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DROUGHT RISK MANAGEMENT IN SOUTHERN AFRICA

The Potential of Long Lead Climate Forecasts for Improved Drought Management

A report produced for ODA and the World Bank
by
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"Drought is a normal part of southern Africa's climate and one of the most important natural disasters in southern Africa. In fact, it is becoming increasingly unusual for drought not to occur somewhere in southern Africa each year. The dependence of most of southern Africa's economies on rain-fed agriculture emphasises the importance of drought early warning products for short and long-term decision making in various sectors of the national economies of the region" [L Unganai, **Drought Network News, 6** [2], p7, 1994].

"The rich will find out, but the poor will have to be told...." Meeting with the Southern District Ranchers Association, Kanye, Botswana, on the subject of seasonal forecasting, November 1995.

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DROUGHT RISK MANAGEMENT IN SOUTHERN AFRICA

1. EXECUTIVE SUMMARY

Although climate variability is the single most important factor affecting the livelihood of the people of southern Africa, there is no country in which drought risk is managed well.

This mission set out to determine whether the social and economic benefits from making use of long lead climate forecast techniques for managing drought risk in southern Africa would justify investment directed towards bringing forward the techniques into operational usage.

The four person mission consulted a wide range of decision makers, weather information users and technical specialists in Botswana, Malawi, South Africa and Zimbabwe during the month of July 1995. The views of those consulted were markedly positive and convergent. Reliable drought prediction is a very high priority for the people and economies of southern Africa.

The mission found that:

- while climates are always changing, southern Africa does indeed appear to be becoming increasingly drought affected;
- for many governments, people and purposes in the region, reliable indication of the quality of the next wet season is probably the most useful single item of information that could be provided;
- ongoing climate research is much closer than is generally appreciated to being able to provide reliable and timely information of this kind;
- It is not logical to wait for forecast skill to be 100% reliable before beginning to incorporate forecasts into decision making
- meteorological institutions in the region are not capable of realising the full potential of their global links in their present state: they need both investment and development;
- while improved long lead forecasts offer the prospect of significant benefits, these will not be fully realised without a number of concurrent developments across the economy.

The mission concludes that relatively modest investment towards both improving climate prediction and strengthening information dissemination and uptake pathways could revolutionise drought risk management-enhancing economic responsibility, food security and natural resource management throughout the region. Benefits from the better management of strategic grain reserves alone would justify the necessary investment.

The mission recommends that ODA, the World Bank and other development organisations recognise the important potential of these techniques for mitigating many of the effects of recurrent drought, and seek the means to ensure their broad multi-disciplinary implementation for maximum impact and benefit.

Conceptual Framework for Identifying Potential Applications and Benefits from Improved Climate Forecasts: Part 1

Type of User	Potential Application	Nature of Benefits	Key Preconditions
Commercial Producers	Multi-Year Forecasts: Capital investment decisions. Land development decisions. Seasonal Forecasts: Acreage decisions. Planting dates. Crop/Variety selection. Water management. Within-Season: Water management. Inputs application dates (fertiliser, pesticides, insecticides). Harvesting dates.	Increased certainty and reduced risk. Improved financial viability. Long term survival. Enhancement of comparative advantage.	Response of agricultural support services. Marketing environment. Farmers resource base.
Subsistence Producers	Multi-Year-Seasonal Forecasts: Limited. Seasonal Forecasts: Planting dates. Crop/Variety selection. Within-Season Forecasts: Limited.	Improved food security in poor years. Improved marketable surpluses in good years.	Farmers resource base. Effective extension advice. Response of agricultural support services. Response of commodity markets (in good years).
Agricultural Support Services: (Seed, Fertiliser, Credit, etc.)	Multi-Year Forecasts: Plant & capital investment decisions. Research & Development priorities. Location decisions. Production strategies. Seasonal Forecasts: Product selection. Sales forecasts. Pricing policy. Within-Season Forecasts: Adjustments to marketing strategy (e.g., product switching)	Improved financial viability. Ability to respond better to farmers requirements.	Marketing environment. Farmers resource base.
Agricultural Extension Services	Multi-Year Forecasts: Promotion of drought mitigation strategies. Development of improved extension advice. Seasonal Forecasts: Preparation of dynamic, climate specific extension advice to subsistence/ smallholder producers. Within-Season Forecasts: Specific adjustments to earlier extension messages/advice.	Better extension service to subsistence/smallholder producers.	Farmers resource base Extension service resource base.

Conceptual Framework for Identifying Potential Applications and Benefits from Improved Climate Forecasts: Part 2

Agricultural Commodity Exchanges	<u>Multi-Year Forecasts</u>: Limited. <u>Seasonal Forecasts</u>: Determination of forward and futures market prices. <u>Within-Season Forecasts</u>: Adjustment of forward and futures market prices.	Increased trade within SADC and between SADC and rest of the world. Increased ability of market to cope with domestic shortfall and surplus situation. Reduced need for government intervention.	Market environment.
Early Warning Systems	<u>Multi-Year Forecasts</u>: Limited. <u>Seasonal Forecasts</u>: Crop forecasting. Drought preparedness advice. <u>Within-Season Forecasts</u>: Refinement of agrometerological yield forecasting models.	Enable pre-emptive measures to be introduced (by farmers and other) to reduce impact of drought on agricultural production. Earlier and more accurate assessments of harvest prospects, food availability and import needs/exportable surpluses. Facilitating utilisation of commodity exchanges to cope with domestic shortfall and surplus situations.	Market environment. Farmers resource base.
Strategic Grain Reserve Managers	<u>Multi-Year Forecasts</u>: Limited. <u>Seasonal Forecasts</u>: SGR stock build-up/draw-down decisions. <u>Within-Season Forecasts</u>: Limited.	More cost effective Strategic Gram Reserve policy	Strategic Gram Reserve resource base. Timely and reliable early warnings/crop assessments.
Public Sector Planners	<u>Multi-Year Forecasts</u>: Sectoral and development plans and policies. Capital investment projects. <u>Seasonal Forecasts</u>: Fiscal and monetary policy. <u>Within-Season Forecasts</u>: Limited.	Improved performance of public sector plans and policies leading to more sustained economic growth and food security. Selection of more technically and financially viable projects. Implementation of fiscal and other measures to dampen drought impact.	Market environment. Public sector resource base.
Private Sector Investors	<u>Multi-Year Forecasts</u>: Capital investment decisions. <u>Seasonal Forecasts</u>: Strategic planning decisions. <u>Within-Season Forecasts</u>: Limited.	Increased investor confidence leading to increased investment in more viable projects.	Market environment. Private sector resource base.

2. INTRODUCTION

Much of southern Africa is dry and agricultural production vulnerable to drought. Populations are growing and pressures on limited land and water resources are steadily increasing throughout much of SADC. In addition, there are concerns that drought risk will increase as a consequence of global warming, which would exacerbate problems for vulnerable households and whole economies alike. Ever since biblical times, mankind has been trying with limited success to predict the occurrence of drought in order to best mitigate subsequent impacts. During the last ten years progress towards reliable long lead climate forecasting and useful drought prediction has been rapid, far exceeding developments over the previous 10,000 years. Suddenly, consequent on climate change research *at global scale*, a totally new and potentially very powerful technology is appearing that should help to address the age-old problem of optimising resource management under conditions of climatic uncertainty. We must learn to use this opportunity wisely, deriving maximum benefit for the people of southern Africa, and elsewhere.

Mission Objectives The objective of this study was to scope out current understanding of the use and benefits of long lead climate forecasting as a tool for improved management of agriculture and food security in the chronically drought-vulnerable countries of southern Africa. Cognisant of the need and demand for improved drought proofing of the agricultural sectors in countries of southern Africa and surmising the potential of new long lead forecasting techniques to improve drought risk management, [but dubious of the capabilities of existing institutions to deliver this new kind of information to maximum advantage] ODA and the World Bank commissioned this investigation to explore benefits and issues, and make recommendations accordingly.

Long Lead Climate Forecasting While Australia and USA currently lead the world in the development and implementation of long lead forecasting techniques for the benefit of agriculture, recent work has shown promising results for many other areas including India, Brazil, Chile, Peru as well as west, east and southern Africa. For the purposes of this investigation such forecasts are considered in three time scales:

- multi-year: outlook of trends from 1 to 10 years
- seasonal forecasts: quality of next wet season from 3 months out to 1 year
- within-season: information on likely weather from 5 days to 3 months ahead

Multi-year forecasts are not known to be operational anywhere in the world yet, but may soon be so. Seasonal and within-season forecasts however are already within reach for preliminary application in southern Africa. Management of their introduction for operational usage, and optimising further development of reliability and precision to meet a wide range of particular needs is becoming important. How might this best be done?

Drought and its Management Affects the Whole Economy A number of factors determine the economic impact of drought, including: prevailing economic conditions, policy environment, water resource management, international commodity prices, relative importance of rain-fed and irrigated agriculture and cropping policy, foodstock levels, internal/external conflict, and the severity of the drought. In response, Government drought mitigation programmes must be flexible, dependent on current factors and be applied across the economy. In principle therefore, such programmes would be expected to be open to deriving good advantage from reliable and timely long lead forecasts.

Use of Information The present weakness of meteorological services in southern Africa was recognised *a priori* as a major potential constraint on the delivery and uptake of any new products. How can long lead climate forecasting help to develop [e.g]) risk aversion strategies in rain-fed agricultural economies unless local meteorological services are up to speed? Reliable drought warning may be economically and socially highly beneficial, but such information must be easily accessible and understandable for timely decision-making at all scales. Potential users range from the subsistence farmer through to large commercial farmers, and include grain traders, water resource managers, economic and investment planners among many others. Issues pertaining to better capacity utilisation of existing meteorological institutions in the region were identified as requiring particularly close attention by the mission.

Mission Activities After due preparation, the four person mission consulted a wide range of decision makers, weather information users and technical specialists concerned with drought management in Botswana, Malawi, South Africa and Zimbabwe during July 1995. Technical specialists in USA and Europe were also consulted. The outcome is this report, of which Volume 1 provides a synthesis, and Volume 2 the technical rationale.

This Report Much of the work for this report was virgin territory. According to the review of socio-economic benefits from long lead forecasts completed for WMO[1] in April 1995, very few if any previous investigations have been successful in attempts to assess macro economic benefits of long lead forecasts, especially in developing countries. Consequently, this report centres around the benefits identified and detailed in Section 4, following a brief description of the importance of drought, its impact in southern Africa and demand for long lead forecasting in Section 3. The present state of the science and future developments in long lead forecasting are addressed briefly in Section 5 [and in much more detail in Annex 3]. This is followed by an examination of institutional issues and the need to develop meteorological services in order that greater advantage can be derived in developing countries from long lead forecasts and the abundance of ancillary "new" information becoming available from the global data explosion and information revolution. Finally, suggestions for ways to ensure that long lead forecasts are fully incorporated into decision making across the economy are addressed in Section 7. Conclusions, challenges and recommendations are found in section 8. More detailed technical discussion of most of the issues can be found in the four technical annexes of Volume 2.

Acknowledgements The mission is very grateful for all the assistance rendered by so many helpful and positive people en route, most of whom are acknowledged by name in Annex 5, Volume 2: our gratitude to all and apologies to those omitted in error. Suggestions for revision of the text are also gratefully acknowledged, with apologies for the unconscionable delay.

[1] The Socio-economic Benefits of Climate Forecasts: Literature Review and Recomendations: prepared by a Global Climate Observing System working group for theWorld Meteorological Organisation, April 1995; principal author Alan Murphy.

3. THE IMPORTANCE OF DROUGHT IN SOUTHERN AFRICA

3.1 The Impact of Drought[2]

The predominance of rain-fed subsistence agriculture and an over dependency on [water demanding] maize serves to ensure that food security across southern Africa is inextricably linked to the quality of each rainy season. Both agricultural and livestock production are extremely susceptible to seasonal rainfall and, as a result, have shown considerable volatility in recent years. For the majority of people in southern Africa livelihoods are more or less seriously affected by drought and for many, increasingly so.

Drought shock, however, extends well beyond the confines of agriculture and livestock [see diagrame next page[3]], partly because of the important role that these two sectors play in the overall economy of southern African states. Agriculture and livestock are major employers and make significant contributions to gross domestic product and export earnings[4]. Moreover, both sectors have strong forward and backward links with the rest of the economy. They are both major sources of raw materials for industries such as textiles, food processing and fuel refining, and are major markets for other industries such as machinery, animal feeds, fuel and fertiliser.

