SEASONAL CLIMATIC FORECASTING: WHO CAN USE IT AND HOW SHOULD IT BE DISSEMINATED?

Roger Blench[1]

Recent technical progress in seasonal climate forecasting, particularly in relation to the El Niño Southern Oscillation, has stimulated considerable interest from potential users such as large-scale farmers, utilities, and the insurance and banking industries. Multi-lateral agencies such as the World Bank are urging that forecasts be made available to small-scale farmers, to increase food security. Disaster-preparedness strategies have begun to take account of such forecasts, and there is considerable interest in assigning them an economic value. However, field studies of the impact of recent forecasts in southern Africa suggests that there is a considerable gap between the information needed by small-scale farmers and that provided by the meteorological services. This paper suggests how the profiles of users can be enriched so that forecasters can generate output likely to be useful to them.

Policy conclusions

- Although progress in seasonal climate forecasting means that it has a clear interest to commercial bodies and agencies concerned with disaster preparedness, its present value to small-scale farmers is less certain.
- Governments and meteorological bodies have not yet developed effective methods of communicating probabilistic forecasts through conventional channels such as extension services. The necessary simplification may be more confusing than useful.
- Climate forecasts need to be integrated with other aspects of infrastructure and input supply; for instance, at present a prediction of drought is unlikely to be linked to increased availability of appropriate seeds.
- Increased reliability of forecasts coupled with the accelerating commercialisation of meteorological agencies will encourage them to oversell their product, especially in areas of the world where the signal is much weaker than the El Niño Southern Oscillation, such as West Africa. Caution is thus mandatory in investing in this type of output.
- Agencies will increasingly use multiple channels, such as satellite television and the internet, to bypass national governments and it will be essential to develop the capacity to filter, synthesise, and redisseminate information in more authoritative forms.

Background

Recent technical progress has increased considerably both the data available for seasonal climate forecasting and the actual forecasts available. In 1997–8, the El Niño Southern Oscillation (ENSO) attracted considerable coverage in the world's media, some of it extremely misguided. However, it did act to focus attention on the issue of seasonal climatic forecasting in general and this has been taken up by multilateral agencies such as the World Bank, by private enterprises such as insurance companies and by national governments. In regions of the world dominated by rainfed agriculture, and where the majority of farm enterprises can be classified as subsistence, foreknowledge of the extent and distribution of rainfall potentially has especial relevance to food security and poverty reduction programmes. In southern Africa, north-eastern Brazil and insular SE Asia, where the ENSO presents a particularly strong signal, the potential to integrate such forecasts with overall agricultural strategy is high.

Improved techniques are making it possible to present the farming community in semi-arid Africa with climate forecasts some three to six months ahead. Since the 1980s there has been a notable increase in the capacity to model planetary weather systems and every year brings new refinements to the General Circulation Models (GCMs) (e.g. Delecluse et al., 1998). Output from models is not deterministic but is typically presented as a range of probabilities (Box 1).

The use of this format for seasonal forecasts is being promoted by the Regional Outlook Fora (ROFs) which were initiated in 1996 for the southern African region (see NOAA/USDC, (1999)). These have now been expanded to cover tropical America, the Caribbean, South and SE Asia and West Africa, and the ROFs have been consistently expanded to include a wider range of users. The output of the ROFs is plotted on national or regional maps and then disseminated to national weather services.

If climatic events *can* be predicted to a degree that makes it possible to respond effectively in the agricultural sector, then this would potentially have a major impact on worldwide food security. Farmers should be better prepared for climatic anomalies and thus less vulnerable. Multilateral agencies such as the World Bank are promoting the availability of such forecasts to small-scale farmers, especially in semi-arid areas. Disaster-preparedness strategies, both of governments and non-governmental organisations (NGOs), have begun to take account of such forecasts, and there is considerable interest in putting an economic value on them. However, field studies of the impact of recent forecasts in southern Africa indicate that there is a considerable gap between the information needed by small-scale farmers and that provided by the meteorological services. This paper suggests that there are both technical problems in transforming the output of GCMs into seasonal forecasts as well as a failure to identify users' requirements. African farmers have always had their own strategies for dealing with climatic uncertainty and the paper asks whether these can be combined with predictive functions, or whether the two responses are mutually exclusive.

Box 1 Standard format for presenting precipitation

A standard format has evolved to present the likelihood of precipitation classes over a given region. Percentage probabilities are assigned to terciles and are typically shown as follows:

- Above normal 50
- Normal 30
- Below normal 20

This indicates that the chance of rainfall being above normal is 50%, of being average 30%, and so on. The monthly 'Information Forum' of the South African Weather Bureau is a typical example of this type of presentation.

