

## Communicating agrometeorological information to farming communities

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### Abstract

Agrometeorological information, used for decision making, represents part of a continuum; at the other end is scientific knowledge and understanding. Other components of this continuum are the collection of data and transforming data into useful information. Information has value when it is disseminated in such a way that the end-users get the maximum benefit in applying its content. This paper explores the potential of the new information and communications technologies to improve the access to agrometeorological information. The Internet will play an important role in the collection and transfer of information. In developing countries, Multi-Purpose Community Telecentres (MCTs) will be the equivalent of an information supermarket. Radio can be used to transfer information from MCTs to rural areas. Using response farming as an example, a prototype information system that can have wide applicability is suggested. Procedures on evaluating the impact of agrometeorological information are provided. Future concerns about the information needs of diverse end-users, information on a fee basis, and the training needs of end-users and intermediaries are discussed. Although modern technology has improved agrometeorological 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. © 2000 Elsevier Science B.V. All rights reserved.

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### 1. Introduction

Information can be identified as the cornerstone to successful farming in the 21st Century. Agricultural producers already know that information is important and valuable. Many farmers in developed countries already pay for information ranging from updates on weather conditions, soil and nutrient status, pest man-

agement reports and recommendations, to advice on what genetic seed line to plant for various field conditions. The price that farmers pay for information can be thought of in cost per hectare. Farmers will judge the expected benefit of acquiring information against the cost of implementing a recommendation, e.g., a pesticide application. Technology that provides information to a producer, which would cost more than the cost of the recommendation (a pesticide application), will have a very limited chance of being readily accepted.

It must also be considered that timely availability and appropriate use of agrometeorological information

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are vital to successful farming operations. In order for this information to be considered as a resource it must be shown to have value to the farmers as well as to the various agencies that provide support to the development, generation, and dissemination of this information. The benefits of agrometeorological information need to be communicated to the many potential users in farming communities, especially those in developing countries where agricultural production is low and food insecurity is prevalent.

Agrometeorological information is part of the continuum that begins with scientific knowledge and understanding and ends with evaluation of the information. Scientific knowledge and understanding transcend national borders, cultures, and societies. For example, the C3 photosynthetic pathway is the same in Argentina as it is in Canada. To use this knowledge and understanding to generate agrometeorological information is a function of the user community. While the problems may be similar across different communities, they differ due to the various degree of availability of human, financial and natural resources. Major components that also may differ between developed and developing countries are: capabilities for collection of data, changing data into useful information, dissemination of information, and evaluation of information. Collection of data and changing data into useful information has been discussed by Doriaswamy et al. (2000), Maracchi et al. (2000) and Hoogenboom and Hammer (2000).

The objective of this paper is to address methods of disseminating and evaluating agrometeorological information and to provide examples of these processes. Although concentrating on the developing countries, the ideas presented here are equally valid for the developed world, as the underlying concepts are the same while the implementation is different. The paper concludes by raising and responding to some critical questions about communicating agrometeorological information in the future.

## 2. User community, data, and information

We begin by defining the ‘user community’. The user community for agrometeorological data and information can be understood in its broadest sense to cover the ‘spectrum from institutions and governments

to farmers at the subsistence level; the methodologies and products used to reach the different categories of users vary greatly’ (Gommes, 1997).

The content of agrometeorological information cannot be standardized because of the diverse nature of the user community. Depending on its purpose, the content of information can be related to: early warning advice to prevent famine crisis; the development of agricultural planning policies; the development of national climate policies as a follow-up of the Kyoto Protocol on Climate Change; special advisories provided to farmers through the national extension service; general advisories accessed by farmers directly through the electronic media; and to general issues disseminated to the public.

It is important to distinguish between ‘data’ and ‘information’. Data are digits with the appropriate units, e.g., MJ/m<sup>2</sup> day, degree Celsius, mm of rain, which in these cases represent incoming solar radiation, air temperature, and precipitation. These digits may come from observations or predictions. By themselves, they are not useful for making decisions.

Information is the result of utilizing a statistical simulation or other type of model, such that the output can be used to make a decision. For example, from precipitation data, probabilities of occurrence can be developed, e.g., there is a 75% chance of rain occurring within the next 5 days; thus today may be a good time to plant. In this example, there is direct linkage to meteorological variables. For simulation models, meteorological inputs along with physiological type inputs do not appear in the outputs. The resulting outputs from these simulation models can be put in a form appropriate for the decision-maker, whether it be a probability distribution of yields as a function of irrigation amounts, a table of projected outcomes for different input options such as plant population density or fertilization amount, or the economic consequences of these different input options.