Rainfall variability, and drought in particular, also directly affects the performance of many non-agricultural sectors. A decade or more of below normal rainfall has made water resources increasingly scarce across the whole of southern Africa and has brought home to many the fact that most sectors of the economy - ranging from electricity generation to industry, urban development and health - are heavily dependent on water. At the time of the mission at least five countries in southern Africa had water use restrictions in place. In the future, as demand increases and resources become scarcer, water will increasingly become the limiting factor in economic and social development across the sub continent. The implementation of Structural Adjustment Programmes [SAPs] in a number of southern African countries during the 1980's and the occurrence of a number of droughts since then has highlighted the economy-wide impact of rainfall variability and has increased awareness amongst planners of the need to take climate variability into account in the planning process at all levels within the economy.

Drought Management in the National Economy Economic impact or drought shock affects countries differently, depending on their economic structure. For example simple[5] economies [lowest income countries with the highest proportion of population in subsistence agriculture like Malawi and Zambia] are affected by drought severely with a danger of famine. Intermediate and complex economies like Zimbabwe and South Africa respectively, are generally affected less severely but increased cash cropping results in a decrease in food production and the national economy may be more vulnerable, especially from water shortages. Recovery is not immediate on the return of the rains. Complex or dualistic economies [i.e. with large mining sectors such as Namibia and Botswana] appear to be affected least severely by drought and the effects are largely confined to the agricultural sector.

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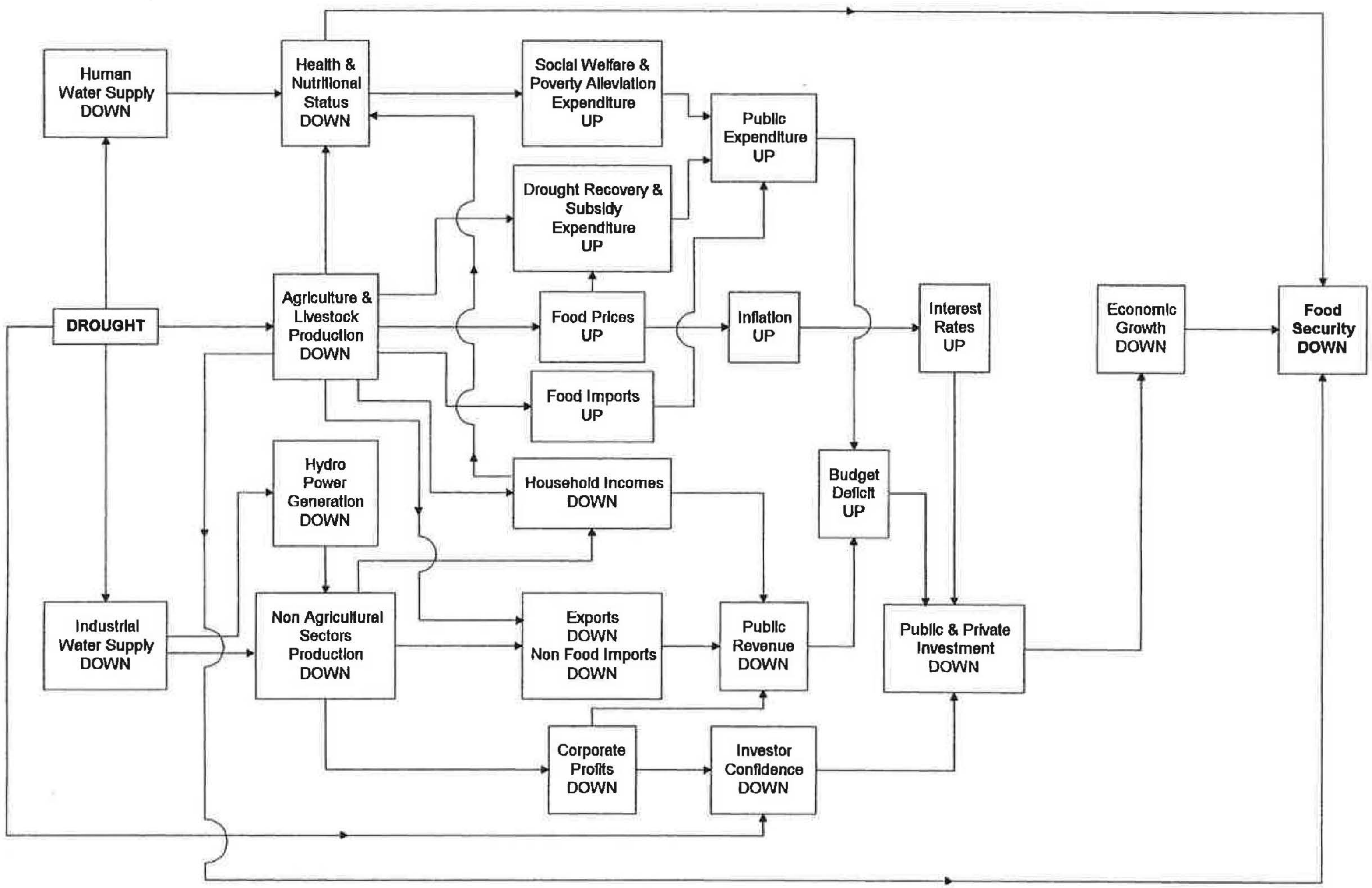
[2] Drought can be defined in many ways according to purpose. In this report a drought is 'an occurrence of significantly below normal rainfall which impacts on productive activities'.

[3] Strictly speaking, in the figure on Drought's Multidimensional Impact over the page, links between the 'Household Income Down' box and 'Food Security Down' should pass through a box entitled 'Access to Food and Consumption Down'.

[4] Even in South Africa, where agriculture accounts for less than 5 per cent of gross domestic product, it has earned in excess of Rand 5.0 billion in exports in each of the past five years (more than the combined annual total of all the other SADC countries) and more than 2.2 million people depend directly on the sector for their livelihoods.

[5] Terminology from Benson, Charlotte & Clay, Edward, 1994: The Impact of Drought on Sub-Saharan African Economies: A Preliminary Examination. Overseas Development Institute, London.

Drought's Multi-Dimensional Impact on Food Security and the Economy...



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Countries in transition between simple and intermediate may be most vulnerable to drought because features typical of simple economies contain the economic effect of drought, with impact largely felt at the rural/household level and within the informal economy.

Drought shocks are therefore not simply limited to increased food insecurity through reduced harvests and food shortages but also to a host of broader economic difficulties such as a worsening balance of payments, increased budget deficits, higher inflation and interest rates and reduced investment. The effects of drought are wide reaching and longer term.

3.2 The Occurrence and Frequency of Drought

Climates are always changing. In many parts of the tropics and sub-tropics, occasional drought is a recurrent problem at local, national and regional scales. In Africa, the dry continent, more persistent drought is not rare. Despite this, the severe and persistent drought or change in west African Sahelian climate during the 1970s and 1980s was a salutary lesson to many, contrasting with the years of plenty in earlier decades. In southern Africa drought conditions affect some part of the region in most years and several region-wide events have occurred this century. There is evidence that drought is becoming more common in the region as a whole [see figures 1 and 2 below].

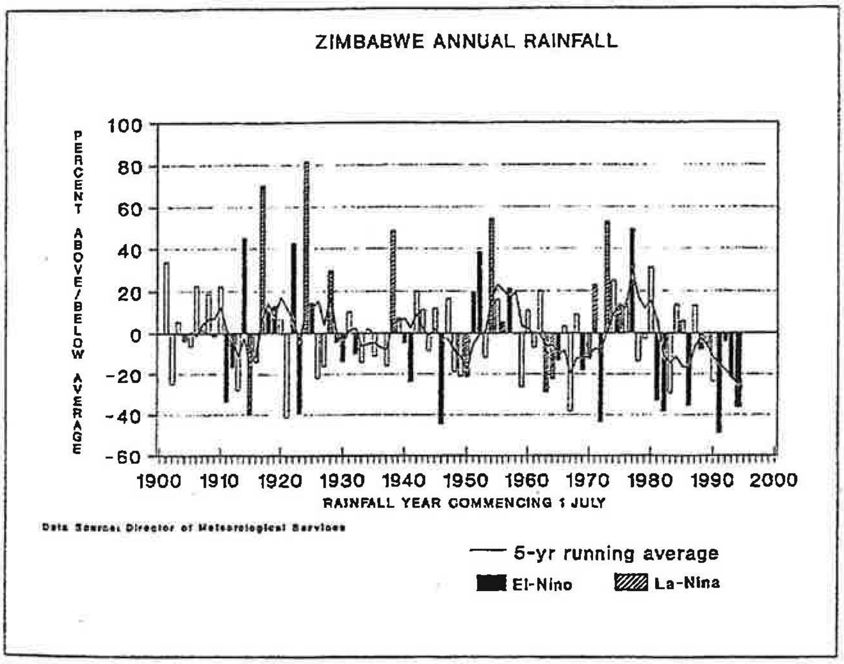


Figure 1. Zimbabwe Annual Rainfall, 1990-1993, showing El Niño and La Niña event years [from Dale, 1994: see Annex 3]

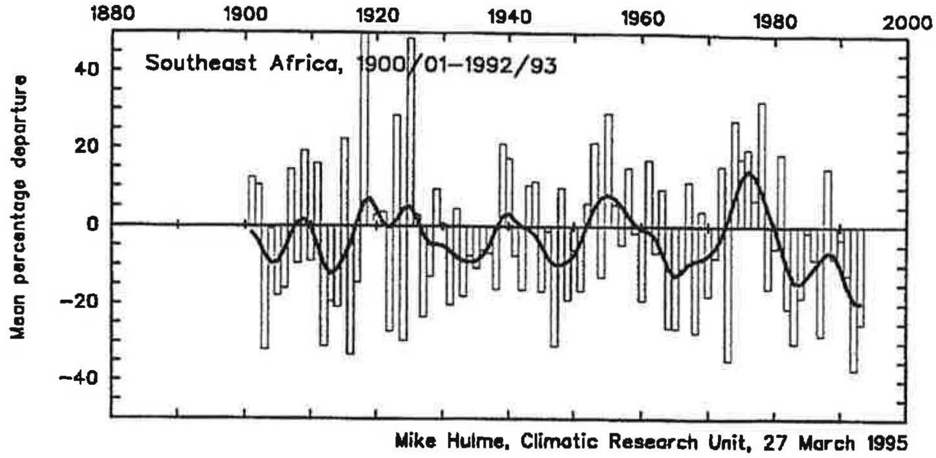


Figure 2. Rainfall in south-eastern Africa [centred on Zimbabwe, Mozambique and northern South Africa], 1901 to 1994, showing a marked drop in rainfall during the 1980s and 1990s.

Throughout most of southern Africa, the 1991-92 wet season was disastrous: one of the most severe droughts this century which caused major economic shock through the region. Again in 1994-95 drought conditions prevailed over large areas as a consequence of poor early and mid season rains. There is now a widely held belief that during the 1980s and 1990s droughts have become more frequent in the region and larger in scale. The rainfall record confirms a recent increase in the frequency of poor years, especially in eastern areas such as Zimbabwe and north-eastern South Africa.

It had been postulated that there is an 18 year [Tyson] cycle of rainfall in large parts of southern Africa, several good years following a group of poor years. Figure 2 shows some evidence of such a periodicity throughout much of the 20th Century. Based on this cycle, it was predicted that the early 1990s would see overall good rains. In the last four or five years the upturn in rainfall has not occurred and the region has seen two severe droughts. For example, [as of 1995] inflow to Lake Kariba and the lake's level continue to drop, the level of Lake Malawi has fallen year-on-year throughout the 1990s, Zimbabwe average national rainfall has fallen significantly since the mid-1970s and late onset of rains has been an increasing problem in many parts of the region.

The qualitative link between drought in southern Africa in the wet season following the occurrence of an ENSO warming in the Pacific Ocean, has also been known for some time. More recent studies have clarified ENSO as the strongest cause of global climate fluctuations on an inter-seasonal scale and quantified some of its effects in southern Africa. Individual ENSO warmings vary in size and impact, and local effects in southern Africa may be moderated by more local conditions prevailing [e.g. Atlantic or Indian Ocean temperature patterns]. Thus not every ENSO is followed by a drought. The most recent double ENSO linked with the 1991-2 and 1994-5 droughts is unusual and may be a factor in the disrupted 18 year Tyson cycle.

These recent experiences have led to concern that the twentieth century 'normal' rainfall pattern is now being disturbed by global warming, just as there is growing evidence that the change in Sahelian rainfall is related to a general warming of the southern hemisphere oceans over a 25 year period. Recent research with improved climate models indicates that overall conditions in southern Africa are likely to be drier and warmer in the mid-twenty-first century than during the past few decades. Increased variability [meaning more severe droughts and floods, more often] is predicted for the 'transition' period. If this turns out to be the case, then the current trend towards more frequent and severe droughts in the region can be expected to continue.

