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FAO'S EXPERIENCE IN THE PROVISION OF AGROMETEOROLOGICAL INFORMATION TO THE USER COMMUNITY

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Abstract

The paper presents a compilation of activities of FAO in the broad field of agricultural climatology and agricultural meteorology.

In fact, climate *per se* is not part of the mandate of the Organization, but the relevance of climate is so obvious in crop and livestock agriculture, fisheries, forestry and socio-economic issues associated with agriculture (warning for food security...) that all sectors actually build climate considerations into their planning and monitoring. An estimate is given of the resources allocated by FAO to climate-related activities.

The user community is understood in a broad sense, covering the spectrum from institutions and governments to farmers at subsistence level; the methodologies and products used to reach the different categories of users vary greatly.

The paper describes especially agroclimatic services provided by FAO in the fields of monitoring and warning for food security, including desert locust and weather, the development and standardization of tool and methods (including software), databases, training and publications and finally advisory services to farmers.

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1. Introduction

Weather and climate affect agriculture and agricultural decision-making, directly and indirectly at the national and sub-national (provincial) levels (planning, impact assessments...) as well as at the farm-level. All "sectors", i.e. crop agriculture, livestock, forestry and fisheries are concerned.

In fact, in an organization of the size of FAO, it is difficult to exactly delimit the "mandate" of Agrometeorology. The "Agrometeorology Group", was recently aggregated with Remote Sensing and Geographic Information Systems -GIS-, the "Rural Energy Group", to establish the new Environment and Natural Resources Service under the Sustainable Development Department. This constitutes a logical decision insofar as climate encompasses some of the main renewable natural resources.

A number of other services with a marked agroclimatic component[2] are provided by the Organization. For instance, irrigation scheduling is dealt with by the Land and Water Development Division, Water Resources Development and Management Service. Microclimate manipulation is an essential component of many of the projects of the Plant Production Service, in particular for vegetables. The same could be said about plant protection and production (including forestry), aquaculture development, etc.

The only group with an explicit mandate to cover agricultural climatology is the Agricultural Meteorology Group. Its principal activities include :

- agroclimatic databases, a collection of worldwide monthly time series and normals for about 25000 stations. This is a service provided to all the departments of FAO[3];
- agrometeorological and remote-sensing based crop monitoring ad forecasting, mainly in Africa, based on ten-daily rainfall reports from FAO country representatives, GTS data and a number of secondary sources;
- international collaboration in the field of climate and weather, including field projects and *ad hoc* activities (e.g. El Niño impact assessments...)

This note starts with an estimate of the resources allocated by FAO to activities with a marked agroclimatic services component. It is followed by a section illustrating some of the activities.

[2] Agroclimatology is assumed to include agrometeorology.

[3] The technical departments include the Agriculture Department (AG), the Forestry Department (FO), the Fisheries Department (FI), the Economic and Social Department (ES), the Sustainable Development Department (SD). The General Affairs and Information Department (GI) could be added as they play a key role in the dissemination of all products, in particular through the World Agriculture Information Centre (WAICENT) and the WWW. This includes agro-climatological products.

2. Resources allocated by FAO to agroclimatic activities

Climate is not mentioned in the fundamental texts of FAO and climate is thus not part of the mandate of FAO[4].

The section below is therefore a subjective estimate based on the knowledge of the activities of the Organization. This was originally prepared as background material for the Inter-Agency Committee on the Climate Agenda and applies to the 1996/97 Programme of Work and Budget. The 1998/99 budget is under preparation, and it is obvious by now that an increase over 1996/97 in real or relative terms is unlikely. However, the orders of magnitude should be correct in spite of adjustments which are being made, in particular in the structure of the Organization.

The Climate Agenda lists several thrusts of which two are of relevance to FAO: *thrust 2* ("Climate services for sustainable development", short "*Services*") is the most relevant in the current context. *Thrust 3* (short: "*Impacts*") covers Studies of climate impact assessments and response strategies to reduce vulnerabilities. Both thrusts thus include a "service" component.

