

FAO CROP YIELD FORECASTING PHILOSOPHY IN NATIONAL FOOD EARLY WARNING SYSTEMS^α

R. Gommès¹, F.L. Snijders and J.Q. Rijks
FAO, Rome

1. INTRODUCTION

The paper describes the crop forecasting philosophy adopted by FAO in the ambit of national and regional food security projects in developing countries.

The word “philosophy” is preferred to “methodology” or any other word with a more specific technical contents because the position of FAO has been to propose a general framework of which the totality, or only some elements, can be adopted by the countries for their national crop forecasting methodology for food security. It is also felt that “philosophy” stresses the fact that, when operating in a field with many partners (economists, marketing experts, nutritionists, statisticians, demographers, *etc.*), the most serious problems are not technical but organisational and institutional: co-ordination of the participants and integration of different sectoral approaches.

2. FLOW OF DATA

The flow of data is illustrated in figure 1. The left hand side of the figure (elliptic boxes) lists the sources of the data: the meteorological network, satellites, field observers (mostly agricultural extension staff) and national services dealing with soils (e.g. soil survey), crops (ministry of agriculture services) and National Agricultural Statistics. The number of partners and the diversity of the data types creates some difficult as well as interesting problems which were described elsewhere (Gommès, 1996).

Each of the sources may contribute one or more types of data (second column, rectangles). For instance, meteorological data can be provided, in addition to the *ad hoc* national network, by remotely sensed sources. Indeed, several methods are now routinely available which are used to derive or interpolate rainfall or sunshine data from satellite information.

The same applies to some crop data, for instance planting dates, which may be estimated, under adequately known conditions, from vegetation index (NDVI²) time series.

Based on the meteorological and agronomic data, several indices are derived which are deemed to be relevant variables in determining crop yield, for instance actual evapotranspiration, crop water satisfaction, surplus and excess moisture, average soil moisture... The indices (variables)

¹ Respectively senior agrometeorologist (Environment and Natural Resources Service), remote sensing officer (Environment and Natural Resources Service) and statistician, Statistical Development Service.

² Normalised difference vegetation index. A satellite index which is roughly and not too far from linearly correlated with standing living biomass. Under normal circumstances, the condition of natural vegetation and crop condition are related.

then enter an equation (the yield function³) to estimate station yield. At this stage, the data are still station-based since most input are by station.

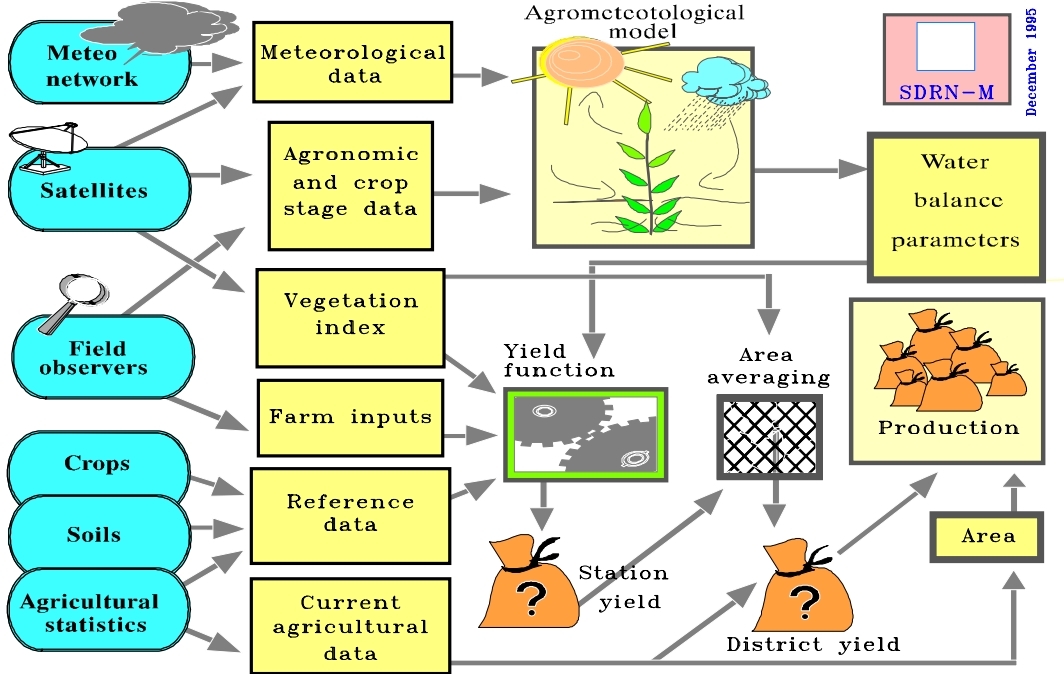


Figure 1: the flow of data in FAO-promoted crop forecasting systems for food security.