Transforming the output of GCMs

Forecasts are essentially of three types:

1. Those forecasting the next few days	Weather forecasts
2. Those forecasting the next few months	Seasonal climate forecasts
3. Those projecting the climate in the years to come	Long-range climate forecasts

Weather forecasts are based on analogue measurement and increasingly depend on satellite imagery. Climatic phenomena can be detected on the images and their probable behaviour predicted several days ahead. Although even these forecasts occasionally misfire, their accuracy is constantly increasing (see *www.atmos.washington.edu/tpop/pop.htm*).

Climatic events in specific parts of the world were formerly treated as discrete, and therefore analysed regionally, but since the 1980s there has been a notable increase in the capacity to model planetary weather systems. This reflects a greater understanding of the mechanisms of oceanic currents but also simply raw computing power. In addition, the installation of sea-surface temperature (SST) arrays in the Pacific provides more immediate data on the movements of water-bodies (see *www.pmel.noaa.gov/toga-tao/realtime.html*). Seasonal climate forecasts combine analogue measurement and modelling. Using models of the interactions of the world's weather systems their likely future behaviour can be projected for up to six months. The ENSO is a good example of this; measurement of SSTs in the Pacific allow us to model the likely evolution of the ENSO in some detail, leading to a seasonal forecast (see *www.cpc.ncep.noaa.gov/products/ analysis_monitoring/ensostuff/*). However, different systems produce markedly different signals; oscillations such as the North Atlantic Oscillation (NAO), which is the strongest influence on West Africa (Hurrell and van Loon, 1997), and the Pacific Decadal Oscillation (PDO) have weaker signals than ENSO and may never allow such accurate predictions.

Long-term forecasts have been the subject of considerable expenditure and scientific effort in the last 30 years. They essentially depend on the analysis of trends in previous climatic data coupled with models of ocean/atmosphere interaction. Either present trends are projected (e.g. global warming will continue) or cycles are detected (as in the proposed 14-year cycle in southern Africa). Sadly, if weather *is* a chaotic system then this type of prediction may prove to be impossible: there is still no clear proof of their validity.

Farmers in theory and in practice

Seasonal forecasts, attractive as they may seem, have significant theoretical problems relating to the testability of predictions. If it is assumed that in a given year one of the three possible outcomes occurs (Box 1), then there is no outcome that can falsify the prediction. The following year an analogous but different probabilistic prediction is announced; again, no real world result can falsify the prediction.

Nonetheless, over a period of time a farmer should stay ahead, assuming the rains are distributed in the forecast pattern and that the farmer always pursues a strategy that assumes the predictions are accurate. However, no such farmer exists, and no rational producer, even in theory, would gamble all their resources on a single strategy, whatever the supposed quality of a forecast. Farmers face real problems of infrastructure maintenance, continuity of trained labour and cash flow. Responses to climate are risk-averse and typically involve the pursuit of a diversity of options, rather than a concentration on a 'best bet' forecast.

The technical aspects of climatic modelling are pushing far ahead of the mechanisms for making practical use of the results. Agencies are pumping out data, plotting it on alluring maps and claiming huge potential economic benefits. Many agencies have commercial arms and this increases pressure on them to promote their models. But attention to the details of integrating climate modelling and seasonal forecasts with national and local agricultural strategy is still relatively low-level, while links with the decision-making processes typical of farmers in semi-arid zones have barely begun.

Medium-range forecasting in semi-arid Africa

Seasonal climate forecasts are of most significance to farmers and livestock producers, health professionals, economists and those in the insurance industry. In regions that depend substantially on rainfed farming, foreknowledge of the likely pattern of precipitation could imply substantial improvements to food security as well as profits to larger-scale producers.

The accuracy of forecasts depends on effective measurement of known predictors, model quality and local interpretation. In 1997–8, indicators showed that an El Niño was in progress, resulting in warm water off the coast of Chile, and drought in NE Brazil, southern Africa and Melanesia. Preparations were made throughout southern Africa, causing considerable scepticism when the expected drought failed to materialise. Similarly, predictions for January to March 1999, adjusted by the SARCOF meeting in December 1998, predicted above average rainfall in southern Africa, whereas observed rainfall was in fact lower than average. These technical failures have had the effect of enforcing more humility on climatologists and called into question the utility of widespread dissemination of forecast material.

Like earthquakes, with which it shares a number of structural features, climate is not easily second-guessed. The human and economic costs of badly wrong predictions can be considerable. Even predictions from the most reliable models still deal in probabilities, and this remains their weakest feature. Can a probabilistic forecast really be transmitted in a format that is useful to farmers? What calculus do farmers already make and can indigenous strategies be combined with external knowledge to decrease risk in agriculture?