2.1 Agrometeorological services

Based on table 1 and the corresponding budget and staffing, it can be estimated that FAO has just above two people (2.1) involved in agrometeorological services. "2.1" is the sum about 0.5 person working on water development in the Department of Agriculture, 0.25 person on desert locust monitoring and control, also in the Department of Agriculture, and about one person in the Sustainable Development Department (agrometeorology and remote sensing, essentially weather monitoring for food security). The remaining 0.35 person covers the rest of FAO.

This regards only the "core programme", i.e. the Regular Programme (RP) covered by the ordinary budget of the Organization. For the programmes under consideration, the extra-budgetary funds amount to about 3 times the RP budget. We could assume that we have 6 persons dealing with agrometeorological services in our Field Programme, although this is probably now on the low side, particularly since we have launched the Special Programme on Food Security (SPFS).

Similarly, the estimated budget of agrometeorological services is about 420000 US$ per annum (of which about 290000 for staff and 130000 for non-staff costs) and the extra-budgetary contribution is close to 1100 thousand US$ per annum. If we assume the same staff/non staff ratio, the staff component on the extra-

[4] This is no doubt one of the reasons why FAO and WMO have very early signed agreements of cooperation (Gommes, 1995b)

budgetary funds would be about 770000 US$ per annum, and the difference of 440000 US$ would be non-staff).

2.2 Agroclimatic impacts

FAO has about 2.7 people supporting impacts**:** 0.7 person working on water development in the Department of Agriculture, 0.3 person on desert locust monitoring and control, also in the Department of Agriculture, 0.2 working for the Global Information and Early Warning System (GIEWS) and about 1.2 person in the Sustainable Development Department (agrometeorology and remote sensing, essentially weather monitoring for food security). The difference (0.3 person) is spread over the other Services and Divisions.

The Field Programme is estimated to have 8 persons on impacts, with a budget of 550000 US$ per annum (of which about 380000 for staff and 170000 for non-staff costs) and the extra-budgetary contribution to about 1200 thousand US$ per annum (composed of extra-budgetary funds amounting to 800000 US$, plus 400000 US$ covering the non-staff component).

3. The user community defined

The user community includes very different categories which can only be outlined here.

Institutional users, in particular governments, have so far received a lot of attention, in particular in the broad domain of Food Security: national programmes have been set up (see below) to inform governments and food donors of the impending food situation . The types of applications under consideration are analyses derived from crop monitoring, warnings, maps, agrometeorological crop production estimates, etc.

At an intermediate level, we find technical users, from scientists working in universities or National Agricultural Research Centres (NARCs) to the professional agrometeorologists of the National Agrometeorological Services (NAmS). They require tools and methods (models, statistical packages...), mainly software to analyze crop and weather data and issue warnings and advice to governments and farmers. A set of related issues concerns the standardization of the above-mentioned software tools.

Finally, farmers no doubt constitute the most important target: they feed the nations, and they often depend on farm management decision, including agrometeorological decisions for most of their income and their very livelihood.

Several products and services are of relevance for more than one category of users, for instance, publications can cover the whole spectrum from the researchers in universities to technicians in the NAmS to officers of agricultural extension services (AExS). On the other hand many units in FAO cover the whole range of users from decisions makers to operations. They sometimes play a direct role in field work, like for instance the desert locust control Group: FAO undertakes field assessment missions and coordinates survey and control operations as well as assistance during locust plagues.

Recently, FAO has set up a WWW home page (www.fao.org) which is regularly used to disseminate studies, data and information pertaining to climate and climate impacts.