## 3. Dissemination of agrometeorological information

Agrometeorological information must be disseminated in an optimum way based on the type of advice required and the needs of the end user. Valuable agrometeorological information can be transmitted to

farmers through the extension services or through the media. In developing countries, radio broadcasts of agrometeorological information to rural farmers plays an important role to provide timely advice at the local level. In order to improve the use of this method of communication among farming communities, in 1992, in Bamako (Mali) a meeting was organized by WMO, FAO and the Technical Center of Agricultural and Rural Co-operation (CTA) on the use of rural radio to transmit advice to farmers (WMO, 1992).

Another way to disseminate information is through ‘agrometeorological bulletins’. At present, most of these bulletins include just meteorological data. Most of the times, agricultural information contained in these bulletins is generated by interviews with farmers, particularly when the agrometeorologist is far away from the area to be monitored. This kind of field information can be very useful, for example, to assess the predictions produced by crop simulation models and to report to central bodies about crop conditions. However, when the farmer makes use of additional inputs (e.g. fertilizer, pesticides, high potential varieties, etc), his own experience may not be sufficient to take advantage of these inputs. In this situation, the farmer would require additional advice beyond that normally received. This information can be supplied through the local extension services or specialised advisory services, and if current trends continue, eventually for a fee.

#### **4. Agrometeorological advisory services for response farming**

A major factor affecting yields and production in developing countries is the inter-seasonal weather variation. There is a clear need to assist subsistence farmers in supplying information in order to adapt the agricultural system to increased weather variability. Farmers should be able to plan their practices, given the recent past weather conditions, i.e. through contingency planning and response farming.

Important contributions to improve agricultural production and food security in developing countries can be achieved by ‘more efficient agrometeorological advisory services to farmers to stabilize their yields through management of agroclimatic resources as well as other inputs (fertilizer, pesticides)’ (Gommes,

1997). Advisory services to farmers can be improved through close collaboration and co-ordination among relevant agencies and organizations, national extension services, national agrometeorological services, specialized NGO communication outlets and farming communities.

Response farming represents a set of techniques to optimize farming practices as a function of current environmental conditions under unusually dry conditions which are likely to lead to poor yields and nullify the added economic return from the use of the inputs, or an increased effort to capture the benefits from unusually favorable rains. In particular, ‘response farming, requires co-ordination among these entities so that experimentation can be carried out under local pilot conditions before application on a wider scale’. A recommended methodology involves the following steps:

- Identify the main focus for agrometeorological advisory services and response farming; determine the technical and operational details of pilot activities;
- Develop the decision tools, including suitable institutional arrangements (national agrometeorological services and extension agencies); briefing and training will be required;
- Carry out statistical, agronomic and economic analyses of the response of selected crop production systems as a function of local decision parameters;
- Transmit the experimental advice to farmers through selected channels and monitor implementation; compare output with and without advice;
- Make available phenology forecasts, yield forecasts, regular weather forecasts and price information to farmers and monitor use in order to assess their potential for the farming community at large;
- Maintain regular contacts with media outlets and work with them to adapt agrometeorological information to the appropriate formats and messages;
- Evaluate the pilot phase and if successful, make plans to expand, i.e., decide on geographic area to cover, prepare documentation on the methodology, train extension technicians and others, determine the most appropriate media for channeling the advice;
- Institutionalize the working arrangements developed during the pilot phase and subsequent phase and prepare long-term plans to cover more areas and crops (Gommes, 1997).

While the above methodology was developed within the context of response farming, these concepts are

equally valid to address the informational needs of other types of farming operations. The reason for the generality of this methodology lies in its basis in the scientific method which transcends geographic boundaries. As noted earlier, the differences between scales of operation are in availability of human, financial, and natural resources.

WHARF, an educational and scientific organization founded in 1984 in Davis, California, is dedicated to extending ‘response farming’ worldwide (Stewart, 1998). Response farming originated from research on rainfall behavior and its predictability in a cropping system project in Kenya sponsored by USDA and USAID. The methodology also includes crop yield estimation procedures developed at UC Davis plus subsequent findings on rainfall behavior sponsored by WHARF.

In Kenya, the project was to design sustainable cropping systems for low-resource farmers in marginal rainfall zones characterized by great seasonal rainfall variability, uncertainty and recurrent drought. Despite the swing from large-scale high-tech irrigated farming in the US to small-scale low-tech rainfed farming in Kenya, crop interactions with the soil–water–weather environment held to the same principles. However, great rainfall variation made it clear that no fixed set of cropping procedures could both minimize the crop failure rate in poor seasons and produce above average yields in good seasons. The need for flexibility in crop management required some useful level predictability of seasonal rains. The selected predictor was the date of onset of the rainy season. The question was, for any given crop(s), how do localized rainfall probabilities differ between seasons in which onset of rains is late versus seasons when it is early?

