USING CLIMATE INFORMATION IN AFRICA: SOME EXAMPLES RELATED TO DROUGHT, RAINFALL FORECASTING AND GLOBAL WARMING

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1 INTRODUCTION

Quantitative records of climate in Africa derived from dedicated measuring instruments commenced in the middle decades of the 19th century and became widespread in the first decades of the present century (Figure 1). As with many colonial institutions, newly established National Meteorological Agencies collated and processed such environmental data partly out of a desire for abstract knowledge (how wet or hot were these new colonies compared with the European homelands?), but partly to generate knowledge which would inform decisions about how best to invest capital in the agricultural or hydrological infrastructure of these 'undeveloped' territories; see Bruckner (1899) for an excellent illustration of this in relation to Sudan. The establishment of irrigation schemes (e.g. the Gezira in Sudan), the introduction of new crops (e.g. coffee in East Africa) and the deliberate cultivation of tree plantations (e.g. cocoa in West Africa) all used, to a greater or lesser extent, systematically generated information about climate (see Worthington, 1958). Climate data was converted into information which was then used as knowledge to inform decisions.

The volume of climate data relating to Africa has increased enormously since those early decades, whether they be measured conventionally, using automatic weather recorders (AWRs) or using satellite platforms. The transformation of these data into information has, in most cases, just about kept pace with the volume of data collected. For example, a comprehensive atlas of African rainfall has been published by Nicholson *et al.* (1988) which includes detailed information about the spatial and temporal distribution of rainfall and its variability through time; climate data have been used in a systematic framework to identify the potential suitability for different tree species throughout Africa (Booth *et al.* 1989); and satellite images of cold cloud duration have been used to construct spatially comprehensive rainfall climatologies and images of biomass productivity[1] have been used to compile inventories of the spatial and interannual variability in vegetation cover.

In recent years there has also been the introduction of a new genre of climate information - real-time assessments and predictions. Such information includes seasonal rainfall forecasts for the Sahel and other regions (Folland *et al.* 1991), near real-time assessment of rainfall distribution and vegetation response (as produced, for example, by the USAID Famine Early Warning System) and the prediction of future climate change (e.g. Houghton *et al.* 1990; 1992; Hulme 1994). Driving these developments has been the (usually implicit) assumption that since climate affects social and economic activity, generating more (and better) climate-related information will lead to more efficient decisions being taken with regard to the management of the social and economic environment. This recent increase in climate-related information has, of course, been a global phenomenon, but has been particularly sought after for Africa. It is in this continent where the exposure of economic activity to climate variability has been most dramatically illustrated in recent years.

This article will examine the assumption that more (better) climate information leads to better decisions being taken about, for example, resource management, aid strategies and economic restructuring. To focus the discussion, three examples concerned with regional drought phenomena, seasonal rainfall forecasting and the global warming debate will be used. The first two examples relate to the use of climate information within Africa and the latter about the value of climate information for African negotiators in an international negotiating context.