The Land and Water Development Division (AGL) is found under:

http://www.fao.org/WAICENT/FaoInfo/Agricult/AGL/Aglhomep.htm

while the Global Information and Early Warning System can be consulted at the address below:

http://www.fao.org/WAICENT/FaoInfo/Economic/giews/english/giewse.htm

A number of documents made available by the Agrometeorology Group can be viewed or retrieved from

http://www.fao.org/WAICENT/FaoInfo/Sustdev/Eldirect/X

where X is climate/Elsp0002.htm with down-loadable digital climate maps, Elan008.htm with an El Niño Primer, AGROMET/FORECAST.HTM for a note on agrometeorological crop forecasting, Elan006.htm for an analysis of the interactions between the Rwandan crisis of 1994 and weather pattern (in French), Elan005.htm for a note on planning strategies against the effects of drought (in French), Elan004.htm for a note on Rainfall Variability and Drought in Sub-Saharan Africa, etc.

Altogether, on 4 November 1997, the FAO web site had about 640 references to climate and weather.

4 Services provided

4.1 Monitoring and warning for institutional users

4.1.1. Food security

FAO has established the Global Information and Early Warning System for Food and Agriculture (GIEWS) in 1975 in the wake of a major world food crisis precipitated by climatic events, including the Sahelian droughts of 1972 and 1973. A unique network was developed for collection, assessment, analysis and dissemination of up-to-date information, and for identification of countries and areas where food supply problems appear imminent.

Sources of information of GIEWS , which is operated from the FAO headquarters in Rome, include, next to country assessments and reports, qualitative assessments of crop condition based on agrometeorological analyses, remotely sensed data and others. Starting in 1978, FAO has established or given support to a number of "Early Warning Systems" (EWS), in Africa, Asia and Latin America where more detailed assessments are carried out.

National EWS come under a variety of names ([5]); at the national level, they contribute to:

- informing national decision makers in advance of the magnitude of any impending food production deficit or surplus;
- improving the planning of food trade, marketing and distribution;
- establishing co-ordination mechanisms between relevant government agencies;
- reducing the risks and suffering associated with the poverty spiral.

Early Warning Systems now typically include three elements: (i) an economic component dealing with food marketing, storage, imports and exports, etc.; (ii) a component monitoring the national food production (agrometeorology, remote sensing and agricultural statistics), and (iii) a household food security and nutrition component which assesses food availability at the level of final consumers, i.e. individual households.

In Early Warning Systems, agrometeorology and remote sensing play an important role in crop monitoring (qualitative) and forecasting (quantitative).

4.1.2 Desert Locusts

The FAO Emergency Centre for Locust Operations (ECLO) provides direct inputs into the analyses of the GIEWS.

The mandate of ECLO includes providing information on the general locust situation to all interested countries and to give timely warnings and forecasts to those countries in danger of invasion. All locust affected countries transmit locust data to FAO who in turn analyzes this information in conjunction with weather and habitat data and satellite imagery in order to assess the current locust situation, provide forecasts up to six weeks in advance and issue warnings on an *ad-hoc* basis. FAO prepares monthly bulletins and periodic updates summarizing the locust situation and forecasting migration and breeding on a country by country basis. These are distributed by email, fax, and post. All locust information is archived at FAO Headquarters.

Note that desert locust monitoring also requires upper-air data (up to 850 hPa) as locust swarms are largely driven by wind.

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[5] For instance "Food Early Warning and Information System (EWFIS)", "Crop Monitoring and Early Warning System(CMEWS)", "Crop Forecasting and Monitoring System (CFMS)", National Early Warning Unit (NEWU)

4.2. Operational tools and methods for technical users

4.2.1 Software

Most agrometeorological tools and methods were developed in the ambit of the above-mentioned food security programmes, starting with the well known “FAO water satisfaction index” by Frère and Popov (1979, 1986) and, until recently, closely following the development of hardware and operating systems (Gommes, 1983, 1985).

Schematically, three groups of software can be listed in the present context (Gommes, 1995a), dealing with (i) agrometeorological data storage and processing (the "Agromet group"), (ii) the analysis remote sensing imagery (the "IDA group"; Hoefsloot, 1996a and b), (iii) general tools like multivariate statistical analyses (the "ADDATI group"; Griguolo, 1996), spatial interpolation of agroclimatic data (COKRIG; Bogaert et al., 1995) etc. Most programmes can be downloaded from the FAO FTP site FTP://FTP.FAO.ORG/SDRN.