Response farming analyses uses localized daily rainfall records for farms, groups of farms, or a village, or groups of records representing projects, regions, etc. Initial analyses determine an onset date for each season of record, critical date separating early seasons from late seasons; reanalysis is then done of the rainfall record for selected crops and their growing periods. Having decided on crops, varieties and acceptable planting criteria, the next step is decide on slopes of plant rows, plant numbers and row spacing as well as fertilizer, which is essential to markedly increase yields in good rainfall years.

Rainfall analyses reveal the critical date separating early from late seasons and guide in designing an early cropping system with suitable modifications for the late seasons. Full details are communicated to farmers, who prepare in advance to follow either plan as soon as the current season date of onset is revealed.

## 5. ICTs: access and applications in developing countries

This paper looks specifically at how information and communication technologies (ICTs), and especially computer-based and Internet communication tools, can be effectively used to reach farming communities with agrometeorological information for appropriate decision-making. Information (its generation and dissemination) and technology are closely linked. The new ICTs generally refer to computer-based technologies and telecommunications. ICTs collect, process, store, retrieve, and disseminate data and information using microelectronics, optics, telecommunication and computers. Talero and Gaudette (1996) view ICTs as hardware, software and media for collection, storage, processing, transmission and presentation of information. Hamelink (1997) says that ICTs enable the handling of information and facilitate different forms of communication among participants, between participants and electronic systems and among electronic systems.

Looking at the role of the Internet in agricultural development, Richardson (1997) concludes that ‘modern information and communication technologies using multi-media computer links and computer tools can potentially benefit national agricultural knowledge and information systems and users in developing countries, including researchers, extension agents and farmers’. He also says that rural communities represent the ‘last mile of connectivity’. While it is conventional wisdom that ‘we live in the information age’, in an era characterized by information ‘superhighways’ that span the globe, it is evident that there is a large gap between the ‘information rich’ and the ‘information poor’.

Nevertheless, the Internet is becoming increasingly a dynamic market as a result of private-sector commercial undertakings in countries where monopolistic Public Telecommunication Operators (PTOs) have liberalized Internet service provision (e.g., Tanzania and

Ghana). Forty-seven of the 54 African countries have some form of Internet access in the capital cities, either through a local dial-up, store and forward e-mail with a gateway to the Internet, or through a full leased-line service. Of the 300 or so Internet Service Providers (ISPs) on the continent, about 200 offer full Internet services; the highest concentration is in South Africa, with over 70 ISPs (Jensen, 1998).

Some observers see the lack of telecommunication infrastructure as a possible advantage in the long run. The low-level of infrastructure may mean that when new telecommunication infrastructure is installed, it will be digital and possibly wireless, from the beginning. Since Internet services rely heavily on the extent of network digitization, developing countries just starting Internet services may be able to quickly develop digital networks. This has been the case in countries such as Botswana, Gambia, Mauritius and Rwanda, where a large percentage of the lines are digital (Manisto et al., 1998).

While it is clear that it will be many years before the majority of rural people in Africa, and elsewhere in the developing world, have a reasonable level of access to even basic telephone services, there are many recent technological developments which can make telecommunication services more widely available. For example, Jensen and Richardson (1998) recently assessed the potential of new developments in the use of radio frequencies for 'wireless weaves' that can help close the gaps in rural telecommunication coverage in Africa. Such an approach could combine land-based infrastructure (copper and fibre optic cables) with technologies such as Very Small Aperture Terminal (VSAT) satellite systems, digital cellular phone systems and point-to-point rural radio systems that make use of advances in cellular phone standards. The use of VSAT offers reasonably high bandwidth (64Kbps–2Mbps) and substantially lower costs than internationally leased circuits supplied by most PTOs. In Ghana, Uganda, Tanzania and Mozambique, where government regulation has been relaxed, various VSAT-based ISPs have sprung up.

'Telecentres' are increasingly being seen as a means to provide a wide range of telecommunication services to rural residents through a single access point. Multi-Purpose Community Telecentres (MCTs) are being established in various countries in Africa, Asia and Latin America by the International Telecom-

munication Union (ITU), with various national and international partners. Located in a shared rural community facility, MCTs can offer telecommunication services such as telephone, fax, e-mail and Internet access along with training and support in their use. In the design of MCTs, attention is being given to specific applications and content for several sectors, for example, health, education and agriculture.