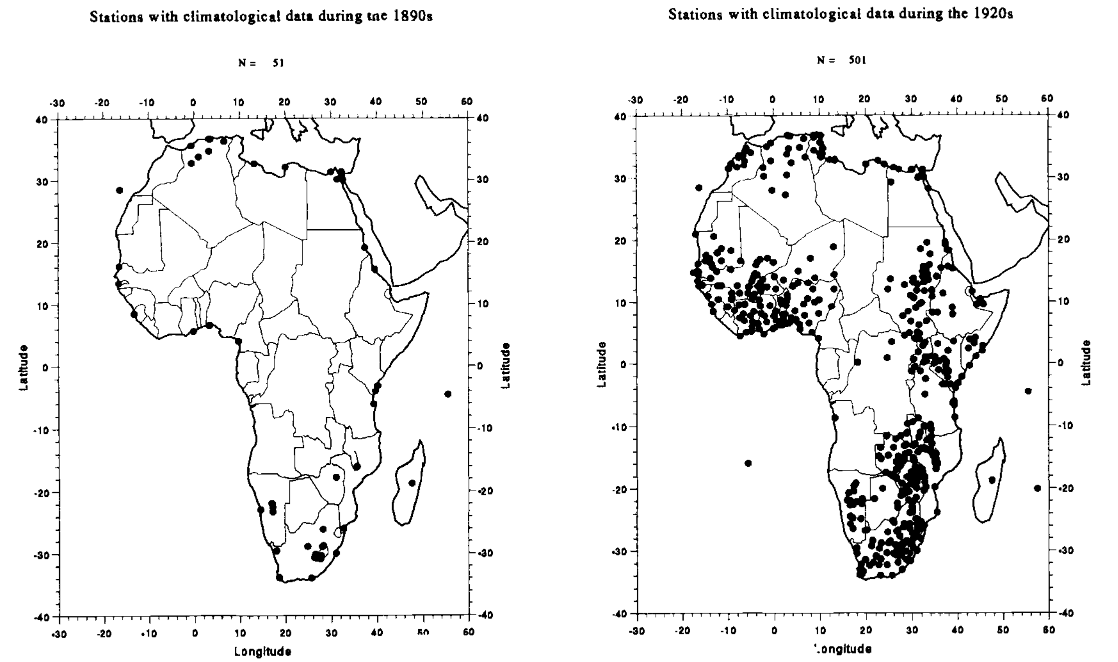
2 REGIONAL DROUGHT

Dryland climates comprise over 50 per cent[2] of the African continent and drought[3] (see next page for footnote) is an inherent characteristic of these climates. This is not such a trivial statement to make. A

[1] The most widely used of these is the Normalizd Difference Vegetation Index (NDVI) which provides an indication of the photosynthetic activity of surface vegetation at a resolution of about 1km.

[2] This estimate excludes hyper-arid climates which cover another 17% of the African land surface. Dryland climates are defined as including arid, semi-arid and dry sub-humid zones.

Figure 1: Distribution of rainfall recording gauges in Africa during the 1890s and the 1920s decades. These distributions are derived from the data held in the global precipitation dataset of the Climatic Research Unit, the most extensive historic precipitation data holding in the world (Eischeid *et al.*, 1991).



full realization of its import would be beneficial for the management of resources in Africa, as recognized by Glantz and Katz (1986: 338): 'It is important to emphasize to policymakers that the probability of a drought lasting two or more years (without any permanent change in climate) is substantial.'

Quantifying the duration and magnitude-frequency of drought events in different regions of the continent is an important application of historic climate data. Three examples are given of how such information could be used.