Station yields are then area-averaged using, for instance, NDVI as a background variable, possibly adjusted with other yield estimated provided by national statistical services, multiplied by planted area to yield a district production estimate⁴.

As indicated, according to countries, variants to this general scheme can be introduced at almost every step. The technical options were adopted mainly to reduce computing overhead and bypass, for the time being, some problems which we feel are difficult to handle in the context of developing countries. More details will be given below, but we consider, for instance, that simple, even elementary solutions are preferable to complex solutions for which the necessary inputs are not available and must virtually be guessed. We also believe that a codified system and reproducible approach, even if very far from perfect, is preferable to no system.

To illustrate the previous point: many countries estimate crop production⁵ by calling a meeting of knowledgeable people (grain board, statistics, agrometeorological services) and, through

³ The yield function is usually an equation, linear in most variables, which was obtained by multiple regression of a combination of time series and cross-sectional data.

⁴ In practice, the situation is slightly more complicated as “station yields” have themselves been calibrated against agricultural statistics which are given by administrative units.

⁵ In most developing countries there are not many alternatives to agrometeorological crop forecasting, with or without remote sensing inputs. Some countries in the Sahel conduct rapid estimates based on interviews with

bargaining, eventually reach an agreement on the current crop production estimate. No specific Statistician, Statistical Development Service methodology is used, and strong political bias - conscious or otherwise - is often a basic ingredient in the forecast.

Under such circumstances, any “system” will avoid political bias and ensure at least a reasonable degree of consistency from year to year and from place to place.

3. TECHNICAL OPTIONS

The main technical options adopted in the FAO crop forecasting philosophy are the following:

- agrometeorological and remotely-sensed data are integrated at all levels whenever possible: at the level of data (rainfall, phenology) and at the level of products (area averaging of yields);
- gridding is done after modelling⁶, under the assumption that there exist variables, such as NDVI, which are at least qualitatively linked to crop condition **in a given area**. If this assumption does not hold in quantitative terms over large areas is not relevant for the interpolation procedures adopted. This also assumes that such factors as soil fertility and the effect of greater soil water holding capacity is captured by NDVI. The time step mostly adopted is the dekad;
- results are calibrated against agricultural statistics through empirical yield functions. It is clear that the accuracy of the forecasts cannot possibly be better than the agricultural statistics used to calibrate them. There is thus some uncertainty about the precision, 10% to 30% is probably a good guess. At the scale at which we work, e.g. districts, provinces, etc, models developed at the field level do not apply. The “agrometeorological models” mentioned in figure 1 are thus usually very simple. They aim more at assessing growing conditions through value-added “water balance parameters” than actually simulating crop-weather-soil interactions. It is, therefore, justified to use empirical yield functions which, in addition, avoid to touch on the most difficult issue of geographic scale effects;
- tools are modular, i.e the crop forecasting system uses a number of software tools that carry the analysis from the data to the final production estimate (see Gommès, 1995, for a more detailed account of the software). Depending on the local conditions, national

farmers. Other countries have developed biometric systems based on measured crop indices (plant density, maize cob size). In some countries agricultural statistics are so uncertain that the agrometeorological forecasts are taken as final yield and production figures. The agrometeorological approach usually gives best results in semi-arid areas where the water deficit is the main limiting factor. It performs poorly in some mountainous areas where (i) farming does not follow a homogeneous pattern, (ii) coverage by the weather stations is insufficient and (iii) water surplus, or pests and diseases, tend to be the main limiting factor(s). Simple statistical (trend) models perform very poorly in semi-arid countries, where the inter-annual variability of yields reaches very high values. This being said, after an initial spell of enthusiasm, the hope to use direct correlations between satellite indices and yields as a forecasting tool, was gradually abandoned. The methods worked only in few countries, if given the help of additional data collected at ground level.