In Mali, FAO is helping to develop agricultural and rural development applications for an MCT in Timbuktu. Depending on the results of a survey of the information needs of local rural groups, applications may include marketing information, specialized information (e.g., weather, environmental protection, disease and pest monitoring, water management), agricultural products and services trading networks and information networks linking research and extension agencies, agricultural colleges and even farmer organizations. There are plans to link the MCT to community radio stations and provide training in adapting information from the telecentre for broadcast to wider audiences in local languages.

In many cases, the effectiveness of ICTs for agrometeorological information dissemination can be enhanced by linking them to other communication media, especially media which are more accessible to farmers such as rural radio. In this way, a 'multiplier effect' can be achieved.

Changes in radio technology will have an important impact on the dissemination of information. Low powered radio stations that can broadcast a signal within a radius of 20 km are available at the cost of a moderately priced PC. Radios that do not depend on batteries or line voltage are ideally suited for use in remote locations. These radios have a built in generator that is operated by a crank mechanism, one revolution is equivalent to approximately 45 min of playing time. A major limitation of this radio is the cost, currently around US\$ 100.

The FAO has established Internet information and communication networks among farmers in Chile and in Mexico (Richardson, 1997). Through information centres located at the offices of farmer organizations and NGOs, the networks provide farmers with data on crops, international crop status, regional, national and international marketing information, weather and technical crop production information. The most important aspect of this initiative is its specific attention

to the assessment of local information needs and the provision of training the staff of farmer organizations and NGOs to help them develop the skills necessary to access, analyze, adapt and disseminate information that is locally relevant.

## 6. Communicating agrometeorological information

The advent of ICTs has impacted many aspects of agrometeorology, the collection and archiving of meteorological data and the generation of climate related information being just one important example. In the developed countries, networks of automatic weather stations have existed since the early 1980s (Hubbard et al., 1983). Data from these networks have been used in a wide variety of applications, e.g., phenological predictions, irrigation scheduling, yield predictions, and pest management strategies. In 1980, the University of California established the Statewide Integrated Pest Management Project (UC-IPM) to develop and promote the use of integrated, ecologically sound pest management programmes (<http://www.ipm.ucdavis.edu/>). The California Weather database (<http://www.ipm.ucdavis/WEATHER/weather1.html>) stores both current and historical daily weather data for approximately 350 weather stations throughout California. This database consists of data from: automated weather stations, part of the CIMIS (California Irrigation and Management Information System), operated by the California Department of Water Resources; volunteer observers; and weather stations operated by NOAA.

The poor telecommunication infrastructure in most developing countries, and in particular in remote rural areas, makes the use of receive-only Intranets and receive-only PCs for 'data-casting', or the transmission of data at regular intervals via satellite, an attractive option. The Inmarsat-D system provides a good example of data casting. The Inmarsat organization, located in London, is the provider of satellite telephone services to over 70 countries. Only a small proportion of the capacity of the system is used to transmit digital information, for example, about market prices and weather conditions. To receive the information, all that is needed is a small palm-sized receiver connected to a PC, which stores the incom-

ing data. In a similar fashion, farming advisory services, or even farmers through their organizations or through telecentres, could access agrometeorological information with small dish antennas and a PC. The information and communication technology is available in many cases; what are lacking are agrometeorological data-casting services that convert data into site-specific information that farmers can use for agricultural decision-making, including response farming.

The following examples from a variety of sources illustrate the different approaches that can be used to communicate agrometeorological information. It is not an exhaustive list. No doubt given the rapid changes in ICTs, some of these examples will be outdated in a short time, while new applications of ICTs will be developed and accepted.

The California PestCast system is a joint effort of the UC-IPM Project, the US Environmental Protection Agency, and the California Department of Pesticide Regulation ([http://www.ipm.ucdavis.edu/DISEASE/california\\_pestcast.html](http://www.ipm.ucdavis.edu/DISEASE/california_pestcast.html)). The overall goal of this effort is to expand the application of computer based crop disease forecasting in order to reduce unnecessary pesticide usage. There are currently 15 disease models available for use in fruits, vegetables, and turf. Weather data for use in these disease forecasting models comes from automated stations located in the appropriate fields. Data are transmitted either by telephone, cellular phone, or radio telemetry and can be reported on intervals of 15 min, hourly, or daily. This database is different than the California Weather Database, previously discussed.