Ethnometeorology and responses to risk

Forecasts also compete with indigenous knowledge systems. In different parts of the world, farmers depending on rainfed cultivation have developed complex cultural models of weather and may be able to cite local predictors of seasonal climate (Pepin, 1996). This has sometimes led to inappropriate reification of this type of knowledge by researchers; since, in reality, farmers themselves seem to place limited trust in these predictors; hence the evolution of complex risk-aversion strategies in rainfed agriculture across the world. Nonetheless, understanding the perception and categorisation of weather and climate in different cultures is essential to the process of making meteorological information useful.

Risk-aversion strategies in semi-arid production systems do, however, pose a problem for adapting forecast information. Low-income farmers are therefore interested in a broader range of characteristics of precipitation, notably: total rainfall; patchiness of rainfall; intensity; and starting date. Long dry spells will reduce yields, irrespective of the total precipitation. Similarly, falls above a certain intensity may cause flooding or otherwise damage the crops, and, in any event, the impact of dry spells or high-intensity rainfall will depend on local soils and topography.

Climate models can make probabilistic predictions about the aggregate rainfall, but can say almost nothing about key variables such as patchiness and intensity. Farmers' strategies

depend not only on expected rainfall patterns and soil/slope characteristics but also build in availability and cost of labour, seeds, pesticides and other inputs, as well as the likelihood of famine relief if they pursue an inappropriate strategy. Food-aid, paradoxically, may impel farmers to take greater risks with climate, because the gains are high if they succeed and the state picks up the pieces if they fail. This is typically a problem in parts of southern Africa, where food-security mechanisms still function in rural areas and prices for maize remain high.

Responses to such a spectrum of risks vary between countries, communities and individuals, but historically, farmers have spread risks by managing diversity. A mix of cultivars and of species were planted, and the exact composition reflected both the date of the first rains and the period that the rains 'set in'. It is not unusual for farmers in West Africa to plant two or three times at the beginning of the rains and to vary the cultivar mix each time, or even to uproot seedlings when it becomes clear they are inappropriate for the observed rainfall. Similarly, during the season, water availability can be manipulated both by restructuring the pattern of ridges or beds and by hand-irrigation.

Small-scale farmers thus pursue dynamic strategies in relation to rainfall, in contrast to single strategies where one prediction prior to cultivation predetermines a series of decisions.

With some adaptation, this model can also be applied to pastoralists; mobile livestock producers have developed elaborate information networks to gain opportunistic access to pasture and water, and change their strategies constantly during rainfall periods. Pastoralists have fewer means of countering unfavourable climatic events (they cannot, for example, change their livestock breed in time for the growing season in the way crop producers can change seed) but they have also less investment in a particular locale. Figure 1 shows a schematic representation of this contrast.

Typically this type of approach reflects the scale of enterprises; the larger the enterprise the greater the costs of making changes to strategies as the season progresses. As a consequence, the economic value of accurate forecasting is proportionately greater to larger enterprises. Moreover, larger enterprises have greater reserves of cash to ride out the years when the forecast is inaccurate.

The inverse is also true; if the forecast is inaccurate and a small-scale farmer invests heavily in a wrong outcome the overall costs to the household enterprise are correspondingly greater. The consequences – such as the food aid and labour migration observed in the southern African droughts of the early 1990s – could be particularly severe if households put too much faith in a 'good year' forecast and invest heavily in purchased inputs and fertiliser-responsive crop varieties.