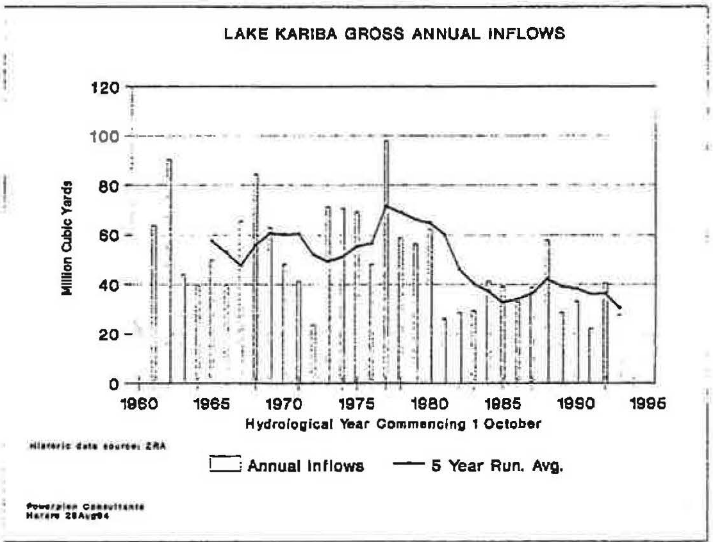


Figure 3. Inflow into Lake Kariba, 1962 to 1993
[from Dale, 1994]

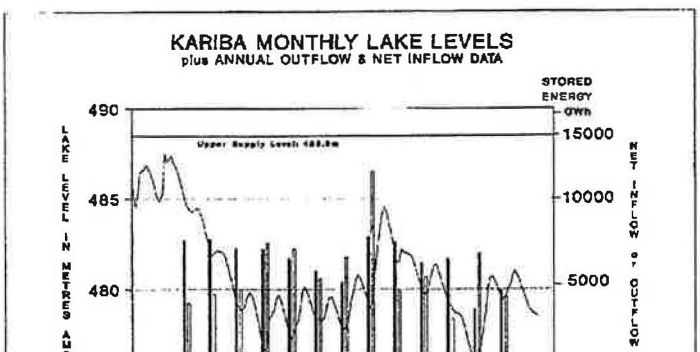


Figure 4. Lake Kariba lake level, 1981 to 1994
[from Dale, 1994]

3.3 Demand for Long Lead Climate Forecasting If the impact of drought in southern Africa is so important, and the potential impact of long lead forecasting for drought risk management is as great as surmised, one might expect at least some of the potential beneficiaries to articulate strong demands for this service. They do.

For a long time, meteorological services in Africa have recognised the value and need at government level for reliable seasonal forecasts, and have frequently requested assistance from global centres to develop suitable products ever since the first experimental wet season forecasts for the Sahel were disseminated by UKMO in the 1980s. Since knowledge of **global** weather patterns is required to make local long lead forecasts, small national meteorological services were not able to proceed alone, except in crude empirical ways which are not conducive to building confidence in the science.

Useful skill in long lead forecasting is very new. It is only recently [since the 1991-2 drought] that awareness of the marked effects of the Pacific El Nino Southern Oscillation [ENSO] on the weather in southern Africa has become sufficiently widespread for both meteorologists and potential users to begin to believe that seasonal forecasting [that dream since biblical times] may be developing into a practical proposition. This evolving belief is dampened in many instances by the unresponsiveness and poverty of service provided by national weather organisations. After all, if the local meteorological department is unable to provide a reliable forecast for the following day and is apparently indifferent to uptake and outcomes of their forecasts, how can they be expected to produce a reliable and useful forecast of wet season quality several months in advance. Farmers have a major preoccupation with the weather, and frequently seek a seasonal outlook, but ambivalent attitudes and lack of suitable channels frustrate open communication. During the mission, a great majority of those with whom the subject was discussed [from subsistence farmers to futures dealers] were strongly interested in the possibility of long lead forecasting and most keen that its further development be promoted as an extremely high priority for southern Africa. The extraordinary dependence of the Zimbabwe stock exchange on rainfall is a clear indicator of need. For such a new technology, this is strong demand indeed.

Long lead forecasting does present problems though to people of superstitious or strongly religious persuasions. Forecasting the quality of the next wet season is very much the domain of gods, and suffering the inflicted drought [even by not preparing for it] can be seen as important part of the atonement process. That said, ethno-meteorological reports describe a wide variety of traditional forecast systems based on plant or animal behaviour, and testify to the strong desire for farming people to be able to forecast the quality of the next season. In somewhat similar vein, since "unforeseen drought problems" are reported to cover a multitude of incompetences and economic mismanagement in Government, it is argued that at a certain level people actually do not want to be advised of future climate, because that would make them more accountable for their [lack of] actions.

4. THE BENEFITS OF IMPROVED CLIMATE INFORMATION & WEATHER SERVICES

4.1. Macro Level Benefits [See Annex 1 for more detail]

Like any information service, weather forecasts only acquire value when they are put to use. At the present time however, forecasts have little if any influence in drought risk management. The principal reason is not a lack of appreciation of the potential applications for climate forecasts but rather a lack of confidence by users in the reliability of currently available forecasts.

Throughout the region there is already considerable interest in climate forecasting and the **potential** value of forecasts in drought risk management is widely recognized. There is also a growing appreciation amongst potential users of climatic phenomena such as the ENSO [El Niño - Southern Oscillation] and the ITCZ [Inter Tropical Convergence Zone] and the role that they play in determining the quality and characteristics of the wet season.

Bearing in mind the critical role that rainfall plays in production and development, the absence of reliable predictions of drought or forecasts of rainfall variability is a principle source of uncertainty and a principal cause of disruption. The availability of reliable climate forecasts would thus have significant and far reaching implications for drought risk management. As such, there is an overwhelming interest in the prospect of improved climate prediction.

Each of the three temporal scales of forecasts [multi-year, seasonal and within-season[have distinct applications and benefits. In terms of immediate future, multi-year and seasonal forecasts offer considerably more utility than shorter term forecasts. However, one of the difficulties in identifying the full range of potential uses is that many applications may only become apparent once improved forecasting products are made available; as has been the case with other types of information technologies, such as remote sensing.

4.1.1 Multi-year Forecasts *Improved multi-year forecasts, which could provide a reliable indication of the quality of the next few wet seasons would diminish a major element of uncertainty in long term planning and thereby facilitate the preparation and execution of better policies, plans and investments.*

Throughout the world, the unpredictability of the climate is a major source of uncertainty in long term planning and investment decision making. In southern Africa, such uncertainty is exacerbated by the high degree of year to year variability which characterizes the climate of the region. Without the aid of reliable long term forecasts, decision makers, from small subsistence farmers to governments and large corporations, resort to making assumptions regarding the future climate based on past experience. Too often such assumptions are breached and as a result expectations and targets are jeopardized.

The benefits from improved multi-year forecasts could be realized not only in the public sector but in drought risk management throughout the economy, wherever long term planning and investment decisions are made. Moreover, such benefits could be effected from relatively broad definition forecasts. From a users point of view, the essential characteristic for long term forecasts is not so much the degree of geographic or quantitative precision but rather their overall reliability. Three year forecasts would be a minimum for capital investment purposes, while sectoral and development planners would feel more confident with longer term, say five and ten year forecasts.

4.1.1.1 Development and Sectoral Planning *Improved multi-year forecasts would enable better development and sectoral plans and strategies to be prepared, which reflect the prevailing climatic environment.*

Despite increasing market liberalization, long term *development planning* remains a key function of central government in the region. The Government of Malawi, for example, is currently in the process of finalizing a *ten* year Agricultural Strategy, while in many countries three, five or even ten year development plans remain the blueprint for economic and social progress. At present, the absence of reliable long term forecasts means that there is a always a high degree of uncertainty concerning the outcome of such long term plans and strategies: the occurrence of an unanticipated drought is often offered, rightly or wrongly, as the reason for the non attainment of planning targets.

As water becomes an increasingly scarce resource in the region, long term forecasts would help to ensure that available resources are utilized as efficiently as possible. Reliable long term forecasts would offer the opportunity to establish more realistic *water pricing policies* which reflect the true value of the resource and which would help to ensure its most effective utilization within the Water Strategy for Africa, presently being formulated.

4.1.1.2 Drought Preparedness and Mitigation Strategies *Improved long term forecasts could provide responsible governments with the necessary justification and confidence to embark on long term drought preparedness and mitigation strategies.*

Such long term strategies often involve sensitive political decisions such as the relocation of populations or the promotion of alternative food crops, as well as substantial financial investments in infrastructural development such as sustainable irrigation. In the absence of any dependable information regarding long term climate trends, governments and donors are understandably hesitant to commit resources to such long term preparedness and mitigation measures and end up trapped into responding to drought through short term relief and recovery measures, time after time. Experience has shown however, that post-drought relief and recovery measures such as supplementary feeding and the provision of "crop packs" have been most effective at keeping people alive but have had little systematic effect on enhancing the ability of affected populations to cope better with future droughts. Once long term forecasts become more reliable, drought preparedness and appropriate mitigation options can be incorporated into development plans and acted on in timely fashion, minimising disruption throughout the economy.

4.1.1.3 Capital Investment Projects *The availability of reliable multi-year forecasts would create a more certain environment for investors throughout the economy.*

Improved long term climate forecasts could enhance the technical and financial viability of climate sensitive and water related capital investment projects in both the public and private sectors. In particular, *water supply projects*, such as the construction of dams, hydro-electric power and long distance water transfer schemes, stand to benefit substantially from greater certainty regarding the future climatic environment. As growing demand for water continues to outstrip easily available resources, governments and donors are embarking on more and more ambitious water capture and transfer projects throughout the SADC and beyond. While it may not be feasible to provide reliable forecasts over the full duration of such long span projects, even an indication of the quality of the next few wet seasons might be sufficient to justify modifications in the start date or design of the project which could have major financial implications. For example, knowing with confidence that rainfall over the Bulawayo catchment area was going to remain similar to that experienced over the past decade could provide the necessary reassurance and justification to persuade investors to finance the much debated water transfer scheme from the Shangani or Zambezi river to the drought struck city.

Improved multi-year forecasts would have similar applications in capital investment decision making in many other sectors of the economy. With water resources becoming ever more scarce, access to water supplies, or more particularly the cost of ensuring adequate water availability, will become an increasingly important factor in decisions pertaining to the location of industry, population centres and public services. Within the agriculture and livestock sectors, reliable long term forecasts will facilitate more prudent decision making concerning land development, cropping options and capital investment.

4.1.2 Seasonal Forecasts *The ability to predict with confidence the quality of the next wet season is, without doubt, the single most sought after item of climatic information for drought risk management.*

A reliable forecast, issued some months in advance of the wet season, even if at a relatively unrefined geographic and quantitative scale, could have a number of immediate applications at the macro level which would result in enhanced food security and improved drought risk management. As such, seasonal forecasts probably offer the greatest achievable benefits of any of the three temporal scales.

The most significant of these benefits involve improvements to the principal drought risk management tools of *early warning systems* and *strategic grain reserves* and, the promotion of increased trade through *agricultural commodity exchanges*, which in turn would further enhance food security and also lessen the need for direct Government intervention. The potential cost savings from a more rational strategic grain reserve strategy alone could justify the investment needed to make such forecasts available.

4.1.2.1 Macro Economic Management *Improved seasonal forecasts coupled with a growing understanding of the mechanics of drought's impact on the economy could enable governments, for the first time, to build climatic variability and drought into the macro economic management process.*

Dependable seasonal forecasts could enable governments to implement specific budgetary measures to dampen the adverse effect of drought on the wider economy. For example, governments might try to restrict public expenditure on certain pre-identified non-core activities, in anticipation of the need to increase expenditure later in the year. They might also introduce measures, such as an increase in the lending rate, to restrain demand within the economy in advance of a drought. Food price inflation, which can become rampant even before drought has impacted on the harvest due to speculative hoarding, could be restrained by enacting measures to ensure plentiful supplies. Reliable seasonal forecasts might also empower governments and their donor partners to adjust and refine Structural

Adjustment and Import Support Programmes by switching support to less climate sensitive sectors in the event of drought. Similar strategic planning exercises could be applied within the private sector in order to minimize the adverse impact of drought.