In the early stages (roughly around 1980), methodology and software developments remained very much a local *ad hoc* and project-driven exercise. It soon became clear that food security has to be dealt with regionally, not only to better take into account trans-boundary movements of food, but also to take advantage of regional availability of food stocks.

Regional Early Warning Systems (REWS) were established in Harare (latter mid 1986, covering the SADC region([6])) and in Djibouti (1989, covering the IGADD countries([7])). Since mid 1988, two "sister" regional projects have been providing remote sensing inputs, mainly in the form of Normalised Difference Vegetation Index (NDVI) imagery and rainfall estimates based on Cold Cloud Duration (CCD).

It is one of the main activities of the regional projects to co-ordinate and consolidate the analyses carried out in the National Early Warning Systems (NEWS).

This has obviously led to the gradual standardisation of some of the methods and analytical procedures and data exchange formats, and FAO has been playing a central role in Early Warning software development, ensuring co-ordination and continuity under a variety of funding sources ([8]). An area particularly worth

[6] SADC, the Southern African Development Community presently includes the following 10 countries: Tanzania, Zambia, Malawi, Mozambique, Zimbabwe, Botswana, Lesotho, Swaziland, Namibia and Angola.

[7] The Inter-government Agency on Drought and Development is composed of Djibouti, Eritrea, Ethiopia, Sudan, Uganda , Kenya and Somalia.

[8] Italy (GCP/RAF/256/ITA in Djibouti: ADDATI, CARTE, ABC...), Belgium (TF/INT/439-002/BEL/AGRT in Rome: AGDAT and FAOCLIM, the GMS shell for the FAO agroclimatic database), EEC (GCP/INT/534/EEC and GCP/INT/535/EEC in Rome: GIEWS workstation and the risk mapping project), Japan (GCP/RAF/232/JPN in Harare: the international version of SUIVI, FIS and SMIDA), UNDP (URT/91/024 in Dar Es Salaam for FIS), Denmark (GCP/RAF/270/DEN in Maseru for the early AGDAT data base)...

mentioning is the use of remote sensing methods and data for food security applications (Gommes, 1991 and 1993; Snijders, 1992; Hielkema and Snijders, 1993; Gommes, Snijders and Rijks, 1996).

For instance, the AGRHYMET Centre in Niamey, where the SUIVI ([9]) programme was originally developed (Hoefsloot, 1993), is a multi-donor undertaking supported by CILSS ([10]), WMO, UNDP, FAO and a number of bilateral inputs. Version 1.0 of SUIVI was a French language programme covering only the CILSS countries where the cropping season coincides with the northern hemisphere summer. Subsequently, it was further developed in one of the FAO remote sensing projects in Harare to include countries where the cropping season spans over a 4 to 7 months period of two calendar years during the southern hemisphere summer. SUIVI also evolved into a multi-language package (English and Portuguese in addition to French). The structure of the programme is now such that any language can be added easily.

IDA, a DOS based public domain software developed jointly between FAO and USAID's Famine Early Warning System (FEWS) for displaying, processing and analysing satellite images, followed a similar history. It was developed with funds from different sources, namely USAID (Famine Early Warning System), FAO (Dutch funded ARTEMIS programme) and USGS/EROS Data Centre ([11]).

WinDisp3 is the Windows-based successor to IDA, and was developed with funding for the European Union as part of the FAO Global Information and Early Warning System "GIEWS Workstation Project". Recently the SADC Food Security Technical Unit, FAO ARTEMIS, USAID FEWS, the USGS EROS Data Center and the US Forest Service have contributed funds to add additional analytical features to WinDisp3.