⁶ Gridding of actual data, for instance weather data for short time intervals, is the typical example where we feel that the available techniques have not reached the a level of reliability which would justify our transferring the methodology to national services in developing countries.

services can choose between different tools (for instance for area averaging). Any specific tools can be changed without touching the whole structure of the system: the system remains light and easily upgradable and maintainable. This is facilitated by standardisation⁷ through common file names and structures and early reduction of RS images (Snijders, 1995). What this means is that the users, who are responsible for carrying out the analyses and the forecasts, need not worry about the technical (remote-sensing technical) aspects of satellite inputs.

4. INSTITUTIONAL OPTIONS

As regards institutional options, the crop forecasting systems are typically set up in two steps: establishment of a national operational structure as a monitoring system, which is calibrated and fine-tuned to become a crop forecasting system, upon inclusion of further inputs such as information on nutrition and markets. Needless to say, this usually requires a consequent training effort co-ordinated between FAO and the national services. About 50% of the Early Warning projects in Africa do issue quantitative forecasts, while the other half is still at a “monitoring stage”. It is usually not the poor quality of data that prevents countries from going from qualitative to quantitative: the limiting factor tends to be the lack of qualified agrometeorologists. Training, and reduced staff turnover, are two of the solutions to this situation.

It is essential that users receive only products that are stable in time and space and that such products (tools and data) be low cost/free-ware. One of the ways to achieve this is to have the tools developed and made available by FAO or other non-profit organisations.

5. DEVELOPMENTS ARE DEMAND- AND TOOL-DRIVEN

Many tools were developed in regional food security projects in direct response to national requirements, i.e the crop forecasting activities of FAO are largely demand- and tool-driven.

There is indeed a demand for data, such as background information on field inputs and satellite indices, and FAO has often been instrumental in triggering the demand by illustrating the potential of new data types, in particular remotely sensed data. There is also an obvious demand for tools (methods and programmes) growing out of simple requirements such as the water balance of crops, improved interpolation in time and space of data, availability of new data (rainfall, crop phenology) and improved interpretation methods. Again, FAO and other agencies, NGOs etc have played an positive role in promoting new tools, such as rainfall estimates from satellite data, e-mail, low cost NOAA stations, improved interpretation methods, *etc*.

⁷ This issue was addressed by a recent meeting organised by FAO (FAO, 1995).

6. DISSEMINATION OF CENTRALLY DEVELOPED TOOLS

This section focuses on the transfer of crop forecasting and monitoring technology from the regional/continental ("central") level to the national ("local") level. It draws from both the experience of the EU MARS-project and FAO experience in Early Warning Systems. The discussion applies, generally, to the transfer of methods/tools from a higher level to a lower level, hence the wording "central" and "local".

In order to maximise the return from tool development efforts, it is usually desirable that techniques developed at the central level should be transferable to the local level. Doing so has several advantages, but the transfer is technically feasible only if a certain set of prerequisites are met. It should also be noted that actually many tools were originally developed at the national level, but generalised in view of their wider distribution at the central level.

Among the advantages, (i) reduced development cost ranks highest, as money and manpower inputs do not need to be repeated at the local level. Other advantages include (ii) reduced maintenance⁸ cost; (iii) reduced training cost⁹; (iv) results of analyses are comparable across levels (central-local and local-local).

The prerequisites are not only of a technical nature. Obviously, the tools must be general enough to be adaptable to all levels, but, in addition, all those involved must actually be willing to co-operate. They will do so only if they see a definite advantage in the adoption of the new technology. Whoever is at the central level must be ready to loose part of the control: the local units will communicate directly as well and bypass the centre!

Difficult situations may arise when local levels have already developed their own tools and when there is a large disparity between actual (or perceived) technical development of the local levels.

An important issue is terminology, and the point could have been listed under prerequisites above. It is obvious that we are confronted with a variety of terms which not everybody understands the same way (not to speak of different languages!). Some examples taken from a list one of the authors prepared during the recent EU/FAO meeting in Villefranche (FAO/EU, 1997): *assessment, monitoring, prediction, forecast, evaluation, estimation, operational and experimental methods, variability, risk, uncertainty, accuracy, precision, validation, verification, bench-marking, alarm, warning, etc.*

The problem is not just a lexical one: different people understand very different things by an "operational crop forecasting system". Some consider a system to be "operational" when it has been physically set up (computers, data collection channels, software...). Others would rather use the word "operational" only once the system has started producing results which are both **usable** and **used**.