4.1.2.2 Earlier Warning Systems *Improved seasonal forecasts could transform early warning systems from their current function of supporting drought relief and recovery interventions into pro-active agents guiding drought mitigation and preparedness.*

Under the auspices of SADC, a region wide early warning system has been established in southern Africa. The system is a key component of an integrated regional approach to drought risk management and provides governments, donors and NGOs with a certain amount of advance warning of the likely impact of climate on crop harvest prospects and hence on staple food availability and import requirements. The absence of reliable climate forecasts imposes a major limitation on the operation and utility of the present system. In particular, without dependable climate forecasts a reliable assessment of harvest prospects cannot be undertaken until the growing season is already well under way. This considerably reduces the amount of response time available to make decisions to safeguard food supplies, especially in the case of land locked, foreign exchange constrained countries. The availability of reliable pre-season forecasts would enable early warning systems to release not only earlier but also more accurate assessments of harvest prospects, food availability and import needs, and thereby help, with good government, to safeguard food security.

More significantly, the availability of reliable pre-season forecasts, issued well in advance of the start of the wet season, would enable early warning systems to function as a *tool for drought mitigation* and preparedness. Knowing in advance when the wet season will commence and how good it is going to be would enable early warning systems to provide information which could be used to influence domestic production strategies, thereby mitigating the full impact of drought on food security. Thus, for example, if the seasonal forecast indicated a late start and, as a result, a shorter wet season, the early warning system could issue advice to extension services to emphasise the promotion of early maturing maize varieties and drought-tolerant crops in more marginal areas.

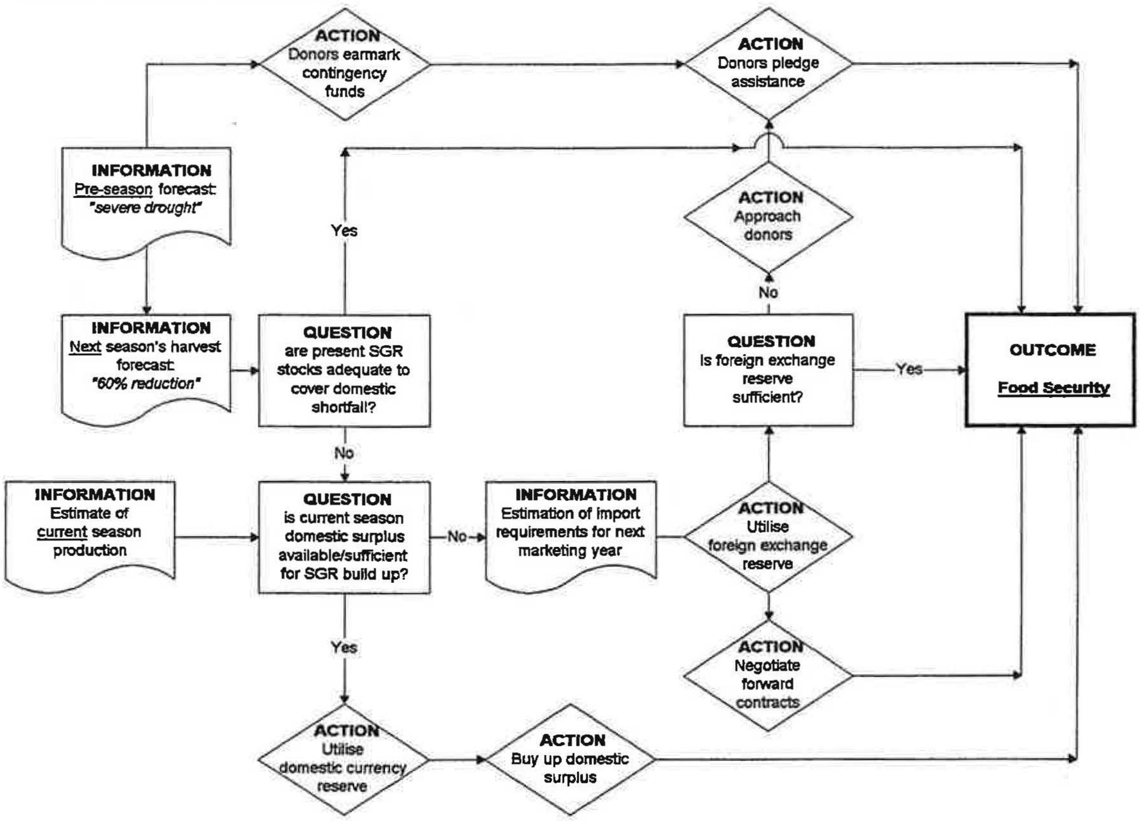
Paradoxically, the ability to influence planting decisions by improved seasonal forecasts would complicate the task of preparing reliable crop forecasts as account would have to be taken of likely farmer response to such information.

4.1.2.3 Agricultural Commodity Trade *Reliable seasonal forecasts would encourage greater trade in agricultural commodities, both between SADC countries and with the rest of the world.*

In particular, a reliable indication of the quality of the next season would help support the further development of fledgling *forward* and *future contract* markets for agricultural commodities which have already been established in Zimbabwe and South Africa. Such markets would reduce the exposure of both producers and consumers to the volatility of spot market prices and thereby stimulate greater trade, which would enable the market place to respond more efficiently to periodic shortages and surpluses. This, in turn, would reduce the need for direct government and donor intervention in many situations, allowing relief efforts to be concentrated on real needs.

An early indication of a poor wet season in southern Africa could, for example, lead commodity brokers to negotiate forward contracts with producers in other parts of the world, particularly North America. More specifically, contracts could be negotiated with such producers to grow *white* rather than yellow maize, thus helping to ensure the availability of preferred white maize for importation into southern Africa in drought affected years.

POTENTIAL FOOD SECURITY RESPONSE STRATEGY WITH IMPROVED SEASONAL FORECASTS



4.1.2.4 Strategic Grain Reserve Policy *Improved seasonal forecasts would enable countries to safeguard national level food security without having to maintain expensive physical grain stocks.*

As long as a substantial proportion of the population of southern African countries remains impoverished and subsistence dependent, Governments are likely to continue to play a role in safeguarding food security. The combined benefits of earlier and more reliable food security warnings and the development of efficient commodity exchanges, which would be brought about by improved seasonal forecasts, could be used to establish a more cost effective and efficient strategic grain reserve strategy in many countries.

With interest rates in the region of 30 to 50 per cent, the cost of borrowing to purchase grain for strategic reserves in many southern African countries is astronomical. In Zimbabwe, the borrowing costs alone to maintain the ceiling reserve of 936,000 metric tons would amount to more than US$30 million per annum, while in Malawi, where the strategic reserve ceiling is a more modest 180,000 metric tons, interest payments are in the region of US$8 million per annum. Apart from the cost of borrowing, strategic reserves are costly to maintain and operate and require a high degree of management to ensure that they are kept in good order. Moreover, maintaining expensive physical stocks reduces governments' ability to meet other welfare goals and restrict the public sector's ability to invest. It also hinders private sector participation in grain marketing and, by contributing towards high borrowing needs, helps to keep interest rates high.

Although many countries may be unwilling to do away with physical reserves completely, the existence of earlier and more reliable forecasts of harvest prospect could persuade them to reduce their physical stocks dramatically and safeguard national level food security through the operation of commodity exchanges. In a number of countries where there may be concerns about access of funds, the establishment of financial reserves to replace physical stocks may help to ensure that funding is readily available when required to negotiate forward contracts or spot purchases.

A financial food security reserve could consist of a *domestic currency* and/or a *foreign exchange* component, depending on the circumstances of individual countries. The domestic currency reserve could be utilized to make within country grain purchases in the event of an unfavorable forecast for the forthcoming season. The foreign exchange reserve could be used to enter into forward or future contracts or even, in the event of an immediate crisis, to make urgent purchases on world or regional spot markets.

Even for countries such as South Africa, where strategic stocks are no longer maintained as part of a food security strategy, improved seasonal forecasts could still have benefits in stabilizing the food supply situation. For example a pessimistic seasonal forecast, which would tend to raise future prices, might trigger farmers and cooperatives to accumulate surplus stocks rather than to sell them to the Maize Board's export pool. In addition, a number of donor agencies have expressed the view that earlier and reliable seasonal forecasts would help them to earmark contingency funds in the event of a developing food crisis, thus enabling them to respond more quickly to drought emergencies when confirmed.

4.1.3 Within-Season Forecasts *The one immediate and clear macro-scale application for improved short term forecasts is in the refinement of crop yield modeling.*

Improvements in within-season forecasts offer the least amount of utility in drought risk management at the macro level, primarily because the temporal scale of such forecasts does not provide much scope for decision making and also because short term climatic changes generally have less impact on macro level issues. Agrometeorological crop yield models which utilize the relationship between rainfall and yield performance are an important early warning tool for assessing harvest prospects. Improved within-season forecasts would enable such models to be run earlier in the season and to produce more reliable yield forecasts throughout the course of the growing season. With earlier and more accurate assessments of expected harvests, early warning systems could prepare more reliable and timely appraisals of import needs. This would enable import plans to be implemented in good time minimising congestion of transportation and storage infrastructure.

4.2. Agriculture Sector - Farm Level Benefits [See Annex 2 for amplification]

As at the macro-level, benefits at the individual user level [usually the farmer] from improved climate prediction are generally recognised but current forecasts are rarely available in a useable form. Improved weather forecasting capability through multi-year, seasonal, within-season and weekly forecasts constitutes a powerful tool for government, business and farmers themselves to help increase farm productivity.

4.2.1. Multi-year Forecasts: Policy and Investment Decisions for Farmers

Policy Level With reliable five to ten year climate predictions, governments would have the possibility of assisting their national agricultural industry in a more realistic way, making it more drought proof. The widespread and increasing reliance on drought-sensitive maize as the main cereal crop in the region needs to be addressed especially if the trend towards increased climatic dryness continues. Concerted extension advice, improved seed availability and pricing strategies might help. Policy directives could be issued on the funding of only certain types of farm development, or stocking rates appropriate to expected climatic conditions in different ecological zones. "Water Plans" could be devised which allow more rational use of water supplies by farmers, domestic and industrial users, especially in times of deficit. The area of South Africa to which this applies, for example, is increasing steadily and is by no means confined to the Vaal Triangle. For instance, the largely irrigation-dependent Natal sugar industry increasingly competes with the coastal tourist and industrial developments of Kwazulu-Natal for water.

Research Long lead climate forecasting should revolutionise agricultural research. With reliable multi-year and trend forecasts, the whole thrust of agronomic research can be realigned to take best advantage of **expected** climatic conditions. Researchers in Botswana began to concentrate more on the plant spacing and geometry of sorghum and sunflower at the expense of the cultivation of early-maturing maize and cotton **after** the series of bad droughts in the 1960's. Both plant and animal breeders will be able to take future weather conditions into account more reliably when setting goals, as is already happening in Malawi where maize breeders are showing renewed interest in open-pollinated maize varieties in addition to their continuing work with the genetically more uniform hybrids, in anticipation of continued rainfall unreliability characteristic of the last few years. The many under-researched drought tolerant crops [such as sorghum, millet and cowpeas] can confidently be given a higher profile in research programmes if a systematic shift to drier weather patterns is confirmed.

Extension and Support Services Reliable and comprehensible long lead climate forecasts can only improve extension and agricultural support services towards better drought management. Training programmes and their syllabi for extension workers can be made much more realistic if climatic trends are known. Government agencies and NGOs can similarly adapt material assistance packages for farmers by targeting them better, as happened with the issue of "drought recovery packs" in Zimbabwe when farmers were given seed of more drought tolerant cereals better suited to the drier climatic regime of the 1990's. Longer term advice on fertiliser requirements, and the likely benefits of other inputs can more safely be advocated if weather trends are known. In this way, the extension service can become a more effective force in improving and sustaining farm productivity. Planning of drought resistant seed production is another key area where long-term climatic predictions are vital in view of the lead time seedsmen require to bulk up seed of new varieties or crops. This cannot always be safely left to the market which often overlooks the subsistence farmer whose individual needs may not be sufficiently interesting to address, even though as in Malawi, he or she makes up the bulk of the farming population.

Farm Level Activities While farmers at all levels can make use of multi-year forecasts, it is the bigger **commercial farmers** who have access to long-term loan finance and who can direct their investments into enterprises and developments which will have better returns under future expected climatic regimes that stand to benefit most. Investment in irrigation [dams, pump schemes[is a key area for this, as would plantation or other long-cycle crops, especially trees. The recent droughts in Malawi have been accompanied by higher temperatures which have had a detrimental effect on some eighteen-years old forests of Pinus patula, while in Kwazulu-Natal there has been over-investment in some irrigation schemes with irrigation equipment lying idle [and being stolen[due to inadequate water supplies after below-average rainy seasons. For **emerging farmers,** *given good information,* these forecasts can be used to adjust farm development plans and crop and livestock strategies to minimise risks which could be fatal to their aspirations to gradually build up a cash surplus from their operations. For **subsistence farmers** there are probably fewer material advantages from multi-year forecasts but with confidence and good community leadership, groups can invest their dry season time better and dig wells, build small dams [as with the "Ipelegeng" Food-for-Work schemes in Botswana in the late 1960's[, arrange to 'harvest' local runoff, improve river or swamp crossings and protect wetlands for example. Individuals can improve and enlarge their crop handling and storage facilities if a series of favourable years are expected.