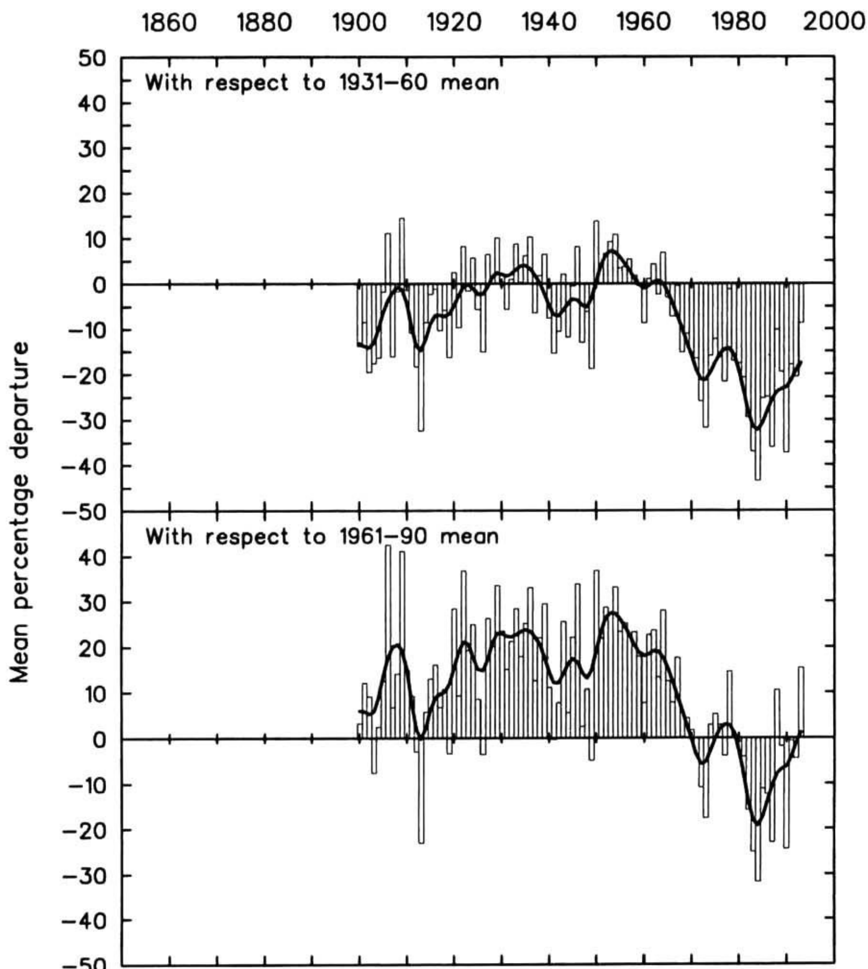
Figure 2 shows two annual Rainfall Anomaly Indices for the Sahel region of Africa. The only difference between these time series is the reference period used to define the average condition: 1931-60 in one case and 1961-90 in the other. The different perspective on rainfall events in the Sahel that these two graphs provide is startling. This different perspective is illustrated in Figure 3 where the two driest years in the instrumental record - 1984 and 1990 - are located in relation to these different reference period statistics. From the perspective of 1931-60 statistics, both 1984 and 1990 were substantially drier than anything that may have been anticipated; the previous driest year was only 20 per cent below average compared to -43 per cent in 1984 and -37 per cent in 1990. When the reference period is changed to 1961-90, however, neither year appears quite so exceptional: -32 per cent and -24 per cent respectively. The importance of which reference period (or perspective) is used to define drought extremes is a point that has been made many times before (e.g. Quinlan 1986; Farmer 1989). For the most robust analysis, the full instrumental record should be taken to define drought extremes. Figure 3 indicates, however, that were this to be done using the longer 1931-

[3] Drought is taken throughout this paper to refer to meteorological drought, therefore excluding agricultural and hydrological definitions. 'Drought' (two or more years of below-average rainfall) should be distinguished from 'desiccation' (aridification resulting from a dry period lasting a decade or more) and 'desertification' (land degradation in dryland regions).

90 perspective, these two years would still appear as unusually dry events.

The importance of this type of analysis is well illustrated by the experience of the South Chad Irrigation Project (Kolawole 1987). This project, to exploit the waters of Lake Chad for the irrigated cultivation of rice, maize, cotton and vegetables, was conceived and planned in the late 1960s and executed in successive stages during the 1970s. The single most critical requirement for success was the level of Lake Chad. The minimum level for abstraction of water from the Lake was 279.9m (above sea level). Prior to the 1970s, the Lake had only twice fallen below this level since records began in the 1890s and on both occasions - 1942 and 1943 - had rapidly recovered. Due to the low rainfalls in the Sahel of the early 1970s and, again, the late 1970s and early 1980s, the Lake level

Figure 2: An annual Rainfall Anomaly Index for the Sahel (1900-93) calculated using two different reference periods or perspectives: 1931-60 and 1961-90. Over 100 gauge records contribute to these series. The smooth curves represent the time series filtered to suppress variations on time scales of less than 10 years.



fell to 278m in 1973 and to 275m in 1984. Less than 10 per cent of the targeted irrigated area was cultivated in 1983/84 and in the 1984/85 cropping season no crop yields at all were forthcoming. Subsequent performance has remained very far short of the planned production. A project, which was adequately designed assuming 1931-60 (or even 1900-70) rainfall variability, has proved an expensive disaster in view of the drought and desiccation which has occurred in the Lake Chad catchment over the last 20 years. Either a more cautious interpretation of the instrumental rainfall record or a longer-term perspective on climate change in the region would have resulted in a more resilient design specification for water abstraction from the Lake in periods of low rainfall.

