Contents of Agrometeorological Bulletins and Advisories: Optimum and Minimum Details**

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1. Introduction

The contents of a bulletin determine the success or failure of the publication. The type of information provided must be useful and relevant for the recipient of the bulletin. The data must help build a knowledge base to assist the decision making process. To achieve this ultimate objective, a number of factors must be considered which can be summarized by the following statement: *The right information must be provided to the right user at the right time.*

This may be a simple statement but it is a complex task to achieve. First and foremost, it is essential to know who are the users of the bulletin. What type of information will assist them with their decisions? When do they need this information? Finally, once these user needs are identified and established, it is also necessary to maintain current awareness of changing informational needs and to demonstrate responsiveness to these changes. These questions satisfy only user information that is needed to determine the contents of the bulletin.

It is also essential to identify data availability. There must be consistent reporting of useful information that will be provided to the users. While data networks are usually insufficient for comprehensive analysis, the key to successful bulletins and advisories is a reliable and accurate set of benchmark or base stations that can be used routinely to produce the information sought and expected by the recipients. Alternative data sources, including non-conventional sources of data, and data base management procedures can then be factored into this process to enhance the analysis and the preparation of results.

The third essential feature of a bulletin is the delivery of the informational products to the appropriate users in time for them to utilize the information in decisions. This is crucial to the success of the bulletin and also probably the most challenging aspect. However, with resource mobilization, enhanced cooperation, proper training, and greater interaction between providers and users of information, the electronic age offers a great opportunity to overcome many of the hurdles and to meet the challenges.

The purpose of this paper is to discuss minimum and optimum requirements of the bulletin and advisory as they relate to these topics. An agrometeorological bulletin or advisory is unique in that the information base is derived from both meteorological and agricultural data. Meteorological data consist of both weather station data and climate observations. These data are collected at intervals

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ranging from hourly to daily. Current weather conditions and short-term forecasts aid farmers with daily operational decisions, while climate data and trends are required for longer-term planning decisions.

Agrometeorological data, on the other hand, may be quantitative observations or qualitative assessments. These data range from measurement of evapotranspiration, photosynthesis, and energy exchange to field observations of crop condition or stage of growth. Thus, different types of information may be available and can be used for a variety of decisions. Knowledge of agronomic and crop physiological information are also essential to the proper understanding of weather and climate's impact on agriculture.

Great strides have been made in the latter half of the 20th century at research institutions around the world to gain more knowledge on the relationships between meteorology and agriculture. Weather=s impact on both phenological stages of development and physiological growth patterns are better understood. Significant progress has been achieved in quantifying the importance of meteorology in the soil-plant-atmosphere continuum. The major task of an agrometeorological bulletin is to glean from these research studies useful operational tools that will assist farmers and planners with information needed to make decisions. It is also very important to ensure that the information is stated in terms that are understandable to the user. The user must know why the contents of the bulletin are important and how they can be used for decisions or plans.

There are three types of services provided in a bulletin. The first is current measurements and observational data services. These services consist of the operation of acquisition programs, observing systems, data collection and quality control, and networks to provide data essential to defining the state of the atmosphere and it impacts on agriculture. They are largely concerned with assembling weather observations into usable data bases and providing them in a format for use in analyses and applications. Some users prefer the actual data and basic products as input to their own decision-making process. This type of bulletin service would most suit these users.

The second type of service is agroclimate services. These services provide for the acquisition, storage, management, and summarization of historical weather and agricultural data. They also include the analyses of climatological, phenological, physiological data to characterize agroclimatic conditions or regimes for different geographical areas or time periods. Climate services may also include the development of normals, freeze/heat probabilities, and drought indices. Users of this type of service, often do not want the basic data, but instead want the results of analyses presented in a format that can be readily used in making decisions or planning for some action.

The third type of service is forecasting services. Prediction of future weather events or climatic conditions and their associated probabilities are extremely important for both daily farming decisions, such as planting, spraying or fertilizing, and, long-term planning decisions both on the farm and in agribusiness. Users of this third type of service understand the risk of forecast verification and proceed to make decisions based on their confidence level of the service provided in the advisory. The proper mix of these three services in a bulletin or advisory depends largely on the needs of the user community.