4.2.2. Seasonal Forecasts: Strategic Planning Decisions

Policy Level Government has less room to intervene on a seasonal basis but in all the countries visited, it still has effective control of much seasonal credit for **small and emerging farmers.** With a reliable seasonal forecast, there would be room to influence such farmers' cropping strategies by making loans conditional on appropriate cropping plans or stocking rates, debts could be rolled over and tax relief measures introduced earlier. Such a policy would reduce the risk of massive drought-induced defaults as has happened in Malawi, and in Botswana where the entire National Development Bank had to be "re-structured". As a further incentive, floor prices for "appropriate" crops could be significantly raised, and timely importation of extra seed for these crops could be arranged with early indication of drought.

Research The availability of reliable seasonal forecasts should vastly extend the scope of response farming, allowing researchers to develop a limited range of different agronomic packages; in any particular year the most appropriate packages could be promoted in accordance with the actual forecast for the area. Not only the date of onset of the rains, the maturity periods of the different crops and cultivars, days required for planting to be completed, soil depths and water holding capacities, crop co-efficients for estimation of water requirements and expected seasonal evaporation, but also the *predicted* length and wetness of the coming season can be inbuilt. This will demand close co-operation of agrometeorologists and agronomists but could become very effective towards removing the main cause of present uncertainty. In addition, where basic research is being carried out, such forecasts will enable researchers to make contingency plans to ensure that their trials are not lost or invalidated by unexpected weather conditions - especially drought; trials could be irrigated or relocated to wetter areas accordingly.

Extension and Support Services The concept of the "Extension Package" is well suited to an agricultural industry with access to reliable seasonal forecasts because it can be greatly simplified and targeted more closely without so many "ifs" and "ors". This would be of particular benefit to **small and emerging farmers** to whom much extension effort is directed. Furthermore once small farmers can see reliability in the forecasts and researchers produce more useful packages to suit them, the influence and status of the extension service will be enhanced. **Support services** will also be able to adjust stock with inventories [especially of seed, pesticides and fertilisers] more relevant to the expected agricultural season leading to less wastage and out-of-date stock and possibly lower prices.

Farm Level Activities The majority of effective drought management takes place on the farm. Farmers at all levels are very interested in the weather and concerned about drought . While large scale farmers may talk about weather and the stock market or their debts, small scale farmers talk more about weather and hunger. At present farmers gamble on the quality of the next wet season, whereas they would like to be able to plan. The prospect of **reliable** forecasts of the quality of the approaching wet season evinced the greatest response from people consulted. Farmers, in effect, farm sunlight. It is the energy source which drives the whole farming industry - both crops and livestock - and which, with water and soil fertility, makes a farm productive. Since sunlight in southern Africa is rarely limiting, farm production is usually seen as dependent on water and fertility. The latter can be ameliorated with fairly modest investment, but the former depends largely on the provision of irrigation [a major investment] or the weather. The vast majority of southern African farmers are resource-poor and so totally dependent on rain, while the **emerging and commercial farmers'** prosperity is also heavily dependent on rainfall. Consequently, when farmers plan, [and, despite the random appearance of much of southern Africa's farms, farmers do plan] they have to make assumptions about how much rain they will receive in the growing season. They mostly - the **subsistence farmers** especially - plan for the expected [hoped for], i.e. a good rainy season. But there is a growing consensus of opinion supporting the view that the expected no longer occurs with its traditional frequency so that farmers are increasingly surprised by unusually early [or late] rains, severe mid-season droughts or unseasonal rains in the dry season, and hence appear to be gambling. But, despite their poverty they still have a few options such as depth, density and time of planting [see below]. A good extension service will be able to translate a seasonal forecast into useful advice even at this level.

Conversely, good **commercial farmers** increasingly plan for bad seasons, especially those with access to irrigation where water has to be rationed onto crops. In many cases, especially in Zimbabwe, this water is used to start crop growth in order to make best use of the sunlight and good growing temperatures in the two months preceding the onset of the rains. In planning activities, a seasonal forecast will be used by the commercial farmer [and to a lesser extent by the emerging farmer] to determine the relative areas to be planted of different crops and varieties of those crops and the level of inputs they will receive; to determine when those crops will be planted, the amount of irrigation they may receive and the type of tillage that will be used - "conservation tillage" reduces costs and lessens the risk of crop failure in poor seasons though it may curtail yields under optimum conditions. Later, as the season unfolds, farmers may interplant secondary crops through existing crops [as is often done in the drier parts of the Transvaal] if the forecast suggests there will be adequate late rain. To finance this kind of activity, lending institutions will be able to check clients' farm plans against the seasonal forecast and possibly improve lending terms for appropriate inputs. Further, since commodity traders will likewise be in a better position to make forward contracts for purchase of crops [as is now happening in South Africa and increasingly in Zimbabwe] farmers' financial positions will be strengthened, improving access to offshore funds.

While most farmers in southern Africa cultivate with the summer rains, there are areas [highlands of Malawi and Zimbabwe and the Free State and Kwazulu-Natal of South Africa] where winter rainfall can be significant. Though even more unreliable, these rains are important for winter cereal production in South Africa, for horticultural crops elsewhere. Wherever they fall, such rains can stimulate useful grass growth for livestock as well as having major impact on the water economy of local irrigation schemes dependent on dams. Forecasting the quality of the winter season would also be useful to enable farmers to plan use of these rains better. Conversely, there is the option of not farming at all if a very dry growing season is forecast.

Livestock Producers Decisions on stocking levels and stockfeed management on intensive units would both benefit from reliable seasonal forecasts. Even the still largely **traditional cattle industry** of Botswana is beginning to adopt improved husbandry techniques, according to the Botswana Meat Commission. **Ranchers** echo this view by stating their preparedness to de-stock ahead of any future drought reliably predicted - as much to protect their grazing areas as to protect their breeding herds The largest operators still have the option of moving animals nationally and here the *spatial* dimension of the forecast will be of importance. Given adequate warning, immature animals and breeding stock sent to the big abattoirs might be selected out in advance of very severe drought, and moved to holding grounds outside the problem area. Such animals would then be available for restocking farms when better conditions return.

For **dairy farmers**, seasonal weather forecasts are crucial to budgeting through the impact of the quality of the rainy season on crop and grass growth On a leading dairy farm in Zimbabwe, feed costs were consuming 72% of the milk cheque after the recent dry summer.

For **plantation crops**, seasonal forecasts facilitate much more rational planning of factory operation so that annual maintenance shutdowns need not jeopardise harvests. Tea, and to some extent coffee estates, can also benefit from reliable seasonal forecasts in that their periodic pruning [rejuvenation of bushes which is done every 20 years or so] can be brought forward or deferred a year or two, to keep factory throughput as constant as possible despite variable rainfall.

4.2.3. Within-season Forecasting: Management Decisions

Policy Level Once the growing season is under way, there is little room for policy makers to intervene. However, if forecasts suggested unusually widespread late rains after a very dry early season, importation and distribution of appropriate seeds might be facilitated as an emergency measure.

Research Short-term forecasts will be invaluable for researchers developing application treatments such as sprays, top-dressings and biological pest control agents, and for the development of improved crop, pest and disease models for more timely intervention activities.

Extension and Support Services Co-operation between ecological and crop protection services will facilitate much better pest and disease control: army worm outbreaks can be predicted with some precision from meteorological data sufficiently in advance for controls to be implemented. Increasing use of biological pest control agents is also dependent on weather conditions at the time of their release so that their efficiency can greatly be improved by these kind of forecasts.

Farm Level Activities Within season forecasts are of greatest use to **commercial farmers** who have resource allocation options at all stages of the cropping cycle. But the forecast of the more precise timing and nature of the onset of the rains - the "planting rains" - is information that can be used by all farmers for even the **poorest farmer** can choose whether to plant dry [i.e. before the onset] or wet [after the onset]. Each day delay in planting after the onset of the rains is equivalent to a day of sunlight wasted: commercial maize growers in Zimbabwe estimate the loss in yield on a high-input system at up to 100 kg per hectare per day. While dry planting can be seen as a gamble, it is widely practised by farmers who are not totally risk-averse. Other benefits from early planting include enabling sorghum crops in Botswana to mature before the main flocks of the seed-eating *Quelea* birds arrive, and, in the higher latitudes of southern Africa, minimising late planted crops which may not mature properly due to the onset of winter. Thus, reliable information on the nature and timing of the onset of the rains has a major impact on all arable farmers.

After the planting rains, the next major concern for farmers is the possibility of mid-season drought. This appears to be becoming a more regular feature of the southern African summer rains and, because of its tendency to coincide with pollination in maize, can cause severe yield losses. Knowledge of its *likely* timing and severity would enable farmers to adjust planting dates and choose appropriate cultivars to avoid its worst effects, while knowledge of the likely length and distribution of the rains will enable farmers to choose crops and varieties that best match - *assuming that a wide enough choice of seeds is available*. **Subsistence farmers** with a tradition of planting a wide selection of crops are in a particularly strong position to gain from this practice by being able to adjust the ratios of the different crops in the mixtures they plant. Even **commercial farmers** can plant intercrop legumes into established cereal crops, or follow them with catch crops at the end of the season if good rains are forecast in the second part of the growing season. Besides rainfall variation, temperature extremes are another area where short-term forecasts are useful. The southern African winter is as subject to unseasonal frost as it is to unseasonal rain: late frost, at wheat anthesis, can result in total crop loss; Irish potatoes [a high input crop] can be adversely affected at any stage as well as many other fruits and vegetables. Summer temperatures, meanwhile, tend to be uniformly high across the region but there are often cases of heat-induced loss on farms - usually horticultural crops like cabbage [Botswana] or, more seriously, mortality in high-producing dairy cattle.

SEASONAL WEATHER FORECASTS FOR FARMERS

Weather Feature	Farmers Able to use Prediction	Response Area	Lead Time Required	Minimum Precision/ Accuracy Required
Drought	A,B,C	1. To farm/Not to farm 2. Choice of crops & tillage systems 3. Contingency plans - livestock 4. Contingency plans - water supplies	3 months	90%
Overall Quality of Rainy Season	A,B,C	1. Choice of Crops, crop varieties & tillage systems 2. Irrigation planning to use impounded water efficiently 3. Arrange appropriate seasonal credit.	3 months	80%
Planting Rains - date	A,B,C	Timing of field operations *NB Actual planting date has a highly significant effect on yield*	0.5 - 1 month	80%
Planting Rains* - nature	A,B,C	Whether to risk dry planting	0.5 month	80%
Mid-season Drought - start date	B,C	Choice of variety & planting date	3 months	80%
Mid Season Drought - length	B,C	Choice of crop	3 months	60%
Mid Season Drought - severity	B,C	Preparing to divert grain crops to fodder	3 months	60%
End of rainy season - date	A,B,C	1. Timing of harvest operations 2. Possibility of late catchcrops 3. Plan post-harvest tillage	2 months	80%
Winter Rains - amount	B,C	1. Plan summer crops for optimum winter cereal crop 2. Possibility of other winter crops	6 months	80%
Winter Rains - distribution	B,C	Level of inputs to invest in winter crop	1 month	60%
Frost - first frost date	A,B,C	1. Planting date for late planted crops 2. Cut off planting date for frost sensitive crops	6 months	80%
Frost - last frost date	C	1. Date of winter cereal planting to avoid frost at anthesis 2. Planning spring plantings under irrigation	6 months	80%
Frost - frequency over winter	C	Preparedness for frost on winter horticultural crops	1 month	40%
Dry Season - severity	A,B,C	1. Off-season farm capital development activities 2. Livestock management	1 month	40%

Dry Season - length	A,B,C	1. Disposal of crop residues 2. Fodder rationing to livestock 3. Move livestock if necessary	1 month	40%
Temperature - above normal summer	C	Precautions: dairying, horticulture	3 months	60%
Temperature - below normal winter	C	Precautions: small stock, horticulture	3 months	40%

KEY: Types of farmer- A = subsistence farmers; B = "emerging farmers"; C = Commercial farmers
Precision/Accuracy - 100% = completely reliable; 0% = same as having no forecast at all

* whether - convectional, i.e. highly variable spatially and temporally, dry planting risky or frontal, i.e. widespread, penetrating rains, dry planting advised.