A third illustration of the importance of how historical climate data is interpreted comes from southern Africa. No equivalent desiccating trend to that found in the Sahel has occurred in southern Africa, although in the 1991/92 wet season a regional drought affected large parts of Zimbabwe, Mozambique and northern parts of South Africa. This drought was frequently cited at the time as being of unprecedented severity and that associated impacts were therefore in some sense unanticipated. The historic rainfall record for the region does not, however, support such an interpretation. Previous droughts of similar (1967/68) or more severe (1946/47) magnitude have occurred over the last 100 years (Figure 4). The significance of this false perception is well summarized in the following quotation:

> What I believe to be at stake is the possible misrepresentation of the severity of the drought. Although the drought is severe, from a climatological point of view it is no worse than that of 1982-83, and it is on a par with three previous droughts in the past 80 years. Roughly speaking it is a 1-in-16 year event and therefore cannot be considered unusual. However, judging by the reaction of many interested parties, too much blame is being attributed to the meteorological drought and insufficient blame on the lack of drought planning. Growing population and greater economic expectations are attempting to extract more from our natural climate and

Figure 3: Boxplots of annual Rainfall Anomaly Index values for the Sahel calculated using three different reference periods: 1931-60, 1961-90 and 1931-90. The dots refer to the 1984 (driest) and 1990 (second driest) years.

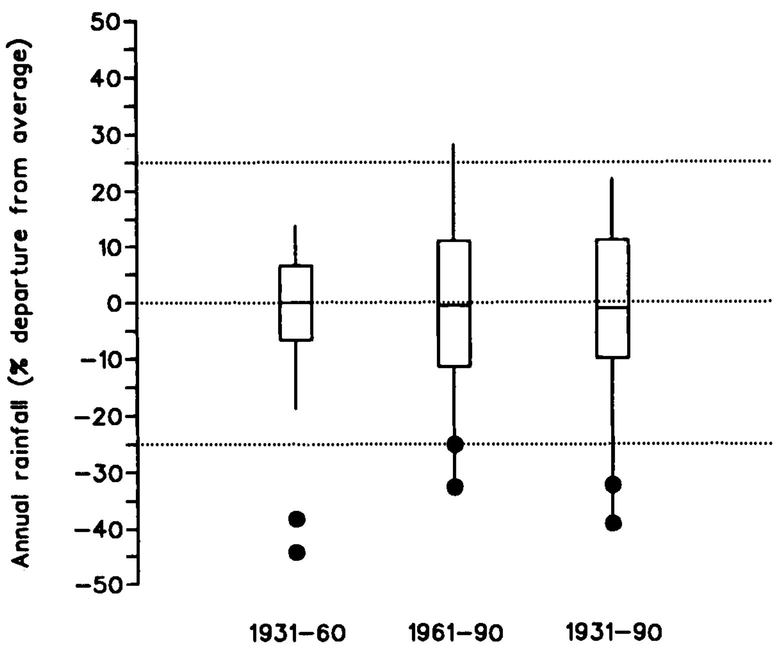
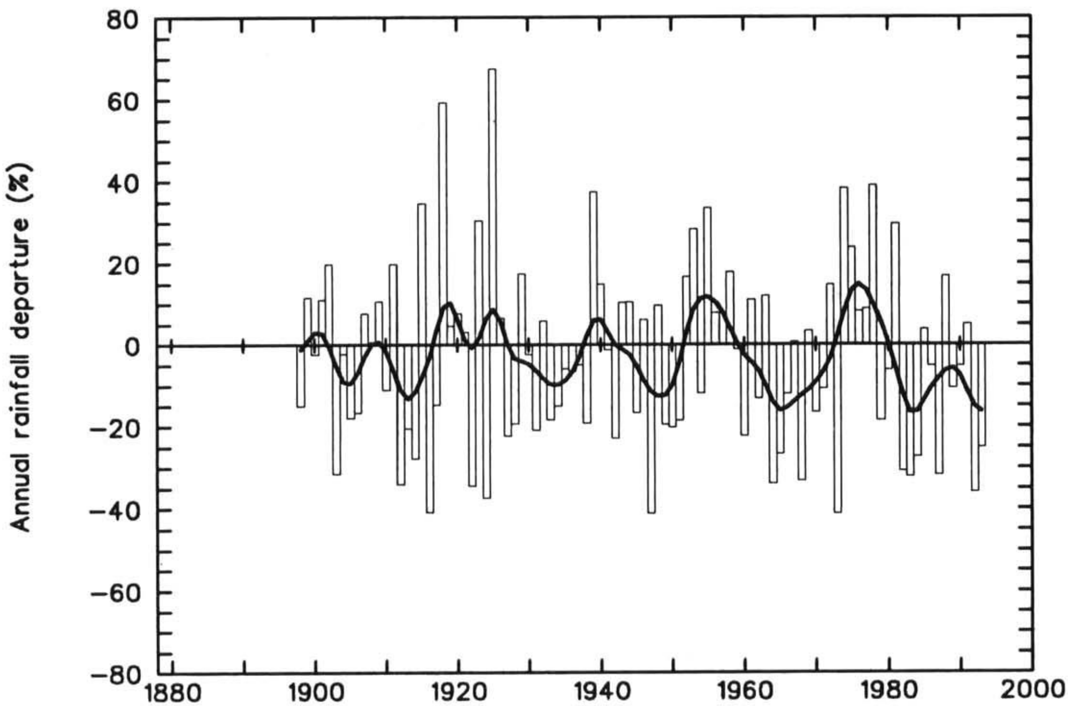


