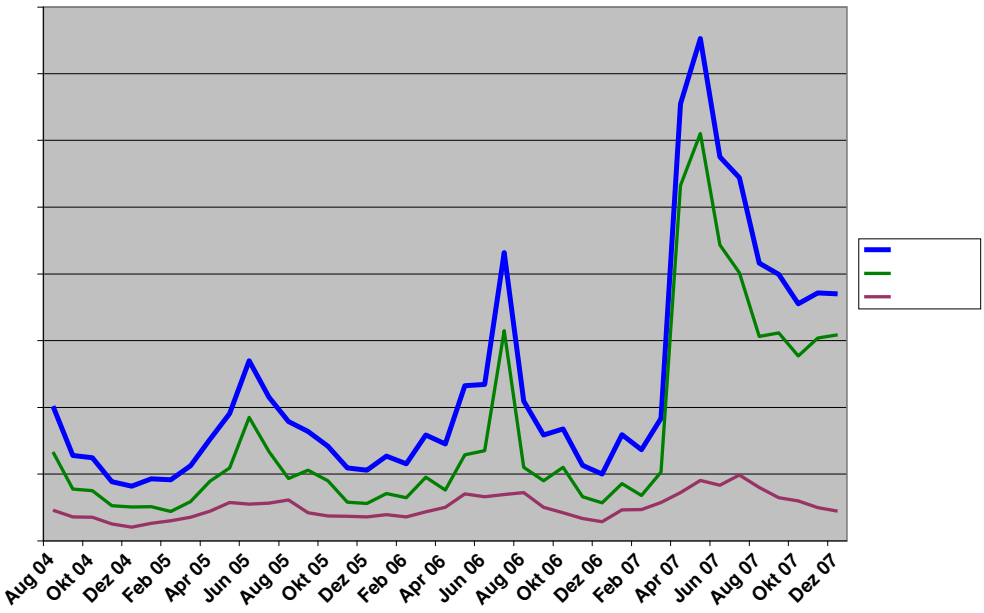
		companies
Fire Risk Model http://www.openaccess.gov.uk/wps/portal/!ut/p/.cmd/cs/.ce/7_0_A/.s/7_0_G3/_s	Website & SMS	Countryside managers
Wind throw alerts	Website, e-mail & SMS	Railway industry
Emissions and air quality modelling from livestock	Reports	Livestock farmers
ADAS Crop Action – weekly weather and arable cropping bulletin	E-mail	Arable farmers
IrriGuide – Irrigation planning service	E-mail	Farmers and growers
Ukraine		
Ukrainian Hydrometeorological Center http://meteo.com.ua/agro/a_review Reports	Web (free of charge)	Farmers' organisations and companies engaged in agriculture

Graphic 1

Page views of DWD Agrometeorological Web Pages

(red curve: fee required pages, green curve: pages free of charge

blue curve: total)