WITHIN SEASON FORECASTS AND THE FARMER)
Some uses for forecasts

Common Farming Operation		Key Weather Feature(s)	Lead time	Minimum Precision required	Response
Planting	- seeds	Rain	1-3 days	80%	Timing
	- transplanting	Rain	1-3 days	95%	"
Fodder	- hay making	Dry weather	1-3 days	95%	Timing
	- silage making	Dry weather	1-3 days	80%	"
Spraying	- terrestrial	Dry weather and wind	1-2 days	80%	Timing
	- aerial	Dry weather and wind	1 day	95%	"
	- animals	Dry weather and wind	1-2 days	80%	"
General	)- top dressing	Rain	1-3 days	80%	Timing
Field	)- weeding	Dry weather	1-3 days	80%	"
Operations	)- inter-row cultivation	Dry weather	1-3 days	60%	"
Reaping	- tobacco	Prolonged dry weather	3 days	80%	Accelerate reaping
	- cotton	Rain	3 days	80%	Accelerate reaping
	- coffee	Rain	1-3 days	80%	Avoid CBD areas
Insertion of intercrop into a widely-spaced cereal crop		Prolonged late rains	3-7 days	80%	Plant it
Irrigation		Past evapo-transpiration data	1 week	80%	Adjust irrigation schedule
		expected " " "	1 week	80%	
Release of predator agents in IPM		Various	1-3 days	<95%	Follow instructions
<u>ANOMALY FORECASTING</u>					
Smoke generation in or ultra-low precipitation sprinkling of horticultural crops		Night frost	>12 hours	80%	Light fires, start sprinklers in night
Moving animals to higher ground, reinforcing water management structures, moving pumps back from river banks.		Unusually heavy rain	>12 hours	80%	
Blight control in potatoes and tomatoes		High humidity	1 week	80%	Apply prophylactic sprays

MULTI-YEAR FORECASTS AND AGRICULTURE

ACTIVITY		Influenced by forecast departures from normal		Scale of Forecast	Response
CROP RESEARCH	Plant Breeding & Agronomy	Rainfall (Amount & Distribution) Temperature	75%	10years	Select for maturity period, yield plasticity. Test different farming systems, crop geometry, manuring, spacing, etc
FORESTRY	Plantation establishment	Temperature Rainfall	80%	10 years	Species choice, spacing in plantation
SEED PRODUCTION	Strategy	Rainfall	80%	5-10 years	Choice of appropriate ranges of crops & varieties
	Bulking	Rainfall - below normal	80%	2-5 years	Secure irrigated sites
PLANTATION & ORCHARD CROPS	Establishment	Rainfall Temperature Humidity	80%	5-10 years	Choice of crop and site
IRRIGATION	Development	Rain	80%	5-10 years	Size of dam, spillway, capacity of pumps, reticulation, area to be irrigated
DROUGHT-RECOVERY	SUBSIDIES	Rain	50%	2-5 years	Issue appropriate seeds, Distribute hardy smallstock, donkeysets, hafirs & other water conservation measures
COMMUNITY ACTION		Rain	50%	2-5 years	Labour-intensive projects in roads, dams, wells, land clearing, afforestation
LIVESTOCK MANAGEMENT	Herd size	Rain	75%	5-10 years	Culling policy, retention of young females in herd, grazing development
MANAGEMENT OF NATIONAL HERD (Cattle)		Rain - below average	50%	2-10 years	Establish protected holding grounds for immature & young females intercepted from slaughter market

4.3 Multi-Sectoral Benefits Across the Economy

Water The main emphasis of the mission was to evaluate agriculturally related benefits of long lead forecasts. It quickly became clear however that demand for water - urban, rural, industrial, agricultural and ecological - is increasingly outstripping supply in southern Africa; options to satisfy future requirements increasingly demand international collaboration. Potential benefits from better *regional* water resource planning and management would themselves justify major investment in improving the reliability and precision of long lead forecasts. this should be a major consideration in current development of the Water Strategy for Africa.

- The Water Research Board in South Africa is responsible for supporting most of the current university research into long lead forecasting within the region.
- The Lesotho Highlands Water Development Scheme requires some 14 000 million Rand [$4billion] for the first two phases intended to supply South Africa with a steady 18cumecs supply. Plans exist for expanding supply to 70cumecs.
- Public expenditure on dams in Zimbabwe runs to several hundred million Zimbabwe dollars every year: the Department of Water Development operates on the principle that the next wet season will be a one in ten year drought. Multi-year and seasonal forecasts will allow priorities to be set and resources managed much more effectively.

Power Almost 100% of electricity generated in Malawi is hydropower from lake outflow. Another dry year could see the level of Lake Malawi drop below the critical threshold. Levels in Lake Kariba are also persistently low from a 'dry decade'. Multi-year forecasts, once reliable enough to use, will be most beneficial for investment decisions and improved management of the hydropower sector.

Forestry Forestry sector planning needs to be adjusted to seasonal quality. Reforestation efforts are best concentrated in years of good rainfall and fire protection measures emphasized in dry years. Selection of appropriate species and varieties for plantation forestry depends on long term rainfall trends. Foresters can plan the scale and timing of their nursery plantings according to the forthcoming seasonal forecast. Subsequent transplanting can be better timed with the more expensive "holing out" pre-planting operation [to concentrate rainfall on the actual planting position] only being carried out when necessary.

Protected Area Management Natural vegetation and wildlife resources are most vulnerable and exploited particularly heavily during drought periods. Seasonal forecasts will allow managers to adjust stock levels, adapt fire management strategies, prepare water points, protect most vulnerable habitats and adjust offtake strategies in synchrony with local community needs.

Health Malaria among other diseases is becoming a weather related epidemic. The success of control programmes [e.g. spraying water bodies] is much affected by seasonal quality.

Tourism: a major and growing revenue earner for southern Africa can be better managed with prior knowledge of future weather conditions.

In all the sectors approached by the mission, weather sensitive decisions were encountered and benefits were identifiable from early warning of anomalous conditions. This appears to be particularly fertile ground for providers of meteorological information to explore with a view to meeting a larger range of customer needs through tailored products.

4.4 Disbenefits: Caveats on the Use of Forecasts in Farming

Powerful new technologies also bring potential disbenefits which need to be addressed and mitigated wherever practical. Disbenefits from long lead forecasting include:-

- encouraging urban drift
- the consequences of getting it wrong, and
- inequitable access/options.

Urban drift Amongst the cautions on widespread implementation of forecast-led farm planning, the most important new disbenefit identified was the risk of exacerbating urban drift and possibly hastening the abandonment of farming altogether, particularly when a poor season is forecast. This is thought to be a particular danger in South Africa, where farming is already considered a part-time occupation by many. It is also a worry in Zimbabwe and other countries. Uncontrolled drift could lead to social instability in urban areas but may be mitigated in part by timely instigation of rural employment programmes. [Whether ongoing land reforms will create more stable agricultural communities is unclear, but availability of good forecasts will certainly improve the chances of a successful outcome, helping to match expectation and reality].

Getting it wrong If agricultural decision making came to rely too heavily on seasonal forecasting techniques before they were sufficiently reliable, there would be a risk of increasing instability in agricultural systems. In practice, this is thought to be an unlikely outcome as farmers are generally conservative and healthily sceptical towards rapid change. Those who do adopt the new techniques first will quickly learn to match their individual risk profiles to the reliability of the forecasts. Other farmers will wait and see if it pays before committing resources. Uptake is expected to be a gradual process with second order opportunities for the risk taker.

Inequitable access and options[6] There is legitimate concern that wealthier farmers will not only have better access to information than subsistence farmers but also more options with their greater disposable resources to respond and benefit from long lead forecasts in general. In addition, fears have been expressed that the new information might further imbalance gender inequalities in a number of ways. Both these kinds of disbenefit can be mitigated somewhat by improved information dissemination, e.g. through cooperatives, women's groups, and other rural self-help organisations.

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[6] Note that there is an element here and in the last disbenefit of damned if you do use them, and damned if you don't. In practice and given guidance, groups are likely to evolve ways of incorporating this new information into their decision making processes, over time; see section 7.

[2] The Socio-economic Benefits of Climate Forecasts: Literature Review and Recommendations: prepared by a Global Climate Observing System working group for the World Meteorological Organisation, April 1995: principal author Alan Murphy.

4.5 Quantifying Benefits and Deriving Best Advantage: Conclusions

Quantification: That there are major benefits to be derived from reliable long lead forecasting across the economies of southern Africa is undeniable. The nature of the benefits are clear. The magnitudes of the benefits promise to be very large indeed. Precise *a priori* quantification of these *potential* benefits however, is very difficult since many assumptions[2] have to be made as to how individuals and groups will respond in a different future. Therefore since the magnitude of the *actual* return realised will depend on the quality of the technology and how far a country progresses with *utilising* such forecasts, it would seem more sensible to concentrate on how best to ensure delivery and best uptake of priority products rather than academic hypothesising.

Best Advantage The longer the lead time, the greater the potential benefit for investment. Shorter forecast lead times are of more benefit for management of agricultural operations. Reliable indication of the *quality of the next wet season* came through clearly as the most sought after item of information, with probably greatest overall benefit. Somewhat surprisingly the *precision* of the forecast is perceived to be of less importance to potential users than its *reliability*. Terciles [average, below or above] or quintiles [average, below or above, much below or much above] for rainfall quantity being quite sufficient as long as the forecasts can be trusted. A simple but reliable forecast as 'no widespread drought this year' could be highly beneficial. This quantisation suggests that many decisions on strategy and general attitude to the next wet season are made as a series of discontinuous step modifications [lumpy] rather than incremental adjustments in a continuous process. The magnitude of benefits obtainable from broad application of a *correct general approach* to the quality of the next wet season, reducing uncertainty for a whole raft of decisions, is possibly the most important finding of this investigation. It suggests that suppliers of forecasts need to understand better the way decision makers use weather information in order to provide a more effective service. It may not be as difficult as first anticipated.

5. LONG LEAD CLIMATE FORECASTING: STATE OF THE SCIENCE

Long lead climate forecasting results from improved understanding of **global** climate processes, and their interaction with local weather in different regions of the world. Climate processes at global scale can take months or years to complete their evolution, especially when significant oceanic events [warming and/or current changes] are involved. It is this inertia in the oceans, and the strong effect it has on global and local wind patterns that makes [e.g.] seasonal forecasting feasible. The better the processes are understood, the more the reliability of a forecast can be assured.

5.1 Current Ability of Meteorological Science to Produce Reliable Long Lead Climate Forecasts

While ongoing climate research is much closer than is generally appreciated to being able to provide long lead forecasts for different parts of the world including southern Africa [see Table 5.1 below], such research is not always optimally directed towards meeting the most immediate needs of decision makers in the regions concerned.

Forecast Timescale	Operational Status Depending on Region			
	Untried	Experimental	Pre-operational	Operational
Multi-year	Most areas	at global / hemispherical scale	-	-
Seasonal	some equatorial and high latitude areas	many areas	a number of promising areas including Southern Africa	parts of USA, Australia and a few favoured areas
Within season	most areas	many areas including Southern Africa	some developed economies	well researched areas including USA and Europe

Table 5.1: Qualitative assessment of current status of long lead climate forecasts

5.1.1 Multi-year Prediction [more than one year ahead] Long term climate prediction is usually based on global climate models [GCMs], which are becoming increasingly sophisticated and reliable. Recent work at global centres indicates growing confidence that GCMs can usefully forecast future climate changes. Models are getting better at making regional-scale predictions but there is little prospect of reliable multi-year forecasts useful for specific decision making within the next 2-3 years. The constraints on improving climate predictions are technical and scientific and can be removed only through global scale effort. These requirements are being addressed in the World Climate Research Programme addressing climatic variability [CLIVAR] and other programmes, [see Annex 3].

Expertise In southern Africa, a small group at the University of Pretoria is experimenting with regional climate prediction using older generation models. The University of Cape Town is involved in the World Climate Research Programme Atmospheric Model Intercomparison Project [WCRP-AMIP]. There is little or no other activity in the region apart from Tyson's work at University of Witswatersrand on his now famously long standing 18 year cycle. The physical mechanism for this cycle is not yet adequately understood [and it appears to be breaking down in the 1990's just at the moment of maximum interest].

5.1.2 Seasonal Forecasts [up to one year ahead] The climate engine on interannual time scales is the El Niño-Southern Oscillation phenomenon [ENSO]. ENSO mechanisms are now fairly well understood and global research thrusts, including CLIVAR, promise even greater understanding within the next few years. Today, experimental forecasts of drought are issued by the global community for several regions in the tropics and subtropics, including southern Africa. These ENSO-based forecasts can be made easy to understand and appear to be reliable enough to start using for certain decisions up to six months ahead of the wet season. There are clear indications of increasing forecast reliability as ENSO and forcing factors of regional-scale rainfall patterns become better understood. Current ENSO/rainfall relationships explain some 30% of the quantified rainfall variation over large parts of Southern Africa, but can be used with much greater reliability to predict qualitative drought/no drought situations, and even yield variations.