4.2.2 Databases

Several databases have been developed by FAO, many of which are relevant for agrometeorological operations, for instance soil maps - leading to soil water holding capacity - , agricultural statistics -relevant for the calibration of agrometeorological crop forecasting methods- etc. A database specifically designed for crop monitoring purposes is the IGAD Crop Production System Zones by van Velthuizen, Verelst and Santacroce (1995).

This section focuses on ECOCROP, two very useful programmes for crop diversification and modeling developed jointly by the Land and Water Development Division and by the Plant Production and Protection Division in the

[9] SUIVI is a “monitoring database” used for temporarily storing data and formatting them for publication in agrometeorological and other bulletins.
[10] CILSS, the Comité Inter-Etats pour la Lutte contre la Sécheresse au Sahel is composed of Cape Verde, Guinea-Bissau, Senegal, Gambia, Mauritania, Burkina Faso, Mali, Niger and Chad.
[11] "This joint funding is an example of how donor agencies that share common goals can work together to achieve those goals more efficiently than would otherwise be possible" (quoted from the IDA manual).

Agriculture Department (Sims, Diemer and Woods-Sichra, 1994). Crop diversification has the potential to promote under-exploited horticultural species, opening up new market opportunities and broadening the food base.

The information in ECOCROP 1 permits the identification of 1710 plant species whose most important climate and soil requirements match the information on soil and climate entered by the user. It also finds plant species for defined uses. It can be used as a library of crop environmental requirements and it can provide plant species attribute files on crop environmental requirements to be compared with soil and climate maps in Agro-ecological zoning (AEZ) databases or Geographical Information System (GIS) map-based display.

Why is it useful for crop diversification? ECOCROP 1 matches the eco-physiological requirements of crop or tree species requirements with specific environmental conditions. Based on information about local climate and soil conditions, such as temperature, rainfall, light soil texture, depth, pH, salinity and fertility, ECOCROP 1 identifies the plant species with key climate and soil requirements that match the requirements. ECOCROP 1 can also identify crop or tree species for a defined use, or be a library of crop environmental requirements.

The database in ECOCROP 2 is designed as a library of studies on crop responses in relation to environmental and management factors. The programme is created to provide information for crop modeling and at the same time as a tool for scientists to organize and retrieve their own specific information on plant species of interest to them. At present the database holds information on a number of varieties for 20 crops of world-wide importance. Each crop file contains on average 200-220 separate crop environment al response studies or data sets extracted from 40-50 sources. After selecting certain environmental or management factors and crop responses, such as yield, biomass production or photosynthesis rate, of interest, the information contained in the database can be illustrated on the screen in the form of response curves or it can be written out in statistical form.

4.3. Standardization of methods, tools and data

International organisations like FAO and WMO have a clear role to play in the standardisation of methods and tools. For instance, FAO hosted a very successful meeting on the harmonisation of the estimation of crop water requirements, leading to recommended methods of calculation for potential evapotranspiration (Smith, 1991). On crop forecasting in general, FAO and EU jointly organised an expert consultation on crop forecasting methods (FAO/EU, 1997).

At a more technical level, the Agrometeorology Group has been advocating the idea that agroclimatic software compatibility can be improved through the standardisation of data files. This is largely also the approach of CLICOM. Several meetings

Below are some of the feature that describe “standard data files”: (i) they are self descriptive (name, contents, structure, format), (ii) they are **not** user-specific, (iii) they are not programme or application specific, (iv) they are not location specific (cropping seasons) and they are language tolerant and, finally (v) they are not proprietary.

It is also suggested that software should adopt a modular approach, i.e. it should ideally be regarded as the succession of interlocking building blocks. Needless to say, this must be kept in mind at the development stage. The advantages of modular software include (i) reduced development overhead, (ii) reduced training overhead, (iii) ease of maintenance (even by different people!), (iv) ease of upgrading and (v) robust and sustainable systems.

Standard data files and modular application software, together with the complete separation of data management and data analysis are proposed as the three keys to solving most of the problems listed above.