Several meteorological and climatological databases can be easily accessed from the Internet. An extensive list can be found at the Internet site of the Usenet newsgroup *sci.geo.meteorology* (<http://www.scd.ucar.edu/dss/faq/>). The High Plains Climate Center (HPCC) was formed in 1987 with the mission to increase the use and availability of climate data in the High Plains region of the United States. The HPCC's activities include operating the Regional Automated Weather Monitoring system; conducting region-wide soil moisture and drought studies; developing connections with other climate centers; and developing computer software for the summarization and dissemination of important climate-related information (<http://hpccsun.unl.edu>). The Register of Ecological Models (REM) at the University of Kassel (Germany)

is a meta-database for existing mathematical models in ecology (<http://dino.wiz.uni-kassel.de/ecobas.htm>). In South Africa, daily weather data can be retrieved for a large number of stations from the Internet using the web address (<http://www.sawb.gov.za/www/climate/bull.html>).

From the FAO Internet site, the Global Information and Early Warning System on Food and Agriculture (GIEWS) provides extensive agricultural and climatic information for most of the countries in Africa, including crop production areas, crop calendars, and satellite images (<http://www.fao.org/WAICENT/faoinfo/economic/giews/english/giewse.htm>).

In Brazil, two systems have been developed by the National Institute of Meteorology (INMET) for dissemination of meteorological and agrometeorological information. They are 'VISUAL TEMPO' and 'VISUAL CLIMA'. The first system allows the user to have access, through different modalities (BBS or Internet), to real-time meteorological information as weather forecast or satellite imagery. Through the second system, the user can have access to the agrometeorological information as published in the dekadal and monthly bulletin. The software to get access can be downloaded free (<http://www.inmet.gov.br/frameset.htm>).

Also in Brazil, the National Confederation of Agriculture (CNA), in collaboration with the Council of the Small and Mid-Size Enterprise Supporting Service (SEBRAE), has implemented an Internet system called 'SIAGRO' providing useful information about prices, weather, databases on rural legislation and crop and animal protection laws and measures. INMET supplies weather information. The system, at present, can reach almost 2000 small communities in rural areas supplying information at the national level. In the future, it will supply information at regional level (<http://www.siagro.com.br/siagro/ClimaTempo.html>).

The private sector has a role in the dissemination of information as witnessed by the formation of Ade-semi Communications International (formerly known as African Communications Group) and reported in the Wall Street Journal of 25 September 1998. It has '55 employees and nearly 1000 wireless pay phones in Tanzania, with many more to come. It has won a second license, in Ghana, and a move into Sri Lanka is imminent. Just as exciting, the company is developing

wireless kiosks for Internet access and will host Web pages enabling artisans, farmers and other small-time entrepreneurs to set up shop in a global marketplace.'

Creative use of ICTs allowed for the development of a new business model. 'The model is ingeniously simple: communication by voice-mail only'. The company sets up wireless public pay phones at drastically lower cost than burying copper cable. It provides voice-mail accounts and pagers that announce incoming messages. The recipient leaves voice mail in return, using a phone card. The whole package is priced for people making US\$ 200 a month. 'Virtual phone service', the company calls it.

An example of generating, disseminating, and evaluating agrometeorological information is described in Weiss and Kerr (1989) concerning Cercospora leaf spot, CLS, (*Cercospora beticola* Sacc.). CLS can be a serious disease of sugar and table beets. During the 1980s, CLS caused significant reductions in sugar yields in several irrigated sugar beet production areas along the North Platte River in western Nebraska. An advisory system to predict if fungicide treatment was necessary was developed in 1986. A survey on the effectiveness of these advisories was carried out after beet harvest in November 1987.

In the past few years, CLS has increased in severity. Recently, the local sugar company, which purchases the beets and processes them into sugar, bought temperature and relative humidity sensors and data loggers to use in the prediction of this disease. One of the most severe outbreaks of CLS occurred in 1998, and the advisories were well received by growers and the sugar company. A source of funding for information of immediate economic importance is the company that buys the commodity since it is in the company's best interest to have the highest quality product.

The 'AgroExpert' Disease Forecasting System developed by Adcon Telemetry GmbH (<http://www.adcon.at/Products/AgroExpert.html>) is a complex system intended to reduce the amount of chemicals used in the treatment of plant diseases. Basically, the system uses climatic data which is processed according to rules developed by plant protection researchers, to establish the optimum time for chemical treatments. The system has been used in northern Europe for the past 5 years. It employs a network of solar-powered weather stations to monitor rainfall, humidity, temperature, leaf wetness and other factors. Every 15 min,

data are transmitted by radio to a PC at the base station where it is compared with a model of the conditions, which favor attack, by specific diseases. The system issues recommendations to spray at the optimum time when the chemical will be most effective. Farmers can be contacted by phone or pager, or can access the system directly via a PC and modem.