Expertise In southern Africa, the regional Drought Monitoring Centre [DMC] in Harare monitors global forecasts as they emerge and issues modified summary forecasts just before each rainy season. A few groups in South Africa issue their own experimental seasonal forecasts for the next rainy season, up to six months ahead. The small Climate Research Group at Witswatersrand University is technically strong, issuing experimental forecasts based on ENSO for South Africa, modified by regional factors. The South African Weather Bureau issues experimental empirical forecasts before and during each rainy season and similar work is being undertaken at the University of Cape Town. Recently, South African forecasters have formed a network to improve the reliability and delivery of their forecasts. Elsewhere in the region there is interest but little significant capacity.

5.1.3 Within-season Forecasts [five days to three months ahead] Model-based medium range forecasting [5 days lead] is undertaken at a few global centres and distributed world-wide. The global community is experimenting with methods of extending the forecast range to over a month in several regions, using local area and ensemble modelling [model averaging]. This promises much improved forecasts in the next few years. The South African Weather Bureau is pre-operational in this area but constrained by lack of resources and facilities.

A range of empirical methods is available for within-season forecasting. The scientific basis of these is well founded. Empirical/statistical forecasts are issued by the South African Weather Bureau for South Africa alone but these are, as yet, not adequately reliable. There is limited expertise in empirical methods in the region outside South Africa: one or two meteorological services issue five day forecasts based on global model products. This effort is not co-ordinated and attempts to deliver forecasts for more than 24 hours ahead to the benefit of users, have thus far been disappointing.

5.2 Improving the Reliability and Precision of Long Lead Forecasting

Several opportunities exist to improve spatial and temporal precision, and applicability of seasonal forecasts. It is especially important that regional and local 'ENSO modulators' are introduced into forecasting schemes. Local modulators include dynamical processes operating on within-season time scales, serving to link seasonal quality forecasts to the shorter time scales.

Thus, improvements in within-seasonal forecasts are more resource constrained than science limited. Increasing model specificity is only likely to come about by networking through a regional forecasting centre, linked to global centres. Data collection for calibration and validation of developing methods must not be neglected.

Considering the rapidly evolving state of the science and the likely benefits achievable, the highest priorities for support to improve long lead forecast products in southern Africa are:-

1) adaptive research within the region to make use of existing global knowledge together with data from the region, in order to improve wet season forecast reliability, spatial precision and temporal accuracy;
2) adaptive research within the region to make use of existing techniques and data sources to improve precision and lead times of within-seasonal forecasts to meet user priorities [e.g. mid season drought, start/end or wet season, occurrence of exceptional dry/wet periods],
3) basic research at global scale to improve understanding of factors influencing the quality of the wet seasons in southern Africa.

Better forecasting of the quality of the next wet season is the highest priority because of the major potential benefits to be gained by a whole spectrum of users. Improved within-seasonal forecasting is lower priority because the benefits are not so broad and clear cut. Multi-year forecasting will become a priority when the state of the global science improves, probably within 5 years at current levels of investment.

5.3 Next Steps

Practical outputs from this research could be achieved most effectively by strengthening the evolving network of research activities within universities and meteorological institutions of the region [see Annex 3 and 4]. To achieve this, inputs will be required

- to sustain promising efforts within the network
- to nourish activities through contact with global research efforts
- to share ideas and methods between members of the network
- to interface with the user community, disseminating ideas and products and refining priorities and targets

In time, the research network might be broadened to include research into other weather sensitive problem areas in order to assist meteorological services expand the range and quality of their products to meet user needs. All this assumes that the integral Global Climate Observing System [GCOS] can be sustained if not improved.

6. INSTITUTIONAL ISSUES: NEW PRODUCTS FROM OLD SERVICES

The importance of weather and climate information for managing resources and the national economy is widely recognised. There are however, grave doubts as to whether meteorological institutions in their existing state are up to the task of ensuring that the people of southern Africa derive maximum benefit from emerging technologies such as long lead climate forecasting. Government decision makers, donors and weather information users, all expressed reservations to the mission concerning the attitude and performance of national meteorological services. In too many instances, meteorological services are perceived to be more of an artificial constraint on access to timely-information than an opportunity to interface with a growing global network of potentially very useful information .

It is difficult but essential for meteorological institutions to evolve in accordance with an extremely rapidly changing technical environment. The problem extends well beyond southern Africa. Meteorological services have an important role and great potential but useful outputs tend to be minimal unless services have good access to sources of global products together with the capability and incentive to deliver the kinds of information that users need. Pertinent issues are summarised below and explored further in Annex 4.

6.1 Meteorological Institutions in SADC Besides the national meteorological services in each of the countries of SADC there are several other organisations at regional level with interests in meteorology. These include the Drought Monitoring Centre[7] [DMC] in Harare, the Regional Early Warning System based in Harare [REWS], the Southern African Transport Co-ordinating Committee [SATCC] in Maputo, SARCCUS in Pretoria, the regional Food Security, Training and Administration Unit in Harare [FSTAU], SADC-ELMS [Environment and Land Monitoring System] proposed for the near future and several national universities undertaking research including University of Witswatersrand, Cape Town, Natal, Pretoria, and Harare. If progress is to be made in adapting outputs from global centres [such as the recently announced International Research Institute for Seasonal Climate Prediction, IRI-SCP in USA] for the use and benefit of national and local users, then scope exists for using existing research capability in SADC and rationalising the diverse regional interests.

Of the National Meteorological Services in SADC, the South African Weather Bureau in Pretoria is the strongest and is working on both regional forecasting models and regional climate models. SADC are considering the establishment of a regional weather centre by January 1997 to address medium and long range weather forecasting, early warning of severe weather conditions, and issues related to climate change. It is considered likely that Pretoria will take on the role of regional weather centre linked up to the global centres, and out to national centres in SADC. It is also envisaged that by July 1997 the SADC member states will establish a regional training and research centre for supporting effective meteorology services.

[7] Reports of a recent SADC consultancy suggest that the best future for the DMC may lie in its incorporation as part of the FSTAU in Harare.

6.2 Role and Comparative Advantage In general, national meteorological services are quite unique as government bodies:

- They do not make end point decisions themselves but are information providers to an ever growing range of users. This means they do not belong naturally to any one branch of government.

- They work with weather which is part of the environment and of major interest to many, if not all people in the countries concerned.

- They must function in real time, all day and every day. The value of their information is highly perishable and consequently needs to be communicated effectively, in timely fashion, to a diverse range of customers.

- They operate as part of a coherent, operational global network to which they contribute data and receive information back. Without the global network, the ability of individual services to function effectively is very limited. With good access to global weather products, climate forecasts and much satellite data, their potential for meeting a large number of people's needs for timely and reliable information is growing rapidly, and will continue to do so.

It is this extraordinary potential which needs development so that best use can be made at national and local level of long lead forecasts and other products of the global weather network. Until recently meteorological services needed to be large to be effective, hence their emphasis on capacity development. This is no longer the case. Future emphasis must be on capacity *utilisation.*

6.3 The Transitionary Process Meteorological services in SADC as elsewhere are currently at various stages within the transitionary process between traditional and modern working techniques. Satellite and global model output products which have revolutionised meteorology elsewhere are still relatively new and not yet fully accessible to all meteorological services in the region. Those that have good access are at different stages in the process of incorporating the new data and information sources into operational practices.

In future as products from global and regional sources diversify and improve [long lead forecasts included] traditional meteorological practices will be progressively abandoned. This is already leading to changing skill and staff needs. The previous labour-intensive struggle to decipher synoptic scale processes is now being replaced with much greater opportunity for local interpretation and dissemination of useful products. Easily obtained and much higher quality products from global models can thus be used to meet the needs of a much wider variety of local users. At least one service in SADC has recognised this and has already started routinely faxing the five day forecasts received [from ECMWF over MDD] directly to customers, emphasising the role of the service as an information provider to users.

Meteorological services in SADC are in urgent need of support to assist their evolution through this difficult transitionary process. The triple requirement is for investment to assure local access to the full range of global data and products, education and training of both services and users, together with restructuring of meteorological institutions and their working practices to transform productivity.

6.4 Operational Environment The principal consideration for adopting a new institutional form is the macro environment and institutional setting in which the service must function, including the objectives, orientation and expectations for the transformed service. This will set requirements and guide options for new structures. While information management and decision making by governments everywhere is characteristically weak, several governments in SADC have expressed demand for a more timely information service better tuned to their requirements. External factors influencing the objectives, orientation and expectations from a reformed meteorological service include:-

- The extent to which a national natural resource management strategy or system exists [for which an integrated and sustainable environmental monitoring system is essential] and the capability of environmental institutions to deliver.

- The level and development of the national information system or network. National information "networks" are beginning to evolve in RSA, Zimbabwe, Botswana and probably other countries as well.

- National data policy and government attitude to cost recovery processes in the public sector.

- The extent to which government, NGOs or private sector are the main users of information [for policy, planning, investment, management, regulation , business and research purposes].

- The extent to which commercial companies could develop and provide complementary services.

- The need to sustain national participation in the global network.

In SADC, examination of all the above aspects point towards the meteorological service of the future being one of a set of small dynamic public sector units, closely networked with [and accountable to] their customers, each other, and the private sector. In some instances the natural home, and certainly the greatest potential for meteorology in the future, lies in an expanded environment monitoring role. A rapidly growing strength of meteorology lies in real-time remote sensing: a tool of great potential for effective environment monitoring and resource management. It is also worth noting that the easy availability of PCs, software, and better communications all push towards distributed information networking rather than large centralised structures.

6.5. Institutional Development The cost effective meteorological service of the future must be focused on outputs and its performance assessed on how well products meet priority needs of users within the country. From this approach, three work domains can be determined according to national need:

1) Highest priority outputs including statutory obligations: the core domain.
2) Additional lower priority meteorological outputs: optional domain.
3) Supplementary environment monitoring products: optional domain.

Core activities: The Government would need to define and support core activities with a tightly focused, basic unit that would concentrate on:-

- Providing statutory and essential products for easy and effective use.

- Maintaining the necessary network of observations and two-way links with the global community to sustain core products in the long term.

Accountability and Cost Recovery This core unit would be accountable to a governing board comprising representatives of the principal information users. The board would assess performance and any proposed changes and developments in the service in terms of output quality and benefit. The director of the service should be a manager advised by a meteorologist during the transition process. Cost recovery for some core products would be highly desirable but not essential: public good and equity considerations together with the difficulty of selling time perishable and easily transferable information must be considered in the balance.

Additional and Supplementary Activities Any activities meteorological or environmental beyond the core would need to be self financing and hence open to competition from other service providers in public or private sector, or even from regional scale organisations.

Enterprise Arrangements along the above lines would allow more enterprising meteorological services to develop their potential and use their comparative advantages to best effect, while sustaining essential core activities for long term benefit. Incentives to encourage managers and staff to be more enterprising in meeting user requirements will need to be incorporated. Transparent links with private sector companies, universities and other NGOs should be encouraged. In turn, where services could be provided more cost-effectively by the private sector or other bodies, the board should have the power to direct accordingly.

Policy: Data and information management An important element of operating an effective competitive system of this nature is data policy. Incentives towards cost recovery can lead to greatly restricted data availability and least net benefit for the country concerned. In order to encourage greatest use of basic data sources, a clear data policy is required. The American meteorological partnership [described in detail by Friday[8] et al.

[8] The public-private partnership in the USA for the delivery of weather services and its relationship to the international exchange of meteorological and related data and products, by EW Friday, EM Gross and M Yerg, WMO Bulletin, Vol 45-1, January 1996.

and in Annex 4] appears to be one of the most effective working models. This open arrangement guarantees the basic level of service through government support and encourages individual enterprise to develop and sell new products where ever there is a buyo tapery? at the same time. In developing countries, similar arrangements could encourage healthy participation of emerging private sector information management companies, and help to realise more of the myriad advantages to be gained from the current information revolution.

First Steps Essential first steps are:

1. In each country, consultation with governments, meteorological institutions and customers needs be taken forward towards reaching a consensus on the requirement for, expected benefits from, and best way to develop meteorological institutions, coupled with investment for a more productive future.

2. At the same time, in each country, carry out:

- an objective and comprehensive 'weather information' user needs assessment,
- a careful examination of ways of communicating information to priority users,
- development of a 'core business plan' examining priorities, costs and opportunities,
- development of a new institutional structure appropriate to circumstances prevailing.

3. SADC scale: since many of needs for weather information are common between services, there would be cost and efficiency advantages in several services undertaking this exercise together in order to benefit from joint development of the sub-regional network: long lead forecasts being a case in point.