The views above largely result from an expert consultation organised by FAO in Rome in 1993 (FAO, 1995; Gommes, 1996).

4.4. Training and publications

The Organization plays a very active role in training. For instance, a number of training seminars have been organized by FAO to familiarize staff in National Agrometeorological Services with the use of remote sensing for crop (vegetation) and rainfall monitoring. Several roving seminars have been organized jointly with WMO on irrigation planning and management.

Training manuals, or manuals which can be used for training, are also published on a regular basis by several Departments. For instance, the Water Resources, Development and Management Service has a series on irrigation water management training manuals. This series is prepared by FAO in cooperation with ILRI, Wageningen. The manuals are intended for use by field assistants in agricultural extension services (AExS) and irrigation technicians at the village and district level who want to increase their ability to deal with farm-level irrigation issues. They contain material that is intended to provide support for irrigation training courses and to facilitate their conduct.

Some titles are listed below as examples:

- Introduction to irrigation, 1985 (A E F S)
- Elements of topographic surveying, 1985 (E F S)
- Irrigation water needs, 1986 (A E F S)
- Irrigation scheduling, 1989 (E F S)
- Irrigation methods, 1988 (E F S)
- Scheme irrigation water needs and supply, 1992 (A E F S)
- Canals, 1992 (E F S)
- Structures for water control and distribution, 1993 (E F S)

- Drainage of irrigated lands, 1996 (E)

Whenever possible, such publications are available in several languages and constitute a long-term commitment and effort.

Similar series are available for agrometeorology, plant production and protection, desert locust...

4.5 Advice to farmers

While FAO has a long and good record in agricultural extension at all levels, agrometeorological advisory services to farmers have so far received little attention. It is well recognized that this is an important and potentially very useful field (Gommes, 1992) and the Agrometeorology Group is currently trying to develop some activities in this area.

4.5.1. Microclimate manipulation

In addition to well established traditional methods brought into focus by Stigter (1988a and 1988b) and his colleagues (Karing et al, 1992), microclimate manipulation benefits from innovative modern technologies which are now inexpensive enough to be used in several developing countries.

The Horticulture Group of FAO (Plant Production and Protection Division) plays an active role in promoting "non-woven" row covers, a very thin permeable fabric that is used as a crop cover: it can raise the temperature of the soil and the air during the day, diminish heat loss during the night and raise minimum temperature. Its permeability to air, water and light insures a uniform heat and water transfer in order to create a balanced microclimate under the cover.

Table 2 illustrates some of the benefits of using non-woven row covers. It is taken from the WWW homepage of one of the manufacturer of non-woven row covers and clearly shows the agrometeorological approach.

4.5.2 Advisory services to farmers

Many services described above are directed at the technically more advanced users. However, another way to contribute towards greater food security is by helping farmers to develop less weather-dependent practices. This can be achieved by more efficient agrometeorological advisory services to farmers to stabilise their yields through better management of agroclimatic resources as well as other inputs (fertiliser, pesticides). The section below is based on a project document which was recently prepared for the main rice-growing areas of Vietnam.

Agrometeorological advisory services to farmers can be improved only through better co-ordination between the Agricultural Extension Services (AExS) , the National Agrometeorological Services (NAmS) and the Media. In particular, "response farming" has to be "evolved" (experimented) first under local pilot conditions with improved data collected by NAmS and AExS before it can be applied on a wider scale.

The general approach includes several steps: the preparation of the methodology (development of the decision tools) by NAmS and AExS, the experimentation of the management scheme by several pilot areas (farmers, communes), the critical evaluation of the impact of the advise on farm output in terms of quantities and regularity, and eventually the adoption of the method in a larger area. Public information and the involvement of the media constitutes an essential component of the methodology at all stages.

The decision tools are tables/flow-charts or software that assist farm-level management decision-making based on three types of inputs:

- the knowledge of local environmental/agricultural conditions (reference data[12]);
- the measurement of local "decision parameters" by local extension officer or farmer;
- economic considerations.