The foundation of the bulletin is derived from the first type of service; i.e., current measurements and observational data services. It is essential to have a standard and accurate reporting network as weather plays a vital role in all phases of agriculture. The United States Department of Agriculture produced a report in March 1999, outlining operational meteorological data requirements for agriculture. The following tables are reproduced from this report. Table 1 presents a list of weather parameters and agricultural activities that are affected by each of the variables. Appropriate time periods of observation are included in Table 1 to reflect their relevance to each activity. Table 1 provides an optimum set of data that would be useful to farmers and agricultural planners in their management plans. While all of these data are not routinely available at any given time, especially in an operational setting, extremely useful information can be provided to farmers with even a subset of weather information. The key is to provide the most needed and useful information at the right time for the decision making process.

Each agricultural activity has a unique set of weather variables that affect or influence that activity. Favorable soil and weather conditions are required for soil preparation and crop planting, for example. Different sets of conditions favor crop development, ripening, and harvesting. Table 2 lists some important farming activities, the required weather parameters that affect it, and a description of generally favorable criteria for these weather conditions. For example, light wind speeds are optimal for spraying. As wind speeds increase above 10 m/s, the efficiency of spraying decreases. The extreme importance of weather in daily farm management decisions is illustrated by Tables 1 and 2.

Weather and climate data are also very important factors for consideration by government agencies and organizations involved in agricultural policy. Table 3 lists some types of programs requiring weather and climate information to ensure that appropriate triggers are applied for program implementation. These are typically government-sponsored programs. Agrometeorological bulletins and advisories can be effective tools for planners and decisions-makers to implement this type of program assistance in time of need. Again, the issue of timing cannot be overstated.

The content of an agrometeorological bulletin ideally would satisfy the entire range of users, ranging from farmers to policy-level decision-makers. Realistically, there must be a minimum set of relevant information for an economically important subset of users that justifies the resources needed to produce the bulletin. The remainder of this paper focuses on the contents of the bulletin and how to efficiently utilize resources to meet user requirements.

The first step in developing a bulletin or advisory, assuming the user community has been identified, is to identify the basic information that is routinely available to produce an accurate and reliable product. This may include weather station data that provides maximum and minimum temperatures and daily precipitation. If there are climatological normals for a sufficient number of these stations, and, if there are historical data for some stations, significant information can be routinely reported with these basic weather variables. These informational products can be presented in various formats ranging from tabular listings of weather data from benchmark stations to graphical display of spatial averages.

If crop conditions are being monitored, knowledge of crop growing areas, cropping patterns, and crop phenology can be merged with meteorological information to provide meaningful crop-weather analysis. Abundant research on crop weather relationships has yielded significant information on consumptive water use by crops during various growth phases. Seasonal precipitation, evapotranspiration, and growing degree day accumulations can all be accumulated, based on data found in Tables 1 and 2, by growth stage for different crops. Comparisons with long-term averages or with optimal values can provide valuable insight into the sate of crop potential based upon weather and climatic data input. This significant agricultural weather information can be derived and reported routinely during the growing season in the agrometeorological bulletin or advisory. Time scales are important. These crop-weather relationships will not be very meaningful if reported on a daily basis and monthly reporting may be too long an interval. Weekly or decadal reports of this information is generally most appropriate.

In addition to the weather observations presented in Table 1, relevant agrometeorological information can be derived from these data. Growing degree day accumulations over a growing season for specific crops provide a useful phenological tool, especially with respect to normal or historical comparisons. Potential evapotranspiration serves as a meaningful indicator of crop moisture demand which varies by growth stage, and, can be analyzed with respect to the actual supply of moisture to the crop from seasonal precipitation.

The concept of crop coefficients, the ratio between maximum crop evapotranspiration and the reference crop evapotranspiration, was discussed in detail by Doorenbos and Pruitt (1977) and Doorenbos and Kassam (1979). The magnitude of the crop coefficient varies by phenological stages of specific crops. Thus, computations can be made of water requirements of crops and by comparing with actual precipitation, approximations of crop water availability can be determined.

Agricultural data are needed to complete the full range of information for a successful agrometeorological bulletin. Crop condition and crop phenological progress data provide valuable insight into how seasonal-to-date weather has impacted development, and, how the remainder of the crop season may be affected by weather outlooks. Historical crop statistics are also very important background information that can be used to identify analog years for comparison with current conditions. These data can, of course, be used to develop crop-weather models that may also serve as valuable information in a bulletin.