⁸ Maintenance includes debugging of software, improvement of methods, preparation and maintenance of documentation, translation of the documentation, etc.

⁹ Training can be done centrally with standard training material. On the job training is easier too if the various units at the local level can communicate.

The transfer of technology from the central to the local level must thus be accompanied by a whole "scientific and technical culture"¹⁰ and, as stated in the foot-note, it must be seen as a long-term commitment¹¹.

The modularity of software and common file formats mentioned above constitute central issues in the FAO philosophy as regards the development of tools. Problems are likely to appear particularly if tools and methods were developed centrally and the idea to transfer them to others arose only later.

There are, again, no ready-made and absolute recipes. Modularity and standard file formats were mentioned above as central issues. It is suggested that, together, they constitute one of the keys..

Tools that are to be down-transferred must be modular, i.e. the problem to be dealt with must have been thoroughly analysed and decomposed into elementary functions¹². Each of the functions must be implemented separately and "materialised" in a building block, e.g. a computer programme or "routine".

This will greatly facilitate the construction of the more complex applications by just assembling the building blocks.

Needless to say, the blocks must have been carefully designed in such a way that they can actually take data from the previous block and pass them on to the next¹³. Please read the foot-note again: it makes some essential points about the advantages of the modular approach.

It would also be indicated for blocks designed at different local levels to follow the general philosophy as this would facilitate the adoption of the system at the local level.

Modules will be able to exchange data only if they "speak the same language", i.e. the input and output data files must be standardised and the same for all modules, which was mentioned above as standard file formats.

As there are about as many formats as computer programmes, there will be a need for translating from the usual commercial packages and other packages used at the central/local level.

Down-transferring tools has several "risks" attached to it: (i) the risk to loose control over the tools; (ii) the risk to have to spend a lot of time interacting with the people who adopted the tools; (iii) the risk not to be able, in the long-run, to maintain the tools. On the other hand, there are pay-offs too: (i) high return from the initial investment; (ii) greater compatibility between local analyses produced in different countries and, in the best case, (iii) the recognition to have done some useful work.

¹⁰ Maybe "tradition" would be less pedantic than culture in this case. Nevertheless, the idea is that it is not enough to transfer tools and methods if the centre is not ready to invest time in follow-up actions. To put it still differently: transferring tools and expecting that people will adapt them at the local level has to be seen as a long-term moral, as much as technical, commitment.

¹¹ ...for which there are of course financial implications as well.

¹² How elementary exactly is open to debate. But the smaller the better. The modules or blocks can be whole programmes, or "sub-routines" or simple equations. The modularity applies at different levels of complexity.

¹³ In computing terms, the blocks may not be the most efficient approach. But they favour transparency, the ease of maintenance and fine-tuning and the smooth transition to more complex systems.

Below are some final considerations regarding software tools used for crop forecasting: (i) free-ware is better than public-domain software as free-ware ensures that the effort of some will be beneficial to many; (ii) there are more partners in crop forecasting, from rich to poor. Some thoughts and consideration for the technically less advanced would be nice. It is felt that the modular approach outlined above makes provision for both complex, simple and mixed systems.

7. LONG-TERM SUSTAINABILITY

The long-term sustainability of national crop forecasting systems is really the most central concern. The current philosophy regarding this issue is that technical support should be decentralised, as far as possible, using inter-country assistance, with centralised back-up by FAO. FAO's role is thus more and more shifted from direct technical assistance to a co-ordinating, explorative and dissemination role for tools and data and training.

In retrospect, it appears that the most efficient driving force behind the sustainability of national crop forecasting systems is endogenous: the demand by local government authorities for regular and reliable forecasts, *i.e.* political will and commitment. The core of any crop forecasting philosophy should thus be to create the local driving forces.

8. REFERENCES

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¹⁴ An updated version (December 1996) with the newer software was included in the proceedings of a training workshop organised by the Fondation Universitaire Luxembourgeoise in Arlon (Belgium) in September 1996.

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