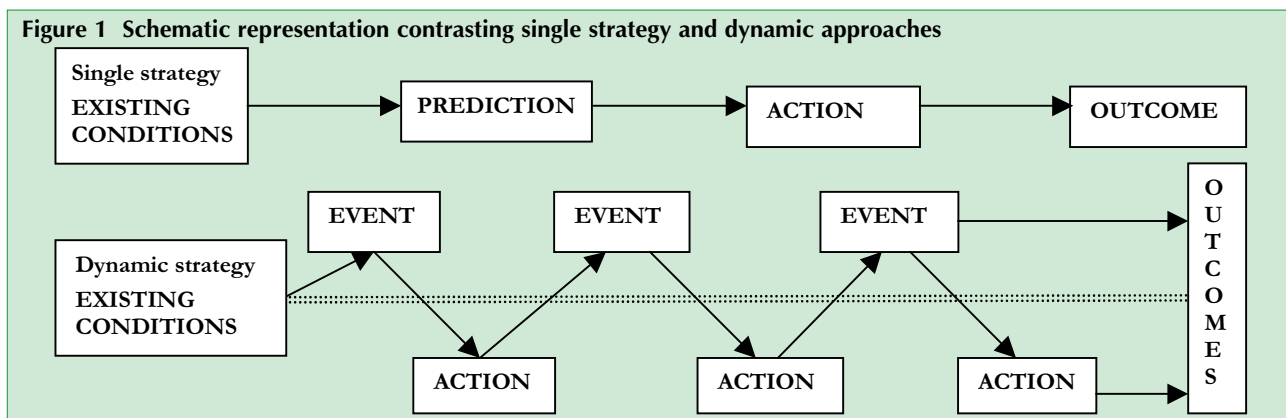The likelihood of farmers making such choices in different parts of semi-arid Africa is not, of course, random, but determined by national policies and cultural preferences. In eastern and southern Africa, a limited number of seed companies have historically dominated commercial sales in rainfed farming areas. They have reinforced the trend against traditional cereal staples and lobbied for policies that interdict open-pollinated varieties of maize. At the same time, the private sector has become relatively efficient at delivering inputs in rural areas. High-input strategies of this kind may be logical at farm level, and acceptable in the wider context if farmers can cover the risk of bad years by taking out crop insurance. Where this is impossible and they instead have to rely on food aid, part of the cost of wrong decisions is transferred to the state, although, of course, where food aid is received from the donors at zero opportunity cost, the national cost may be negligible.
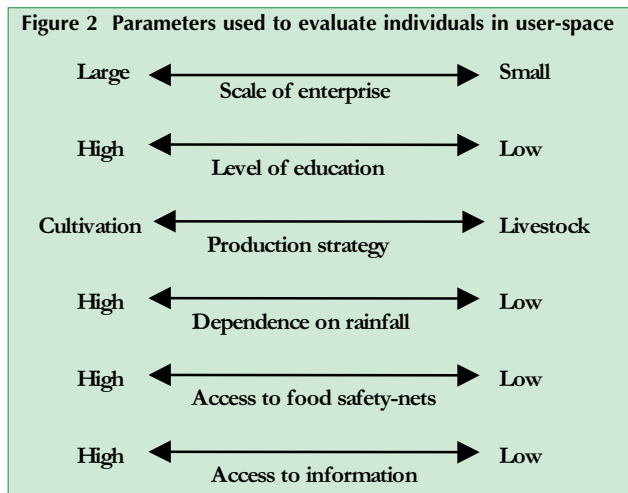
Two conclusions can be drawn from this: that the more dynamic farmers' strategies are, the less value is seasonal forecasting in its current form and that the smaller the enterprise the more it should adopt risk-aversion strategies. Where small-scale farmers adopt single strategies, inaccurate forecasts have greater negative consequences. Forecasts of the type currently promulgated are thus ill-adapted to the way farmers actually farm in much of Africa. The question is then, are there aspects of farmers' existing strategies that can be melded with the new type of data becoming available? 'Research addressed to questions framed by climate science is not necessarily useful to those whom climate affects. A climate forecast is useful to a particular recipient only if it is sufficiently skilful, timely and relevant to actions the recipient can take to make it possible to…improve outcomes', (Stern and Easterling, 1999: 37).

Situating individuals in user-space

The usability of forecasts depends strongly on the characteristics of users, their place in user-space, as it were. At present, the disseminated outputs have tended to focus on a rather oversimplified dichotomy between large-scale commercial farmers and small-scale subsistence farmers. Initial studies of the impact of forecasts on users suggest that a richer user-profile is required if the forecasts are to be accepted by managers of farm enterprises. Some of the key parameters that have been identified are shown in Figure 2.

This complexity implies that the process of intermediation between the producers of technical output, the Weather Bureaux and the ROFs, and the consumers, farmers and pastoralists, will need to be increased substantially. Already in developed economies where climate dependency is high, such as the United States, a large private sector has developed to provide these services. More innovative solutions involving public-private partnerships are likely to be required in less-developed economies, where the value of seasonal forecasts remains to be proven and consumers are much less able to pay for this service.

Figure 1 Schematic representation contrasting single strategy and dynamic approaches

Figure 2 Parameters used to evaluate individuals in user-space

Large ◄———————► Small
Scale of enterprise

High ◄———————► Low
Level of education

Cultivation ◄———————► Livestock
Production strategy

High ◄———————► Low
Dependence on rainfall

High ◄———————► Low
Access to food safety-nets

High ◄———————► Low
Access to information

Reaching farmers

Assuming government or its intermediaries have a confident message for crop and livestock producers, the problem of agricultural extension was often effective within a limited sphere. Even today, when a cash crop such as tobacco is being bought by a well-established company, relations between smallholders and input supply are often well-organised. But improving the production and marketing of staples through motivating government services has only ever been of limited effectiveness. Seasonal forecasts for small, mixed farmers are the type of public good that will not be picked up by the private sector, but which also present a relatively complex message that is typically garbled or ignored by extension services.