As already mentioned, however, the actual information supplied in a routine bulletin is dependent upon the availability of data. Figure 1 depicts the relationship between data, the resulting information, and types of decisions. If data are at the low end of the scale, which implies only basic data from a sparse network for example, the decisions derived from the information output range from scenario analyses to macro-scale analyses. The “what if” scenarios provide useful results and can be based on minimal information. However, this type of decision tool is used to ascertain a possible range of solutions and may deviate considerably from actual conditions.

With more detailed information derived from these data, though limited, a macro-scale analysis can provide useful decision-making information but with low precision. As more data become available, more information can be derived for decision makers. In some instances, the user with a strong technological understanding prefers to have comprehensive data for independent analysis. This self-analysis is then used to make appropriate decisions. In this case, the user does not need significant derived information output in the bulletin. In other instances, the user prefers to have detailed analytical information available along with the data, providing a full range of information for specific decisions. This may be referred to as the optimized output, with the information scaled to each decision. This, of course, is the best option for users to evaluate the contents of a bulletin, but it is also the most difficult to achieve.

Figure 2 depicts a schematic diagram illustrating the concept of a bulletin. The critical first element is the bulletin's user community. The type of weather, climate, and agricultural data must be ascertained to ensure a reliable and consistent flow of input products for bulletin preparation. Based on the user needs and available data, various analytical tools can be employed to produce a multi-disciplinary range of products. The results must then be presented in a format that is readily understood and can be translated into decision making information.

The information age offers internet technology can rapidly disseminate the results to the users in a timely manner either for daily tactical decisions or for long-term strategic planning. Finally, and, very importantly, the internet also allows the essential user feedback to the preparers of the bulletin. There must be a continuous open line of communication to ensure that the bulletin remains a successful vehicle of information for the user community.

References

United States Department of Agriculture, 1999, Operational Meteorological Data Requirements.
Doorenbos, J. and Pruitt, W.O., Crop Water Requirements. FAO Irrigation and Drainage Paper No. 24, 144p.
Doorenbos, J. and Kassaw, A. H., Yield response to water. FAO Irrigation and Drainage Paper No. 33, 193p.

Table 1 -- Specific Weather Data Requirements for Agricultural Activities		
Data	**Time Period**	**Agricultural Activities**
Temperature	Hourly and accumulated means and extremes	Planting, harvesting, crop-weather monitoring, freeze detection/protection, defoliation, crop modeling, disease risk, lambing and calving shelter, pest control, sheep shearing, PET computations, vapor pressure deficit computations, chill hours for stone fruit, growing degree day computations.
Maximum Temperature	Daily and Weekly Extremes	Optimum or unfavorable conditions for crops and livestock, crop modeling, extreme events, snow cover, growing degree day computations.
Minimum Temperature	Daily and Weekly Extremes	Optimum or unfavorable conditions for crops or livestock, freeze detection, defoliation, crop modeling, overwintering conditions, and extreme events, snow cover, growing degree day computations.
Precipitation	Daily	Planting, harvesting, fertilizer applications, cultivation, spraying, irrigation, crop-weather monitoring, crop modeling, disease risk, livestock and poultry protection and watering, extreme events (drought or flood), snow cover.
Rainfall Intensity	Hourly or less	Flood potential, erosion, runoff, water quality
Dew Point and Humidity	Hourly	Harvesting, freeze potential, pollination, spraying, drying conditions, vapor pressure deficit and PET computations, crop stress potential.
Hail	Hourly	Crop damage, risk assessment, productivity impact
RAOBs	Hourly	Arial spraying for agriculture, frost protection measures
Atmospheric Pressure	Hourly	General crop-weather monitoring, type of freeze (radiation, advection etc)
Sky Cover	Hourly	Fertilizer application, spraying or dusting, PET computations
Cloud Height	Hourly	Fertilizer application, spraying or dusting,
Present Weather	Hourly	Snow cover estimations, fieldwork, crop stress potential
Wind Speed	Hourly	Planting, defoliation, harvesting, freeze potential/protection, lambing and calving shelter, pest control, pruning, PET computations, spraying or dusting, pollination, blizzard conditions
Wind Direction	Hourly	Freeze potential/ protection, cold or warm air advection over crop areas
Vapor Pressure Deficit	Hourly	Derived from temperature and dew point
Solar Radiation, Sunshine, **or** Amount of Cloud Cover	Daily	PET computations, crop modeling, planting, harvesting
Snow Depth	Daily	Overwintering conditions for winter wheat, water supply forecasts for water users, estimate soil moisture reserves for the next growing season
Soil Moisture	Daily	Planting, harvesting, fertilizing, crop modeling, transplants, spraying, irrigation, monitoring of growing conditions, stress indices
Blizzards, Hurricanes, Tropical Storms (global)	Daily	Crop monitoring, risk and productivity damage assessments, resource conservation
Storm Tracks/Storm Strengths	Daily	Agricultural impacts, risk management, flood potential, drought monitoring
Soil Temperature	Daily	Planting, overwintering conditions, crop modeling, transplants, fertilizing
Pan Evaporation	Daily	Irrigation scheduling, water budget computations, PET comparisons, crop-water usage