Figure 4: An annual Rainfall Anomaly Index for southeastern Africa (1897/98 to 1992/93) using 1931-90 as the reference period. The rainfall year is taken as July to June. The smooth curve represents the time series filtered to suppress variations on time scales of less than 10 years.



rainfall variations than is available. It is these social pressures that need more attention in order to cope with severe droughts which are characteristic of our summer rainfall regime.

Laing 1992: 17

3 SEASONAL FORECASTING

Various capabilities for forecasting seasonal rainfall in different regions of Africa have been established in recent years. These capabilities are either process (model)-based or statistically-based, but in most cases use regional or global sea surface temperature (SST) anomalies as predictors of subsequent wet season rainfall. Seasonal forecasts are now issued regularly by a variety of national and international organizations, both internal and external to Africa. For example, the Drought Monitoring Centre outside Nairobi was able to forecast the 1991/92 drought in southeastern Africa in the October before the wet season commenced (Masika 1992) using well-established relationships between El Niño/Southern Oscillation (ENSO) events in the Pacific Ocean and regional rainfall anomalies in southeastern Africa. I will consider in some more detail one of these new forecasting capabilities.

As part of a larger research programme into the predictability of climate in the tropics, the UK Met. Office have established a forecast capability for seasonal rainfall in the Sahel region of Africa (see Folland *et al.* 1991). These forecasts have been issued each May and July since 1986 (Figure 5) and are distributed to most of the National Meteorological Agencies in sub-Saharan Africa. Figure 5 indicates that, with the exception of 1990, all of the forecasts issued in mid-July fell within the inter-quartile range of the subsequent individual station observations. Also in each year, however, a substantial number of stations recorded rainfall anomalies of an opposite sign to the forecast, most notably in 1988 (see Hulme and Trilsbach 1989). These data indicate that while there is genuine skill represented by the forecasts, the local variability in rainfall across the Sahel in any given year is large and cannot be captured by a single forecast value.

While such forecast information is of potential benefit for these Sahelian countries, many questions arise about how such information is used and exactly what benefits will accrue to which decision-making activities or sectors of society. The following summary of these issues is based on the work described in Hulme *et al.* (1992) which itself is a specific illustration of many of the general questions about the utility of forecast information in sub-Saharan Africa originally raised by Glantz (1977). A considerable number of agro-meteorological, hydrological, socio-economic and famine and flood Early Warning Systems already exist to aid management and decision-making in sub-Saharan Africa. How can seasonal rainfall forecast information enhance these existing systems?

Forecasts are likely to have their most immediate use at national and international level, providing a new input into existing crop production and hydrological forecasting procedures, and informing Early Warning Systems of likely rainfall conditions in advance of any other information source. Improvements need to be made, however, at several levels (e.g. institution building, forecast acceptance, linking with other forecasting models, etc.) before the usefulness of rainfall forecasts are likely to reach their greatest potential. Demonstrable improvements in forecast skill are important for encouraging government institutions and food aid agencies to react to the rainfall forecast. This, necessarily, requires a good track record over a number of years.