In practice, the following steps (objectives) are proposed:

A. Identification of main focus for agrometeorological advisory services and response farming

- Work out the technical and operational details of the pilot work to be conducted in several geographic areas and several thematic fields, for instance pest and disease risk for some of the main crops, flood and typhoon warnings, cold weather risk, irrigation water salinity...

- Through contacts with the responsible government offices (mainly AExS) assess the interest/willingness of farmers to be involved on a pilot basis, and select several (5?) "pilot" farmers in some pilot areas (municipalities, communes; 12 ?)

- Provide each pilot area with the minimum required equipment[13], and brief farmers and train observers on their use as part of a more comprehensive training package.

- Work out operational detail of the collection of the local parameters, as well as their regular and timely transmission to the NAmS and AExS to help develop/evaluate the experimental "decision tools".

B. Tested decision tools

[12] A simple example of this could be, for instance, a threshold of air moisture or sunshine duration to decide on pest risk, or a threshold of salt content of water to decide on irrigation-salinity risk. Normally, other parameters (economic) also play an important part.
[13] This will include maximum and minimum temperatures, air moisture, rainfall, wind speed and direction (all stations) and water salinity (MD only).

- Find out the most suitable institutional arrangement for the development of the Decision Tools. This includes the level of involvement of central (AExS, NAmS) and Regional offices, agronomic research, etc. Briefing and training sessions will be necessary at the regional offices (sub-offices). A more sustainable system can be developed if the provincial/regional offices are fully involved.

- Carry-out the statistical, agronomic and economic analysis of the response of the local crop production system as a function of the local Decision Parameters. This takes into consideration "reference" data, i.e. knowledge about statistical behaviour of variables like rainfall and water salinity, soil types, likely yield with and without the management decision. Additional parameters can be estimated by the sub-offices or the NAmS , for instance estimates of local (pilot area) radiation based on the interpolation carried out at the sub-office using ground and satellite data.

- Transmit the experimental advice to farmers through the agreed channels, and monitor implementation. Make provision to be able to compare output "with" and "without" advice. It is also necessary that the farmers participating in the exercise should be, if necessary, compensated for losses due to the advice. The quantitative evaluation of the economic gain of the agrometeorological advice will be given due consideration.

- Phenology forecasts (which should be routinely produced by NAmS), yield forecasts, regular weather forecasts and price information should be made available and their use monitored, in order to assess their potential for the farmers' population at large at a later stage of the project.

- Ensure regular contacts with the local and national media (written, radio and television) and ensure that farmers are made aware of the rationale, methods etc. behind the agrometeorological advisory services outside the pilot areas as well.

C. Agrometeorological advisory services are expanded beyond the pilot area

- AExS and NAmS jointly critically evaluate the outcome of the pilot phase, and make final decision on the methodology and the feasibility and relevance of expanding the approach to a wider area (several provinces).

- Based on the analyses above, prepare details of plans to expand the method, i.e. decide which geographic areas to cover, print the documentation about the methodology, prepare the new decision tools (inclusive of programmable calculator programmes), prepare training and briefing material and train provincial officers in the relevant ministries, work out the most appropriate channels to develop the new decision tools and channel the advice, etc.

D. A comprehensive plan to improve Agrometeorological advisory services nation-wide

- Based on the experience gained during the pilot phase, prepare an economic evaluation of agrometeorological advice to farmers in the whole country, including different agro-economic and agro-climatic zones. Evaluate the potential to apply the experience acquired so far in other fields, for instance grain drying, crop insurance, planting dates...

- Critically assess the shortcomings and successes of the activity carried-out so far, in particular as regards institutional working arrangements and bottle-necks, the potential role of other partners beyond AExS and NAmS, but also the role of agricultural research, University, etc.

Identify areas where additional information/studies will be required to improve the efficiency of agrometeorological advice to farmers.

- Institutionalise the working arrangements developed during the pilot and subsequent phase, and prepare long-term plan to cover more areas and more crops, in particular cash crops...