Table 2 -- Data Requirements for Specific Agricultural Activities		
Agricultural Activity	**Station Data Required Weather Parameter**	**Description**
Soil Preparation	Soil Moisture Soil Temperature Precipitation Wind	Workable soil (generally less than 80% field capacity) Above 0 C Less than 1mm Less than 13 m/s
Soil Fumigation to reduce populations of nematodes, weeds, and soil-borne fungi	Soil Moisture Soil Temperature Precipitation Wind	40% to 80% field capacity to depth of 3m 13 C to 27 C at 6 in. depth Less than .3mm Less than 10 m/s
Crop Planting (seed crops)	Soil Moisture Soil Temperature Precipitation Wind	40% to 80% field capacity to 50-100 mm depth Generally above 5 C at 4 inch depth (cotton > 15 C) Less than 1mm Less than 10 m/s
Monitoring Development of succulent transplants such as tomatoes, peppers, egg plants, etc.	Soil Moisture Soil Temperature Air Temperature Precipitation Wind	60% to 90% field capacity to 100-200mm depth Variable, generally above 10 C at 100mm depth Generally above -2 C Less than 1mm Less than 13 m/s
Woody Transplants	Soil Moisture Soil Temperature Air Temperature Precipitation Wind	Greater than 80% field capacity to 3mm depth Generally between 0 C and 10 C to .3mm depth Less than 10 C Less than 1 mm Less than 13 m/s
Crop Fertilization	Soil Moisture Precipitation Wind	60% to 90% field capacity to 200mm depth Less than 1mm Less than 13 m/s
Spraying	Soil Moisture Dew Precipitation Wind	Less than 90% field capacity to 150mm depth Presence and duration None Less than 10 m/s
Irrigation	Soil Moisture Precipitation Wind	Less than 50% field capacity in root zone None Less than 30 mph
Freeze Protection	Air Temperature Type of Freeze Wind	Below 0 C (hours of duration) Radiation, advection, or combination Direction and Speed
Harvesting (moisture sensitive crops)	Soil Moisture Precipitation Wind Humidity Duration of Sunshine Evapotranspiration	Less than 90% field capacity to 150mm depth Dry 2 to 10 m/s Less than 75% relative humidity Hours/day Inches/day
Harvesting (all hardy crops)	Soil Moisture Precipitation Wind	Less than 90% field capacity to 150mm depth Less than 1mm Above 10 m/s (forced harvest) tree fruit

Livestock and poultry (protection)	Temperature Precipitation Wind Blizzard	Above 85 F, below 40 F Greater than .05 in Greater than 25 mph Feed and Shelter
Livestock and poultry (watering)	Air Temperature Precipitation	Less than 20 F Less than .5 in