This technology will next be introduced in Spain and Sicily, where traditional farming is practiced on small (1–15 ha) farms. Farmers who are already producing for international markets, and can afford to invest in the system and have the most to gain from using it, will be targeted first. Local technology relay centres (TRCs), set up by Agricultural Data Management Srl in Sicily and Inforural in Spain, each with expertise in farm sector software development, will manage the installation and validation of the pilot networks and will disseminate results to stimulate farmer 'take-up' of this technology.

Recently, the use of NOAA satellite data, to produce imagery at 1.1 km resolution, which is received in both South Africa and Zimbabwe, has significantly improved prospects for providing relevant information on crop production conditions at the sub-national level. More detailed data with spatial resolutions from 1 km to 20 m will be available from satellites to be launched in the near future. Access to these data, in combination with information from other sources, is essential for extension workers, researchers, NGOs and farming communities. The challenge lies in extracting the information from regional technical databases and national early warning systems and adapting it into formats and styles that are relevant to the information needs of these users. The reverse challenge is to resolve the logistical and methodological problems of retrieving, in a timely manner, farming results and experiences from these users in order to improve the value of the information. Survey techniques is one method to address this concern, and will be addressed later in this paper.

Under a FAO technical assistance project, a well equipped, decentralized system for agrometeorological and remote sensing data handling, processing and analysis, as well as information product generation compatible with relevant background databases, is operational in southern Africa. Activities are carried out by trained staff in the Regional Early Warning Unit for Food Security and the National Early Warn-

ing Systems for Food Security within SADC (South Africa Development Community) countries. Facilities are being established in Harare, Zimbabwe, for the direct acquisition of Meteosat data to support rainfall monitoring across the region. The use of geographic information systems and the FAO-GIEWS (Global Information and Early Warning System on Food and Agriculture) workstation for handling analysis of data from different sources on a common geographic basis exists at the national level within SADC countries.

Under separate FAO technical assistance, a Regional Centre for Communication for Development (RCCD) has also been established in Harare. The centre is capable of providing high-quality advisory and training services to development workers (e.g., extension agents) in SADC member countries. It has a professional staff that can design and deliver training in participatory communication skills and in multi-media message design, including the use of ICTs. The next objective is now to link the agrometeorological data and information systems and GIS services to RCCD in order to provide information on agricultural production conditions and food security outlook to a range of potential users, including research institutions, extension services, NGOs and members of the farming community.

## **7. Evaluating the impact of information and information delivery systems**

Evaluation of the impact of information delivery systems can be done by surveys and by the use of focus groups and innovative end-users. The specific survey instrument or the techniques for gathering information may differ from community to community, but the goal is essentially the same: to evaluate the impact of the information and the information delivery system and to have a quantifiable basis to improve the system.

It is necessary to explain the purpose and importance of the survey or information gathering technique. This justification may be in the form of a cover letter that accompanies the survey. Or it can be the introductory remarks at a meeting of a focus group.

Confidentiality must be stressed in any survey project. Numbered surveys are associated with names and addresses (mailing lists) of potential respondents in order to keep track of who responded to the first

mailing of a survey and to target the names for a second mailing, if necessary. Once the study, based on survey results, has been completed all materials relating to the mailing lists and surveys must be destroyed.

Survey results must be communicated to the necessary agencies that developed and funded the survey for evaluation of current programs and for future planning. The results may be published in the appropriate scientific journals and shared with colleagues at scientific meetings. The initial respondents should not be forgotten in this communication process. By providing a summary of the survey results to the respondents, not only are the survey developers giving feedback to those who participated in the survey, they are developing a marketing tool. The feedback may be used to develop interest, support, and future users of the information dissemination system.

Some of the questions mentioned here may not be relevant to a region, other questions may have to be added, and some questions may have to be deleted. The following questions serve as an example.

- Location: Answers to this question give an idea of the demographics of the end user.
- For pest surveys: Occurrence of pest in the last several years. Response to this question gives an idea of locations where pest has occurred and if these locations fit into what ‘experts’ have predicted or noted. Ability to identify pest. Provide several descriptors. If the end user can’t identify pest or pest symptoms, then this is an area of further education that fits into the training needs of end users.
- Has the respondent used the information delivery system?
- Has the information been helpful? At this point in the survey for the remaining relevant questions, there should be several options such as ‘strongly agree’, ‘agree’, ‘neutral’, ‘disagree’, and ‘strongly disagree’.