5 Conclusions

FAO and other international organizations play a rather “central” part due to their formal links and regular contacts with a number of inter-regional and national institutions. It is thus their role to favor collaboration across borders, institutions and also, to some extent, across technical subjects.

The central position leads to recognizing the large diversity of agrometeorological problems, institutional arrangements, methods, etc. International organizations ensure that links are established between technically interested people, and ensure continuity over time. FAO has contributed towards the development of some “solutions” (methods, tools, software...) that are of wide applicability.

This is best achieved also through the collaboration of related organizations, starting with WMO (including the Commission for Agricultural Meteorology, CAgM) and the institutes under the Consultative Group on International Agricultural research (CGIAR), in particular IRRI, ICRISAT, ICARDA and CIAT which all have a marked interest for agroclimatology.

This paper lists only some examples of the services which can be provided to the rather large community of users of agrometeorological services. The need for such services continues expanding, as a result of increased demand -resulting from development-, but also because new methods keep evolving, for instance in the field of remote sensing applications.

The challenge will be to continue serving the users under conditions of shrinking resources, and this can be achieved only through improved collaboration.

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Table 1: a conservative estimate of the climate-related activities of FAO, arranged according to the Programme of Work of the Organization. The column labeled PCC ("Percent Climate") provides an estimate of the relative share of time/budget allocated to activities with a climate component. The two last columns attempt to further split PCC into "services" and "impacts". The columns are meant to be multiplicative, i.e. 0.10 x 0.05, i.e. 0.005 or 0.5 % of the budget/time of activity 2.1.1.1 (Land and water resources assessment) is fully spent on climate.

Programme and activities	***PCC* Percent Climate**	***Services* percent of PCC**	***Impacts* percent of PCC**
2.1 Agric. production			
2.1.1 Natural resources			
2.1.1.1 Land water resources assessment	10	10	5
2.1.1.2 Land use and LU planning	10	10	10
2.1.1.3 Plant nutrition	2	10	0
2.1.1.4 Water dev. conservation	25	10	15
2.1.1.5 Soil management	5	10	10
2.1.2 Crops			
2.1.2.2 Crop management and diversification	2	10	10
2.1.2.4 Crop protection	5	20	20
2.1.2.5 Grassland and forage	2	10	10
2.1.3 Livestock			
2.1.3.2 Peri-urban and intensive prod and supply	2	10	0
2.1.3.3 Mixed farming systems	2	10	0
2.1.3.4 Pastoral and extensive grazing	2	10	0
2.1.3.5 Transboundary animal diseases	2	10	10
2.1.5 Agric appl of isotopes and biotechnology		10	0
2.1.5.1 Improvement of crops and livestock	1	10	10
2.2. **Agric. policy and development**			
2.2.2 Food and Agric information			
2.2.2.1 Statistics	1	0	10
2.2.2.5 Global information and EWS	5	0	30
2.2.4 Food and agric. policy			
2.2.4.1 Agric towards 2010	1	0	5
2.3 **Fisheries**			
2.3.2 Resources and aquaculture			
2.3.2.1 Marine resources	1	10	0
2.3.2.2 Inland resources	1	10	10
2.4 **Forestry**			
2.4.1 Forest resources			
2.4.1.1 Assessment and management	5	10	10
2.4.1.2 Protection	1	10	0
2.4.1.3 Conservation	1	10	10
2.4.3 Forest policy and planning			
2.4.3.1 Institutions and policy	1	10	10
2.4.3.2 Statistics	1	10	10
2.5 **Sustainable development**			
2.5.4 Environmental information	50	20	25
2.5.5 Coord. and promotion of sust dev	5	5	10

Table 2: some effects and advantages of non-woven row covers on vegetable crops.

Favour....	**Protect against...**
An early germination	Cold and frost
A good quality of vegetables	Rain abundance
A better plant growth	Hail and violent wind
An earlier harvest	Storms
A better yield	Insects