Graphic 2

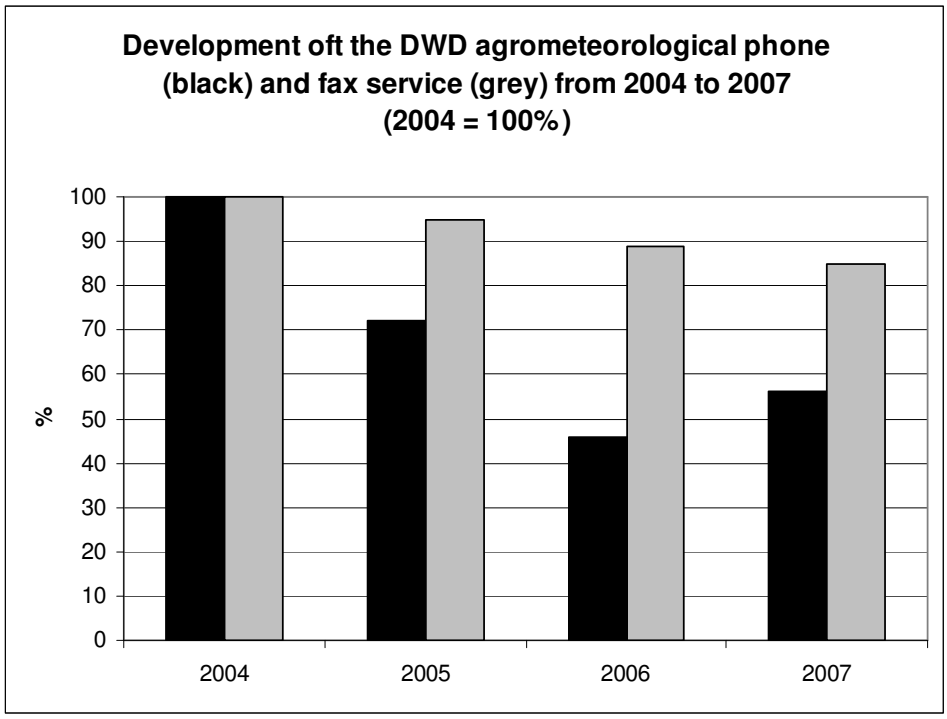
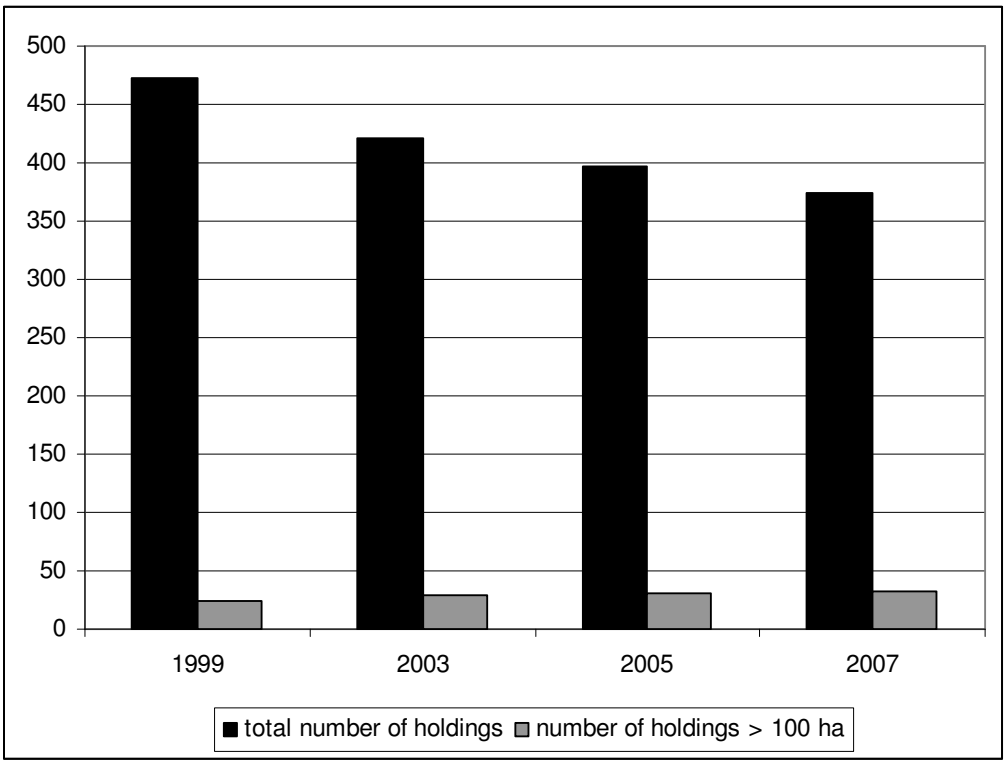


Table 6.2
Agriculture in Germany
Number of agricultural holdings (in 1000 units) and range of the agricultural areas

Development from 1999 to 2007

	1999	2003	2005	2007
Total	472	420,7	396,6	374,5
< 2 ha	37,8	32,6	30,6	25,5
2 - > 10 ha	153,7	132,8	120	113,1
10 - > 30ha	139,1	117,3	110	102,2
30 - > 50ha	62,6	54,5	51,3	48,5
50 - > 75ha	37	36,3	35,5	34,5
75 - > 100ha	17,3	18,7	18,9	18,9
> 100 ha	24,4	28,5	30,3	31,9



Graphic 6.3

Table 6.3
Numbers of the agricultural holdings in the European Union
Development from 2003 to 2007 and change rate (%)

Country	2003	2007	change in %
Romania	4 484 890	3 931 350	**-12,3**
Poland	2 172 210	2 390 960	10,1
Italy	1 963 820	1 679 440	**-14,5**
Spain	1 140 730	1 043 910	**-8,5**
Greece	824 460	860 150	4,3
Hungary	773 380	626 320	**-19**
France	614 000	527 350	**-14,1**

Bulgaria	665 550	493 130	**-25,9**
Germany	412 300	370 480	**-10,1**
UK	280 630	299 830	6,8
Portugal	359 280	275 080	**-23,4**
Lithuania	272 110	230 270	**-15,4**
Austria	173 770	165 420	**-4,8**
Ireland	135 620	128 240	**-5,4**
Latvia	126 610	107 750	**-14,9**
Netherlands	85 500	76 740	**-10,2**
Slovenia	77 150	75 340	**-2,3**
Sweden	67 890	72 610	7
Slovakia	71 740	68 990	**-3,8**
Finland	74 950	68 230	**-9**
Belgium	54 940	48 010	**-12,6**
Denmark	48 610	44 620	**-8,2**
Cyprus	45 200	40 120	**-11,2**
Czech Republic	46 770	39 400	**-13,9**
Estonia	36 860	23 340	**-36,7**
Malta	10 990	11 020	0,3
Luxemburg	2 450	2 300	**-6,1**
EU-27	15 021 410	13 700 400	**-8,8**

Source:
Landwirtschaft in Deutschland und der Europäischen Union
Statistisches Bundesamt, Wiesbaden
Internet: www.destatis.de
Erschienen im Juli 2009
Artikelnummer: 1023207-09900-4