Table 3 -- Data Requirements for Specific Programs		
Specific Programs	**Required Weather Parameter**	**Description**
Water Resource Activities · Water Supply	Precipitation (including snowfall) Air Temperature (Max/Min) Evaporation Wind run Wind speed and direction Soil moisture and temperatures Solar Radiation	Required daily, monthly, and more frequently in extreme events. To provide information on mountain water supplies and snowpack, irrigation reservoirs, and streamflow information.
Water Surveys and Planning	Precipitation (including snowfall) Air Temperature (Max/Min) Evaporation Wind run Wind speed and direction Soil moisture and temperatures Solar Radiation	Required daily, monthly, and more frequently in extreme events. To assist Federal, State, and local agencies and tribal governments to protect watersheds from damage caused by erosion, flood water, and sediment and to conserve and develop water and land resources
Precision Agriculture	Precipitation (amounts and rates) Evapotranspiration Radar Data	Highest spatial and temporal resolution required for resolving precipitation variability, rainfall rates affecting infiltration, runoff, erosion, and water quality. Flood and drought monitoring, risk management, pest management, agricultural models, extension information.
Watersheds Operations	Precipitation (including snowfall) Air Temperature (Max/Min) Evaporation Wind run Wind speed and direction Soil moisture and temperatures Solar Radiation	Required daily, monthly, and more frequently in extreme events. Watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, and wetlands creation and restoration .
Agricultural Air Quality	Precipitation (including snowfall) Air Temperature (Max/Min) Evaporation Wind run Wind speed and direction Soil moisture and temperatures Solar Radiation	Required daily, monthly, and more frequently in extreme events. To strengthen vital research efforts related to agricultural air quality
Wetlands Reserve Program (WRP)	Precipitation (including snowfall) Air Temperature (Max/Min) Radiation and Evaporation Wind run, speed, and direction Soil moisture and temperatures	Required daily and monthly. A voluntary program to restore wetlands
Conservation Reserve Program (CRP)	Precipitation (including snowfall) Air Temperature (Max/Min) Evaporation Wind run, speed, and direction Soil moisture and temperatures Solar Radiation	Required monthly. The conservation reserve program reduces soil erosion, protects the Nation's ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources
Flood Risk Reduction Program	Precipitation (including snowfall) Air Temperature (Max/Min) Evaporation Wind	Required daily and monthly and more frequently in extreme events. Provide incentives to farmers who voluntarily move farming operations from frequently flooded land

Scales of Decision Making Information

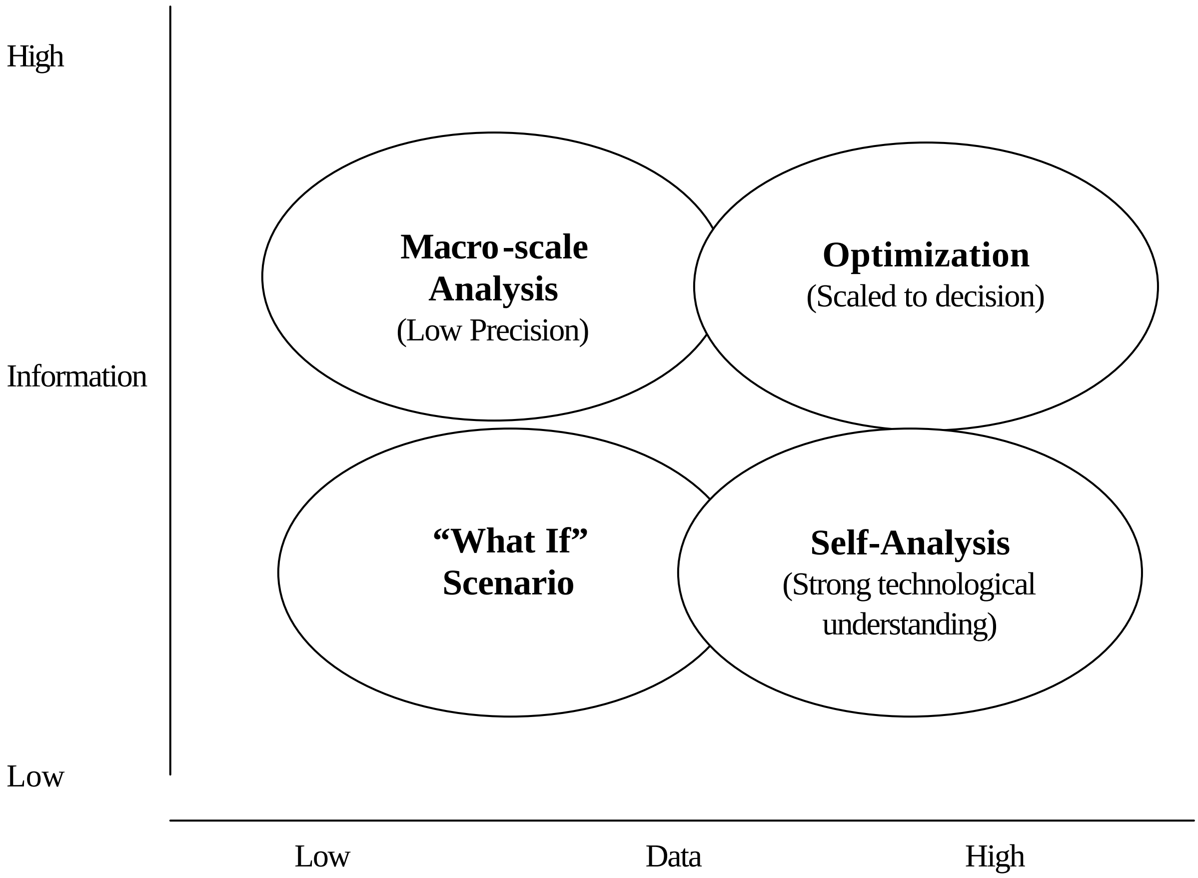

Figure 1. Data availability and information output.