7. THE WAY FORWARD: TOWARDS INTEGRATED DROUGHT RISK MANAGEMENT

Improvements in climate forecasting and meteorological service productivity are both necessary and useful to ensure good information supply, but on their own are not sufficient to ensure better drought risk management. Rather, a number of concurrent developments need to take place to ensure that such information can be taken up by a wide range of decision makers and put to effective use *across the economy*. A number of specific and widespread obstacles to response exist, which need to be addressed through a comprehensive strategy in parallel with reform of meteorological institutions.

7.1 Ability of People to Understand, Use and Benefit from Long Lead Forecasts

Confidence A lack of confidence in forecasts rather than a lack of recognition of their potential applications is the underlying reason why climate forecasts are little utilised today. From a user's perspective, the prime requisites for a useable forecast are *reliability* and *timeliness* and users are often prepared to trade geographic and quantitative precision for greater reliability and timeliness, particularly in the case of multi-year and seasonal forecasts. This is not always appreciated by forecasters, who continue to strive to improve the geographic precision of their products, often at the expense of reliability and timeliness.

Evolving Use How reliable is 'reliable enough'? The propensity to utilise long lead forecasts depends on the individual decision makers' risk profile. Historically, the level of forecast reliability has been too low to be included in serious decision making. At a certain threshold of reliability and user awareness however, depending on the vulnerability of the decision both to drought and to the forecast being incorrect, forecasts will begin to be used *in support of other factors and pressures*. As reliability and user confidence grows, usage of forecasts will evolve until they are an essential component of policy and planning. Thus a simple but sufficiently reliable forecast of 'significant drought' or 'no significant drought' for the next wet season could be extraordinarily useful if it is available when decisions are made [or if it serves to stimulate them]. It is not logical to wait until forecast skill [in virtually any domain] is '100% reliable' before beginning to incorporate forecasts into decision making. Many life processes would be impossible without sensible 'risk' management.

Systematic release The release of forecasts on an infrequent and often ad hoc basis can contribute to the *shock effect* of drought. In the present system, the sudden issuance of a drought pronouncement, after months of apparent inactivity, can create over-reaction and does little to stimulate confidence in forecasters abilities. A system is needed that regularly updates long lead forecasts in a transparently open and reliable way, even if it states 'at the moment there is no clear indication that the next wet season will be abnormal in any way'. It is important that decision makers develop the habit of using the best information available.

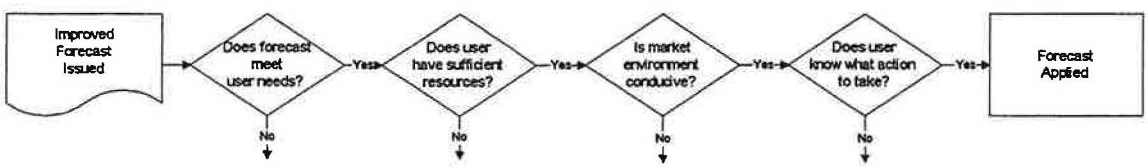
Resources to respond The ability to utilise climate forecasts depends upon the size and diversity of the decision maker's *resource base*. Resource-poor decision makers have less scope and fewer opportunities to utilise climate forecasts, even if they have a high degree of confidence in them. Thus, for example, a country which is severely foreign exchange constrained may not be capable of establishing a foreign exchange financing facility to safeguard food security.

Similarly, resource-poor farmers rarely have the options available to make alternative plans when forecasts suggest that the weather will be other than expected - and if they had, they may not be able to risk the forecast being wrong. Furthermore, such farmers are often strongly dominated in their actions by traditional beliefs and peer pressure that restrict their ability to absorb new concepts and take risks. And in practical terms, the rural economy throughout much of the region is dominated by livestock owners who resist moves to restrict the free grazing of their herds and flocks, so making it difficult, e.g. for small cultivators, to choose an early planting date before livestock are put under control for the duration of the growing season.

Free Market Opportunities for responding to long lead forecasts are also influenced by the *market environment*. In the past, a high degree of central Government control has restricted opportunities by the private sector to respond: market liberalisation is an important prerequisite for uptake of long lead forecasts by the private sector.

Economic Management Finally, as the experience in the region with early warning systems has shown, improvements in the quality of information does not guarantee better drought management. *Good government, fiscal responsibility* and *effective organisation* are important prerequisites to ensure that improved climate forecasts are acted upon. These requirements in particular, should not be underestimated.

Improvements in the Quality of Forecasts alone is not a Guarantee that Forecasts will be Utilised...



7.2 Removing Obstacles to Response

7.2.1 Owning the service and the forecasts: "User Consultative Panels" Efforts are needed to ensure that improvements in forecasting are *user driven*. One way to facilitate this would be to establish *consultative panels* [complementing the board of directors] made up of representatives from various user groups to advise forecasting services on the quality of existing forecast products and on the types of improvements needed. Like many others, NGOs that work on the human side of drought risk management [coping strategies] have much to offer here, but have no forum to express their needs. User Consultative Panels should be attached to national meteorological services as well as to regional institutions such as the SADC Regional Early Warning System and the Drought Monitoring Centre.

Discussions with a broad range of users indicate that forecasting centres should give primary attention to improving the *reliability* of *seasonal forecasts*, since such products offer the greatest utility. The *immediate goal* of forecasters should be to issue *a reliable national level seasonal forecast by the beginning of July each year*.

Forecasting centres should issue *regular* and *frequent forecasting* bulletins for free and widespread dissemination. As a general principle, forecasting centres should establish the routine of issuing rolling forecasts. Fixed time span seasonal forecasts should be reviewed and adjusted regularly in order to minimise the shock effect of sudden unexpected forecasts.

Type of Forecast	Time Span(s)	Rolling/Fixed	Frequency of Issue/Update
Multi-year	3, 5 and 10 years	Rolling	Bi-annually
Seasonal	Growing season	Fixed	Monthly
Within-season	1, 10 and 30 days	Rolling	Daily and dekadal

7.2.2. Helping Resource Poor Users Special measures would need to be directed towards strengthening *the response capabilities of resource poor user groups*, particular *subsistence farmers*. Apart from the need to ensure that forecasts are issued in sufficient time to enable resource poor groups to respond [they will generally need more time], mechanisms would need to be put in place to support less well endowed users. In particular, research and extension services would need to become much more forecast-responsive in their approach to small farmers. They would need to be able to translate seasonal forecasts into specific recommendations for the subsistence and smallholder sectors, in co-ordination with other agricultural support services, such as seasonal input suppliers and credit institutions. Evidence of relatively sophisticated coping strategies obtained from farmers groups, NGOs and the University of Witswatersrand Geography Department suggests that scope for beneficial response to long lead forecasts by subsistence farmers may be larger than is sometimes supposed.

7.2.3. Continued Market Liberalisation Governments must continue to liberalise the market environment if improved forecasts are to have widespread utility. Restrictions on trading practices or access to markets would be detrimental to many potential users. For example, the imposition of export restrictions following a drought which results in the cancellation of forward contracts, would seriously undermine initiatives to develop agricultural commodity exchanges. Marketing restrictions would also impede the ability of agricultural support industries, such as fertiliser and seed suppliers to respond to climate forecasts, thus jeopardising the capacity of both subsistence and commercial farmers to realise potential benefits.

7.2.4. Concerted Action for Improved Decision Support and Information Management Even after ensuring that all the above preconditions for the effective utilisation of improved forecasts are satisfied, the integrated national benefit from application of forecasts in drought risk management will depend upon whether enough users have an adequate understanding as to how to use the new information and, ultimately, an incentive and willingness to apply the forecasts.

Raising Awareness: Risk Management An important part of any initiative to encourage the utilisation of climate forecasts must therefore include organised *user awareness education*. Decision makers throughout government and the private sector need to be encouraged to examine their own risk profiles and the sensitivity of their decision making to the vagaries of weather and climate, and develop strategic options, precautions or contingency arrangements appropriate to a limited range of forecast scenarios [e.g. tercile or quintile assessment of five year trend, wet season quality, delayed start or early finish, severity of mid-season drought.......] in advance of the next ENSO drought forecast. In this way individual decision makers or managers can affirm that existing decision making is appropriate to an uncertain and possibly changing climate, and also accept ownership of drought risks and recognise their responsibility to use available forecasts to minimise losses. Such awareness raising could provide different branches of government and institutions with mechanisms to co-ordinate organisation-wide decision making better, and also enhance understanding of user needs if feedback were arranged through the user consultation panels.

In particular, with the rapid evolution of market liberalisation and moves to encourage the development of a more prominent private sector, there is a need to educate users in the mechanisms of free markets and how improved climate forecasts can be used within a free market environment. Such awareness might, for example, lead governments to reconsider such measures as the imposition of export bans on agricultural commodities following droughts.

Good Governance Last year at least one government in SADC tried to suppress the release of seasonal forecasts in advance of the ENSO related drought. Drought mitigation strategies must be designed to take into account a country's economic circumstances and structure, and likely future weather. In intermediate and complex societies where drought shocks are widely diffused, balance of payments and budgetary support are most effective. In simple economies where drought impact is concentrated in rural areas, more targeted interventions are required. Both responses can be aided by reliable advance knowledge of conditions. Since fiscal responsibility and improved economic management across the board can also reduce the effects of drought, *the development and widespread uptake of reliable long lead forecasts and their incorporation for improved decision making throughout the economy, is rapidly becoming of the utmost priority for the countries of southern Africa.*

8. CONCLUSIONS, CHALLENGES AND RECOMMENDATIONS

The general conclusion of the investigation is that the magnitude of the economic and social benefit to be gained from improved drought risk management in southern Africa through development and use of long lead climate forecasting, does indeed justify further investment in measures to improve forecasting reliability, accessibility, uptake and utilisation. As one senior decision maker put it, information of such fundamental economic value must be easily available in the public domain as early as possible, so as to maximise benefits from the broadest possible range of investment decisions.

Particular Conclusions

1. Seasonal forecasting capability is already skilful enough to start being incorporated in decision making, and is on the threshold of becoming vital for better drought risk management in southern Africa. Improving this capability is a very high priority indeed.

2. In order that countries of southern Africa benefit from more of the considerable potential offered by modern meteorological services when networked into the global system, meteorological institutions in SADC need appropriate investment together with institutional development.

3. Such action however, needs to be part of a more comprehensive approach to natural resource information management and decision making in developing countries.

4. By addressing the use of long lead forecasting for drought risk management in a systematic way, developing countries will refine methods of immediate benefit that will also assist them to adapt more easily to systematic climate change.

Challenges

1. The challenge for the scientific community is to improve reliability and timeliness of long lead forecasting towards meeting priority user needs, as soon as possible.

2. The challenge to government administrators and decision makers is to respond intelligently to the new technology which carries its own obligations towards better economic management, fiscal responsibility and good governance.

3. The challenge to the meteorological community in SADC is to effect reform with imagination and make the most of the many powerful, new opportunities presented.

4. The challenge to the general public and private sector is to demand a better service from government bodies in their supply and use of information.

5. The challenge to the donors is a] to recognise the major potential benefit to be derived from these and other products of the information revolution, b] to adapt their own machinery to be able to address sweeping multisectoral issues of this nature, and c] to ensure benefits are incorporated in pertinent ongoing programmes.

6. The challenge to the global community is to accept likely consequences of anthropo-genic global warming, and seek to mitigate the effects on those least able to adapt.

Recommendations

The study team recommends to ODA and the World Bank that they, along with other donors, banks and governments in the countries concerned, adopt a broad interdisciplinary approach to addressing the issues raised by this study.

1. **Drought Risk Management in Southern Africa**: direct assistance to improving seasonal forecasting in the region is recommended with parallel assistance towards widespread information dissemination, uptake and use. Incorporation of drought risk profile assessments in their existing programmes within the region would be a good first step. Benefits to be gained across economies would justify such an investment.

2. **Reforming Meteorological Institutions in SADC**: Investment coupled with development of meteorological institutions to aid their rapid transition into cost effective, user-friendly, weather advisory services and real-time environment monitoring units is recommended. This is justified by the major potential benefits to be gained from better local access to global weather products and satellite services; long lead forecasts included.

3. Coping with Climate Change. Since the potential of the techniques proposed for best implementation of long lead forecasting would also aid countries in southern Africa cope better with the consequences of global warming, it is recommended that consideration be given to providing support from within the Global Environmental Facility.

4. **Information Management and Decision Making in Developing Countries**: It is difficult enough for developed economies to cope rationally with the consequences of the ongoing information revolution let alone underfunded institutions in developing countries. It is recommended that consideration be given to systematically improving both the quality of basic natural resource/environmental information and decision support available to decision makers [and donors] in developing countries. Modern methods if well targeted can be most cost effective.