It is clear that at the present time **direct** use of the forecast information to rural communities is severely

Figure 5: Seasonal rainfall forecast for the Sahel region of Africa as issued by the UK Met. Office at the end of May (crosses) and mid-July (dots). The forecast is expressed as the percentage of the 1951-80 average rainfall. The superimposed boxplots indicate the range of observed rainfall in each year calculated from a network of up to 100 gauges in the forecast domain. The forecast for 1991 is not known and the observed values for 1993 are provisional.

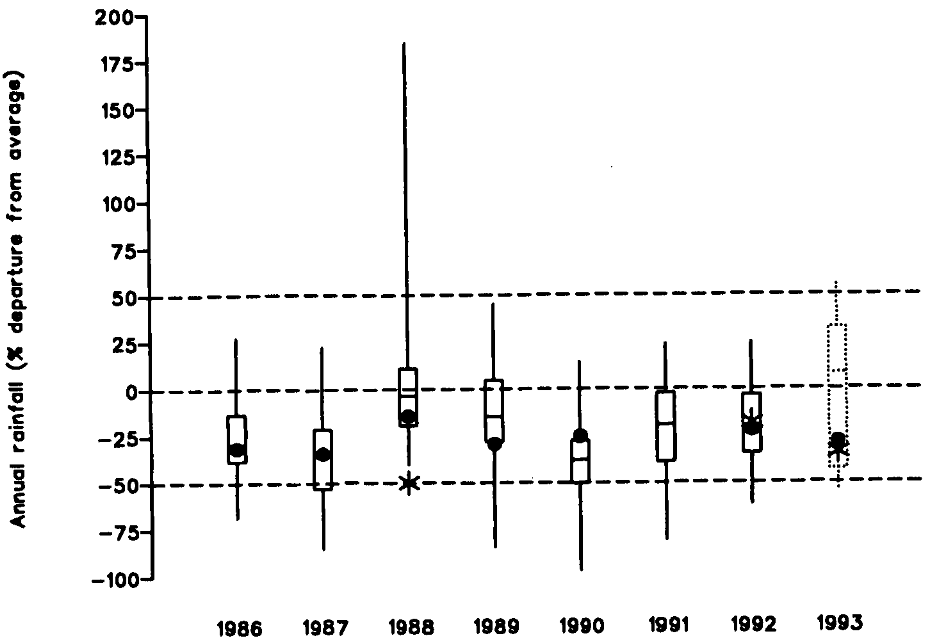
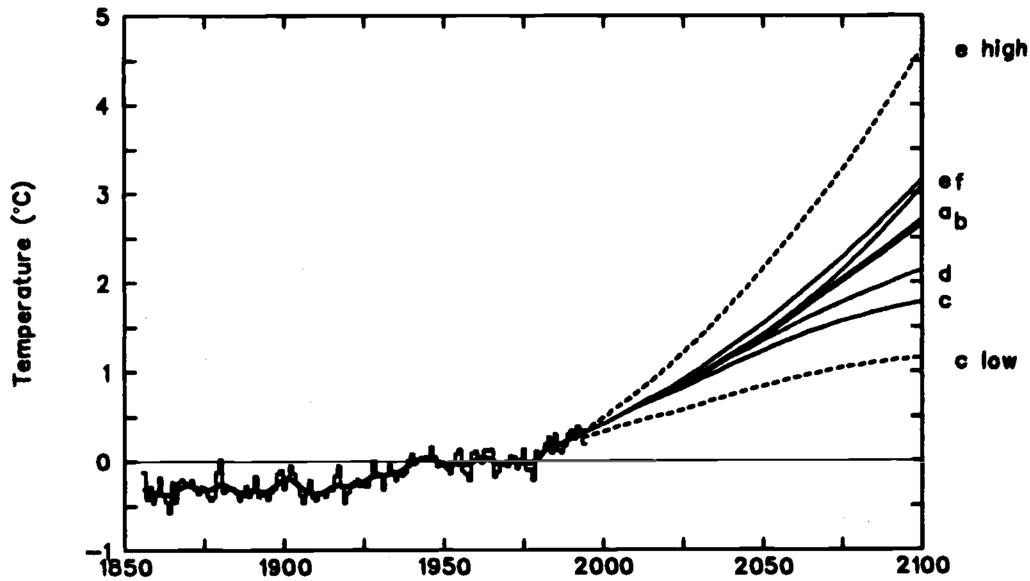