In such a situation, it seems very unlikely that extension agents will be able to present probabilistic predictions in any form useful to farmers. There has been a certain tacit recognition of this, at least in southern Africa, where government has turned to radio, television and even the Internet as alternative channels. This strategy is at present rather inchoate, with no systematic survey of users' needs, or of the impact of different presentation styles. However, it does make use of farmers' existing information systems, an often neglected resource in Africa. Farmers and pastoralists are active collators of information about crop varieties, input supplies, rainfall and government activity and very adept at integrating such information into their production strategies. The complex route of interpreting information, recommending agricultural strategies and communicating them through extension agents may thus be largely a waste of time. The direct broadcasting of fairly raw data together with the development of rapid feedback systems between users and producers may be more effective. The existence of multiple channels and the speed with which information becomes assimilated often make it difficult to detect how users source particular items. As a consequence it will be important to develop focus groups in different user-communities to assess the impact of particular dissemination strategies.

Another aspect of the extension/dissemination debate concerns the evolution of trust between producers and government. Agents are often seen as being out of touch with the realities of agricultural life, recommending higher levels of inputs than farmers can afford, and insisting on rigid schedules which take no account of climatic variability. The dissemination of forecasts in such a vacuum is likely only to exacerbate the low levels of trust that already exist.

Where next?

The next few years will undoubtedly see rapid technical progress in the evolution of GCM models and increased reliability of seasonal forecasts. It also likely that these will be massively oversold by the agencies that produce them, especially in areas of the world where the signal is much weaker than the ENSO, such as West Africa. Caution is thus mandatory in investing in this type of service. Agencies will increasingly use multiple channels, such as satellite television and the Internet to bypass national governments and it will be essential to develop the capacity to filter, synthesise and re-disseminate information in more authoritative forms.

Communications technology is also affecting the ambition of meteorological services in another direction, the provision of 'near real-time information' or 'nowcasting'. As recording systems are connected more directly to central analysis units, and farmers can consult web pages, it is possible to constantly update information. Ten-day rainfall bulletins are a reality in parts of southern Africa and pressure will increase for greater speed and clarity. Pastoralists in semi-arid Africa have always had such real-time information systems through pooling information in markets; the telecommunications revolution may help us mimic these systems.

References

Blench, R. M. and Marriage, Z. (1998) 'Climatic uncertainty and natural resource policy: what should the role of government be?' *Natural Resource Perspectives*, No. 31. London: Overseas Development Institute. See www.oneworld.org/odi/nrp/31.html

Delecluse, O., Davey, M. K., Kitamura, Y. Philander, S. G. H. Suarez, M. and Bengettson, L. (1998) 'Coupled general circulation modelling of the tropical Pacific', *Journal of Geophysical Research*, C7: 14,357–14,373.

Hurrell, J. W. and van Loon, H. (1997) 'Decadal variations in climate associated with the North Atlantic Oscillation', *Climatic change*, 36: 301–326.

NOAA/USDC (1999) 'An experiment in the application of climate forecasts: NOAA-OGP activities related to the 1997–8 El Niño event'. Washington, DC: University Corporation for Atmospheric Research.

Pepin, N. (1996) 'Indigenous knowledge concerning weather. The example of Lesotho', *Weather*, 51 (7): 242–248.

Stern, P. C. and Easterling, W. E. (eds) (1999) *Making climate forecasts matter*. Washington, DC: National Academy Press.

Endnote

[1] These ideas were discussed at a workshop on User Responses to Seasonal Climate Forecasts in southern Africa, held in Dar es Salaam, Tanzania on 10th–11th September 1999. This workshop, funded by the World Bank, brought together researchers working on different aspects of user responses. Participants at the CICERO workshop were: Anna Bartman, Roger Blench, Louise Bohn, Ben Hochobeb, Tharsis Hyera, Amin Bakari Iddi, Nganga Kihupi, Robert Kingakomo, Maynard Lugenja, Lars Otto Naess, Karen O'Brien, Jennifer Phillips, Winifrida Rwamugira, Anne Thomson and Coleen Vogel. A summary of this workshop can be found at *www.cicero.uio.no/Research/Projects/user_responses.html*

See *www.oneworld.org/odi/nrp/* for papers in this series.