If yes, how has the information been helpful? (List several key components of the information delivery system; e.g., timeliness, caused the end user to think differently about the situation, easy to understand the different recommendations and their consequences, easy to implement recommendations).

If no, how has the information not been helpful? (List same options as mentioned earlier.) Possibly the end user knew how to deal with the management situation and the information was not needed.

- What feature did the user like most about the information delivery system? List several options, respondent can also fill in blanks.
- What feature did the user like least about the information delivery system? List several options, respondent can also fill in blanks.
- What improvements would the user like to see in the system? Leave blank spaces to fill in responses. Responses may indicate areas for future research.
- Would the user be willing to pay for this information?

If no, what improvements in the system would make users change their minds? Leave blank spaces to fill in responses. Again, responses may indicate areas for future research or changes in dissemination.

- How should the cost of this information delivery system be supported? Rate percentage of cost to be borne by each entity. Choices should include government, university, farmers association, private industry, and others sources.

## 8. Some critical questions

Continued improvement in communicating agrometeorological information to farming communities requires addressing the following critical questions.

*How can diverse types of agrometeorological data be integrated into useful information that responds to the often-dissimilar application needs of farming communities?*

Agrometeorologists change data into information through whatever tools are available, currently through the use of computer-based technologies. In addressing the first question, we must begin by considering the training of agrometeorologists. Training in this area should include an appreciation of the complex interactions of biotic and abiotic factors on plants and animals. This addition to the traditional training of agrometeorologists is necessary to provide a larger perspective to the transformation of data into useful information.

As plants and animals go through their life cycles, they encounter different meteorological conditions and are subjected to different kinds of biotic and abiotic stresses. While the same meteorological variables are measured (e.g., temperature, solar radiation, precipi-

tation, etc.) throughout these life cycles, their applications to the different potential problems change. It is necessary to know when these different stress related problems can occur and to evaluate these situations based on current and predicted meteorological conditions. For example, plant now or wait a week in anticipation of rain, will it be necessary to irrigate in the next week, should a preventative measure against pests be made, the impact on quality of harvesting now or waiting a week, and contracting grain before harvest.

*What types of information are needed by diverse groups of end-users and, given their different farming, socio-economic and cultural systems, which are the appropriate communication technologies to reach them?*

The information needed for diverse groups of end-users growing the same crops or raising the same animals is basically the same. The differences arise from the human and financial resources available to implement this information and the methods of information dissemination. These differences must be considered in designing any information dissemination system. For those who have access, the Internet is a major source of data and information on all aspects of agricultural production. Data and information on the Internet are available from universities, industry, and advisory services, sometimes for a fee. At present, many national and sub-national agrometeorological services use the Internet to disseminate very useful information, e.g., real-time crop information such as water requirements, advice on pest disease, etc. Another example of useful agrometeorological information provided through Internet can be found at the Provincial Agrometeorological Centre of San Michele all'Adige (Italy): <http://www.ismaa.it/html/ita/meteo/agri.html>.

As we have seen, however, the availability of Internet hosts is extremely limited in many developing countries. ICTs offer great hope for innovative dissemination of agrometeorological information to farming communities. In most cases at present, however, reaching the majority of farmers in developing countries with agrometeorological information, especially small-scale farmers in remote areas, will require special targeted communication efforts that utilize local media such as radio.

*Given diminishing public support for agricultural advisory services, what alternatives exist for the com-*

*munication of agrometeorological information and under which circumstances can it be provided on a fee basis?*

First, as much as possible, agricultural advisory services must accurately document the added value and impacts of these services. This should be done as a proactive rather than a reactive position. The documentation should include the monetary value of the information, if used properly. Just because accurate information is disseminated doesn't mean that it will be used or used properly. Included in this documentation should be detailed descriptions on changes in positive behaviour (impacts), e.g., higher yields due to improved forecasts of the beginning of the rainy season, uses of techniques that minimize chemical applications and ground water pollution, or limit soil erosion, based on disseminated information. This documentation may positively influence government funding.

The information must be prepared by agrometeorologists in a way that the majority of users will easily understand it. Then it can be adapted and sent to key communication outlets such as radio, television, newspapers, bulletins, specialized information networks and web sites for broad-scale as well as targeted dissemination. From the perspective of these media outlets, the information must also have a value, a different value than intended for the end users. Various types of users may buy the products advertised by the different media outlets or subscribe to information services.