Figure 6: Projected increase in global-mean temperature with respect to 1990 due to the six emissions scenarios published by IPCC in 1992 (Leggett et al., 1992). The dashed lines are the likely upper and lower projections and result from applying the range of climate sensitivities (1.5°C to 4.5°C) as stated by the IPCC to the IS92c (lowest) and IS92e (highest) scenarios. [Results adapted from Wigley and Raper, 1992].



limited. They are the user group least likely to benefit directly from the forecast. This is because of the coarse space- and time-scales of the forecast, combined with the complex nature of decision-making in risk-averse production systems and the limited flexibility such systems possess to respond to external information. This is exacerbated by the lack of infrastructure to inform and support producers' choices in the rare cases where such choices can be made. How the forecast is used at national and international levels will be the single greatest determinant of its impact on rural communities.

Effective dissemination of forecast information cannot be planned until other constraints have been resolved; for example, the links between information and the ability to respond to it. The limitations of forecast information should be consistently stressed (e.g. what is **not** being predicted as well as what is). Forecast information should be expressed both in scientific terms and in terms that complement indigenous knowledge systems and local perceptions (e.g. seasons should correspond with local calendars). It must also be delivered in a timely and consistently reliable fashion, most probably via radio (rather than in written form) and through existing extension and information systems. While informal information networks in the rural areas concerned are usually highly developed, the formal information networks are currently very weak. The fact that it is better-endowed farmers and those close to urban areas who tend to have preferential access to formal information networks is relevant in this regard.

4 THE CLIMATE CONVENTION

A third illustration of the ambiguous and/or biased value of climate information comes from the negotiating process which led to the establishment of the UN Framework Convention on Climate Change (FCCC) in June 1992 and its coming into force on 21

March, 1994. The climate science community have made major contributions to the negotiating process (both advertently and inadvertently) through the issuing of reports and statements containing judgements about current climate variability and future climate change and its causes. Some examples of how climate information has influenced this political process as it relates to Africa will be given.

The key scientific statements which motivated the FCCC are contained in the First Scientific Assessment of the Inter-governmental Panel on Climate Change (IPCC) published in 1990 (Houghton *et al.* 1990), with a supplement in 1992 (Houghton *et al.* 1992). (The Second IPCC Assessment is due to appear in 1995). The IPCC Report clearly articulates the possibility that human pollution of the atmosphere has already impacted global climate and that past and continued pollution may lead to significant future climate change. Whether this, and associated, information is in itself enough of a basis on which to formulate a global strategy to combat global warming is debatable and depends on a number of factors: the degree of uncertainty inherent in these predictions, their manifestation at regional scales (e.g. what regional changes in climate will affect Africa), and how one devises and undertakes a benefit/cost analysis of such an interventionist strategy.

While information is intended to reduce the magnitude of uncertainty implicit in decision-making, the IPCC statements may appear to increase uncertainty [4]. Both the rate and magnitude of future global climate change are uncertain (projections of global warming by 2100 range between 1° and 4.5°C; Figure 6) and, indeed, whether the 0.5°C warming observed to date can be clearly attributable to greenhouse gas emissions is still not clear (Wigley and Barnett 1990). How such uncertainty is interpreted depends on the different perspectives of the actors in the climate debate. Thus industrial concerns with capital tied up in fossil fuel extracting or processing technologies regard such uncertainty as sufficient cause to wait, whereas non-governmental organizations (NGOs) with mission statements aimed at 'protecting the Earth' see such uncertainty as demanding intervention now according to the Precautionary Principle (Costanza and Cornwell 1992). The differing perspectives of Northern and Southern governments also condition the way uncertainty is interpreted. Although a generalization, there is a reluctance by Northern governments to intervene strongly in their economies to reduce greenhouse gas emissions, either through taxation or regulation, without a more urgent and unequivocal scientific statement. In contrast, Southern governments see a clear opportunity to extract benefits from the North in the context of an international emissions quota system. Such benefits may be expressed either as direct capital transfers, as technology transfer or through the trading of carbon emissions permits (see Grubb *et al.* 1991). In order to facilitate such benefits, Southern governments may well seek to emphasize up the urgency of the issue.