AGROMETEOROLOGICAL BULLETIN

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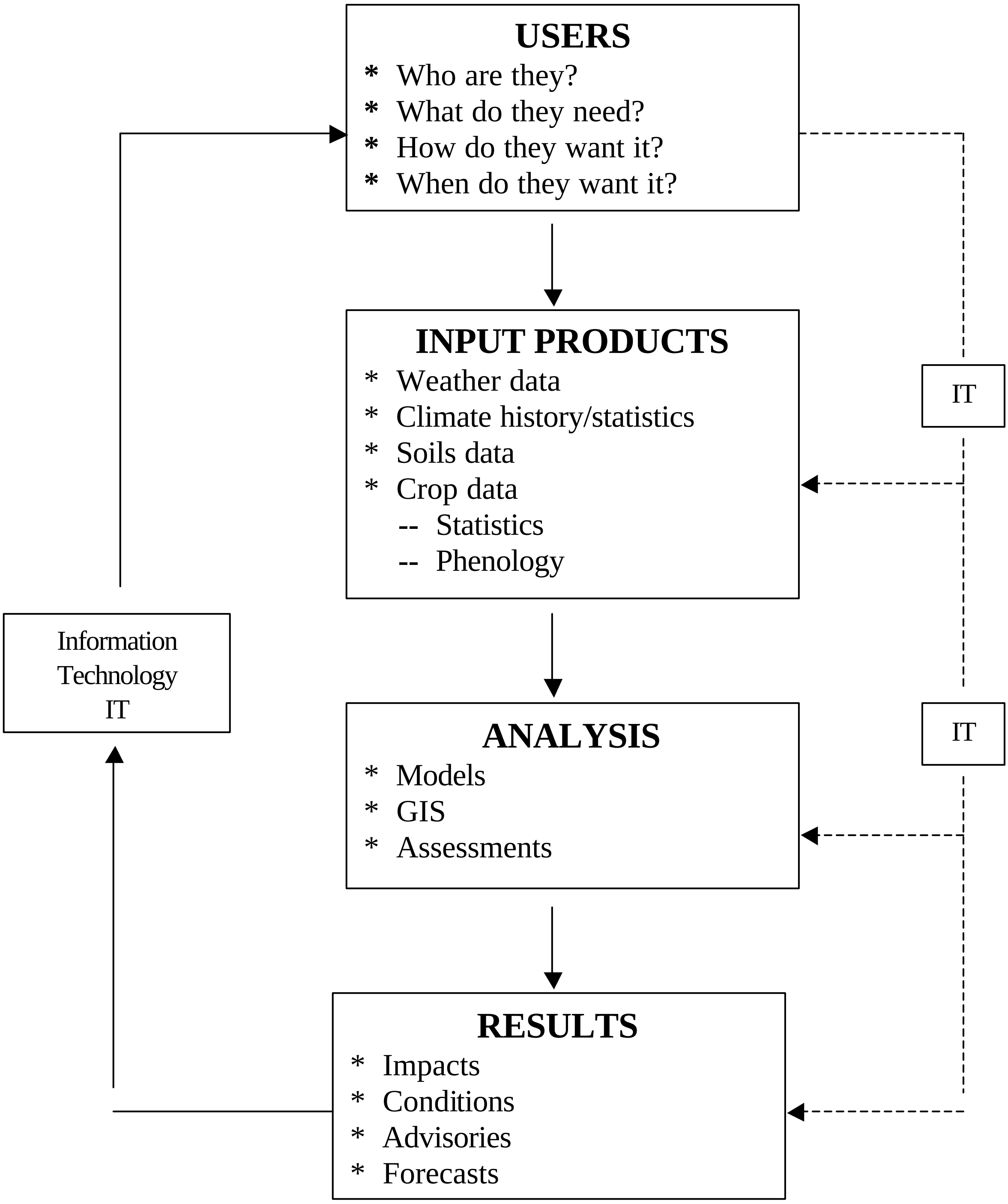

Figure 2. Schematic diagram of bulletin applications.