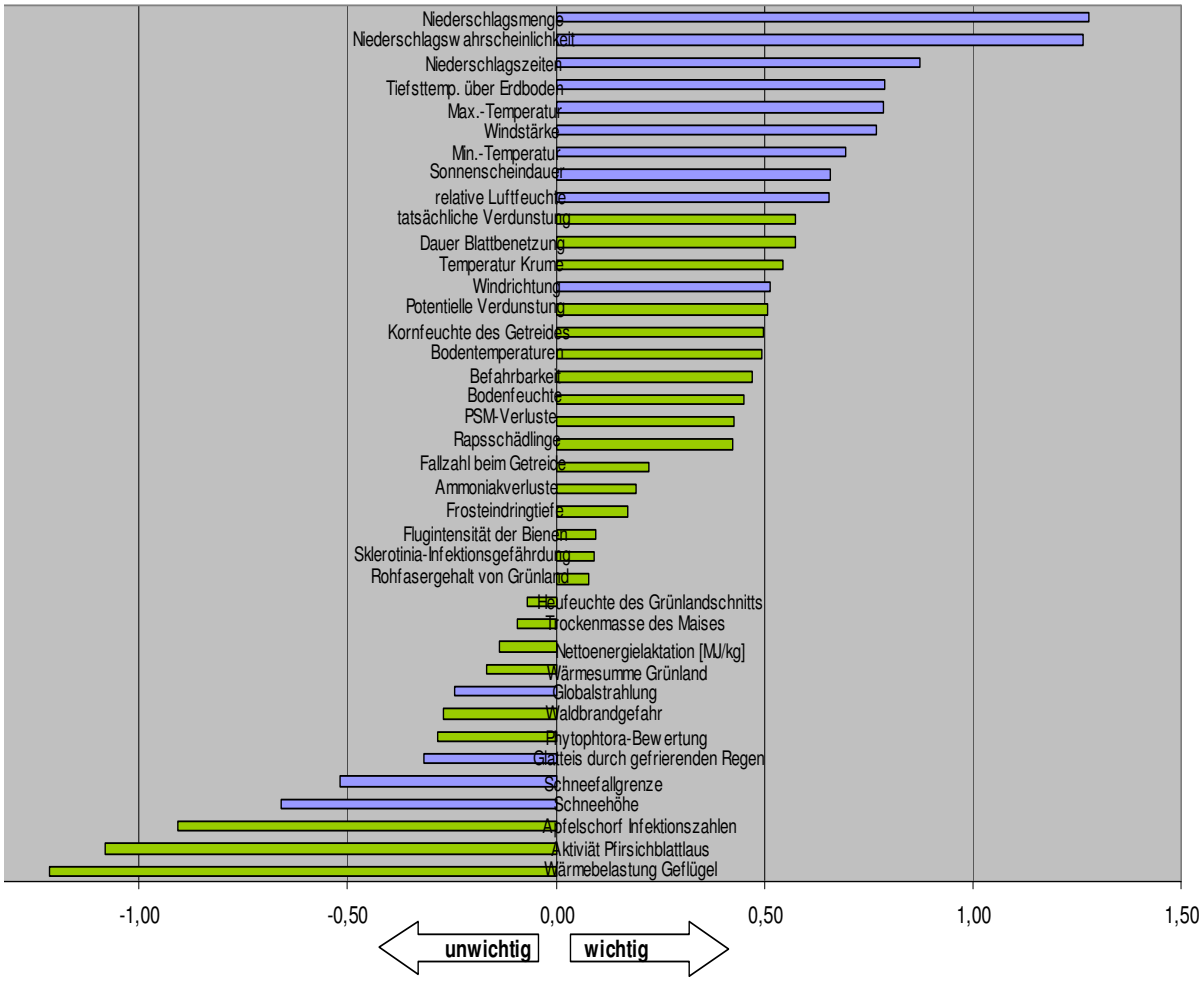
Table 6.4

Ranking of agrometeorological parameters

(Result of polls to farmers using the fax service of the Agrometeorology Dept. of DWD)

Question: Which parameters of the fax table are most important for you?

Welche Tabellenwerte sind besonders wichtig für Sie?



Not important important

(Translation of the name of parameters from the first line downwards)

Not important	**important**
Hay moisture	Rain amount
Dry mass of maize	Probability of rain
Net energy content for lactation	Time of rain
Heat sum	Minimum Temperature (5 cm height)
Global radiation	Maximum Temperature
Forest fire risk	Wind speed
Potatoes blight	Minimum Temperature
glaze by freezing rain	Sunshine duration
Snow line	Rel. humidity
Apple scrap infection	Actual evapotranspiration
Aphids (met. conditions)	Leaf wetness (duration)
Heat stress in poultry	Soil temperature (5cm depth)
	Wind direction
	Pot. evapotranspiration
	Corn moisture
	Soil temperatures
	Tractability
	Soil moisture
	Pesticides volatilisation
	Rape beetle, rape weevils (met. conditions)
	Falling number (cereals)
	Ammonium losses
	Frost depth
	Bee flight (met. conditions)
	Risk of sclerotina
	Fibre content of grass