Trying to clarify whether mitigation and/or adaptation strategies are currently necessary interventions, usually leads to an examination of the predictions of regional climate change - are these substantial enough in relation to current climate variability to cause concern? Predicting regional climate change caused by greenhouse gas forcing is largely dependent on the use of General Circulation Models (GCMs) which provide numerical simulations of the global climate system. These models are not only the result of many thousands of person-years of work, they also demand advanced computing systems on which to run. As a consequence, all GCMs which are currently being used for climate change prediction are located in Northern countries (with the exception of China and, shortly, India); certainly there is no facility within Africa at present to run GCM experiments. The consequence of this is that both African scientists and policy-makers are reliant on interpretations of GCM experiments undertaken by Northern scientists. Opening direct access for African scientists to these models, or at least to their results, is a necessary complement to further scientific development and improvement of the models themselves.

A final stage in the process of deciding whether to act strategically on climate change information concerns the conversion of these predictions into the relative benefits/costs of taking or not taking mitigative or adaptive action now (see Nakicenovic and Töth (1994) for the latest thinking on this matter). Here again, a clear Northern bias exists in most, if not all, of the

[4] There are numerous causes for this uncertainty. Three of the more important ones arise due to our inability to forecast how future emissions of greenhouse gases will evolve ('technological' uncertainty), due to our incomplete knowledge of how the integrated climate system operates ('scientific' uncertainty), and due to our inability to faithfully model what knowledge we do have ('modelling' uncertainty).

studies which have addressed this issue. Abatement and damage costs are usually expressed with regard to developed economies and, more importantly, discount rates (perhaps the single most important parameter in such benefit/cost models) are determined by the cultural conditioning of Northern economics. For example, most analyses use discount rates varying between zero and 10 per cent (e.g. Hope *et al.* 1993). From an African perspective, a benefit/cost analysis addressing the need for Africa to take action now should use very high (>10 per cent) discount rates. Both culturally and in terms of investment priorities, planning horizons are quite correctly relatively short; i.e., there are large and urgent development needs which should consume resources immediately and which mean that future impacts are discounted at very high rates. Applying such a high discount rate to a global warming benefit/cost analysis for Africa would inevitably lead to a conclusion that action taken now to reduce emissions, or even investment to adapt to future climate change, is not cost effective for the continent. This conclusion is strengthened in view of the uncertainty surrounding the damage costs of future regional climate change in Africa in relation to the known and substantial impacts of current variability.

5 CONCLUSIONS

This brief note has illustrated some of the difficulties in ensuring that data relating to African climate is converted into information which can helpfully inform decision-making in the continent. These difficulties arise from, among other things, the selective interpretation of the historic record, from barriers which inhibit the use of forecast information and from the existence of a Northern bias to certain climate change information. In particular, we may identify the following themes:

- Historic climate data need careful interpretation to ensure that maximum value for decision-making is obtained. Exaggerating the climate sensitivity of natural or managed systems, or inadequately quantifying and perceiving natural climate variability, can be a cover for poor government or planning.

- Climate forecast information on seasonal timescales is implicitly assumed to have value for decision-making. There are, however, numerous cultural and institutional barriers in Africa which inhibit such value being realized. Developing the institutions and personnel within Africa which can respond to such information is important in this regard.

- Information relating to longer-term climate change can be interpreted for climate policymaking in different ways. This interpretation is conditioned by the perspectives held by different agents. From an African perspective it is important that the potential 'Northern bias' of some (or much) of this climate change information be recognized and adjusted for. Generating a critical community of African 'experts' is an important parallel activity to the negotiating and implementing of International Conventions. A number of initiatives within Africa to address this need are already underway.

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