In this era of tighter government funding for agriculture, how can agrometeorological based information be effectively disseminated? As noted previously, this information must first have an added value; if it has a value, then there will be a demand for it. For example, the German Weather Service (DWD) has formed public/private partnerships to provide different details of agrometeorological information at different prices to a wide range of users, (Kruger and Dommermuth, 1999). In this process, the Department of Agrometeorology was reorganized into the Business Unit of Agriculture.

Munthali (1999) addressed some of these issues in a survey of users of agrometeorological information in Malawi. Commercial farms, which have well trained staff and access to ICT, were candidates for specialized information on a fee basis. At the other end of the farming spectrum, small holders would require the interaction of extension personnel to obtain

the necessary information. In addressing diminishing public support for meteorological services, it was suggested that information be treated as a commodity, and marketing plans be developed for user fees, where possible.

The earlier mentioned discussion has tacitly assumed that a fee for information implies an exchange of money for a service. This situation may not be appropriate in many developing nations. Fee can also be thought of as an exchange of one service for another service, such as collecting weather or crop data and transmitting these data in a timely fashion to an agrometeorological center. In return, the provider of these data could receive management recommendations not normally provided in a general agricultural weather forecast. For a system based on an exchange of one service for another service to be successful, both sides have to receive value for their service. For the provider of data, it may mean higher yields, while for the agrometeorological center, it may mean data that are needed to help form a governmental policy.

FRIENDS (Farming and Rural Information Expertise and Dissemination Services) is an EU-funded project that provides remote Greek agricultural communities with information and expertise, Thompson (1998). One group of users is ‘access point users’ from the Greek Union of Young Farmers (UYF). The use of access points, which are workstations manned by site managers, helps to overcome the problem that the majority of Greek farmers lack basic computer skills. Site managers help visiting farmers get the information they want to retrieve from the system.

FRIENDS collects, maintains and distributes a wide variety of agricultural information services. These services range from national weather, EU legislation and daily agricultural market prices in Athens to online-consulting and transactions. FRIENDS acts as the information channeler — aggregating, filtering, packaging then disseminating it to the farmers and other users.

A key success factor has been ‘one-stop shopping’ for agricultural information — FRIENDS aggregates agricultural information from many sources and saves users valuable time by aggregating these sources in one format (WebPages) and presenting them in one place (the FRIENDS website). The most basic value FRIENDS adds to its information services is intelligently filtering the information it provides.

*What are the training needs of end-users and of the various intermediaries that provide them with advisory services?*

Before the training needs of end-users and intermediaries can be addressed, the question of motivation for users to access and use the information should be discussed. While altruistic values to use the information can be a source of motivation, e.g., sustainability of the environment, they will probably have minimal success. Farming is a long-term business, and like any business, its practitioners want to be successful — motivation should be based on sustainable profitability. Given this perspective, what information is needed? What information is already available? What information needs to be provided? Of the information that needs to be provided, what information is of primary importance, secondary importance, etc? Addressing these questions requires assessments of the information needs and resources of specific groups within the diverse user community. In order to facilitate the communication of information to the user community, social scientists should interact with agrometeorologists to provide a structure for the information that is suited to the target audience.

## 9. Conclusions

The Internet will play a major role in agrometeorological information either through direct or indirect access. Richardson (1997) summarizes many web sites that document examples of the application of agrometeorological information. Also, Maracchi and De Vincenzi (1995) lists important sites on the Internet where it is possible to obtain meteorological data and information for agrometeorology. In developing countries, Multi-purpose Community Telecentres will be the focal point for many types of information, some of which will come from the Internet. These Telecentres can be the source of agrometeorological information that can be disseminated over rural radio stations in local languages. Remote sensing data and geographic information systems are being used in southern Africa to provide information on agricultural production conditions and food security.

While information can be disseminated, is it being used? A methodology was presented to evaluate the impact of information. This methodology can be ap-

plied as a written survey or through interviews. Evidence is presented that people would be willing to pay a fee for agrometeorological information if it has value, in both the developed and developing world. In some cases, this fee may take the form of an exchange of important information.

Critical questions have been raised but clear responses are linked mainly to the scientific, technological, and social developments that will take place in the 21st Century. It is clear that information and communication technologies will improve in the future as will accessibility. What will limit the generation and dissemination of agrometeorological information in the future is the same that limits it today: the interaction of people, from scientist to extension worker, in the continuum from basic understanding to practical applications. Thus, to prepare for the future now, we have to better integrate the human capital available at all levels of organization. Specifically, we recommend that information and communication technologies be a component of the training of agrometeorologists in order to provide the best possible advice to farmers.

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