

Malawi and Southern Africa

Climatic Variability and
Economic Performance

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The World Bank

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Abbreviations and Acronyms

ADD	Agricultural Development Division
ADMARC	Agricultural Development and Marketing Corporation (Malawi)
cif	Carriage, insurance and freight
CRU	Climatic Research Unit (University of East Anglia, UK)
DFID	Department for International Development (UK)
DMS	Department of Meteorological Services (Malawi)
EEQ	Equatorial East Africa
ENSO	El Niño Southern Oscillation
ESCOM	Electricity Supply Commission of Malawi
FAO	Food and Agriculture Organization of the UN
FEWS NET	Famine Early Warning System Network (USAID project)
GDP	gross domestic production
HIV/AIDS	human immuno-deficiency virus/acquired-immune deficiency syndrome
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate Prediction (USA)
ITCZ	Inter-Tropical Convergence Zone
NFRA	National Food Reserve Agency (Malawi)
NGO	non-governmental organization
NOAA	National Oceanic and Atmospheric Administration (USA)
NRI	Natural Resources Institute (UK)
O&M	operations and maintenance
ODA	Overseas Development Administration (UK)
ODI	Overseas Development Institute (UK)
PER	public expenditure review
RIM	rainfall index for Malawi
SADC	Southern African Development Community
SEA	Southeast Africa
SEARI	Southeast African rainfall index
SST	sea surface temperature
TIP	Targeted Input Program
UNDP	United Nations Development Program
USAID	United States Agency for International Development
WFP	World Food Program
WMO	World Meteorological Organization

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Preface

As part of its efforts to promote disaster prevention and mitigation as an integral part of development activities, the World Bank's Disaster Management Facility (DMF) is undertaking a study on the economic and financial consequences of natural disasters, with the support of the United Kingdom's Department for International Development (DFID) provided through its Conflict and Humanitarian Affairs Department (CHAD). The principal researchers for the study are Charlotte Benson and Edward Clay of the Overseas Development Institute (ODI) in London. Study team members from the World Bank's Disaster Management Facility include Alcira Kreimer, Margaret Arnold, Jonathan Agwe, Maria Eugenia Quintero and Zoe Trohanis.

The study entails a state-of-the art review and three country case studies. The first case study was conducted on Dominica, a small island economy (Benson and Clay 2001). The second study focused on disasters and public finances in Bangladesh (Benson and Clay 2002). The third case study, which focuses on climatic variability in southern Africa including a country study of Malawi, is reported in this document. A final synthesis report draws together the new evidence with that from the researchers' previous studies and other relevant literature.

This report was prepared by a team lead by Edward Clay and including Louise Bohn, Senior Research Associate, Climatic Research Unit, University of East Anglia; P. Dalitso Kabambe, Planning Division, Ministry of Agriculture and Irrigation, Government of Malawi; Hardwick Tchale, Agricultural Economics Section, Rural Development Department, Bunda College of Agriculture, University of Malawi; and Enrique Blanco de Armas as Research Officer. The study includes four background papers prepared by the various members of the team – Kabambe 2002, Bohn 2002, Blanco de Armas and Clay 2002, and Tchale 2002.

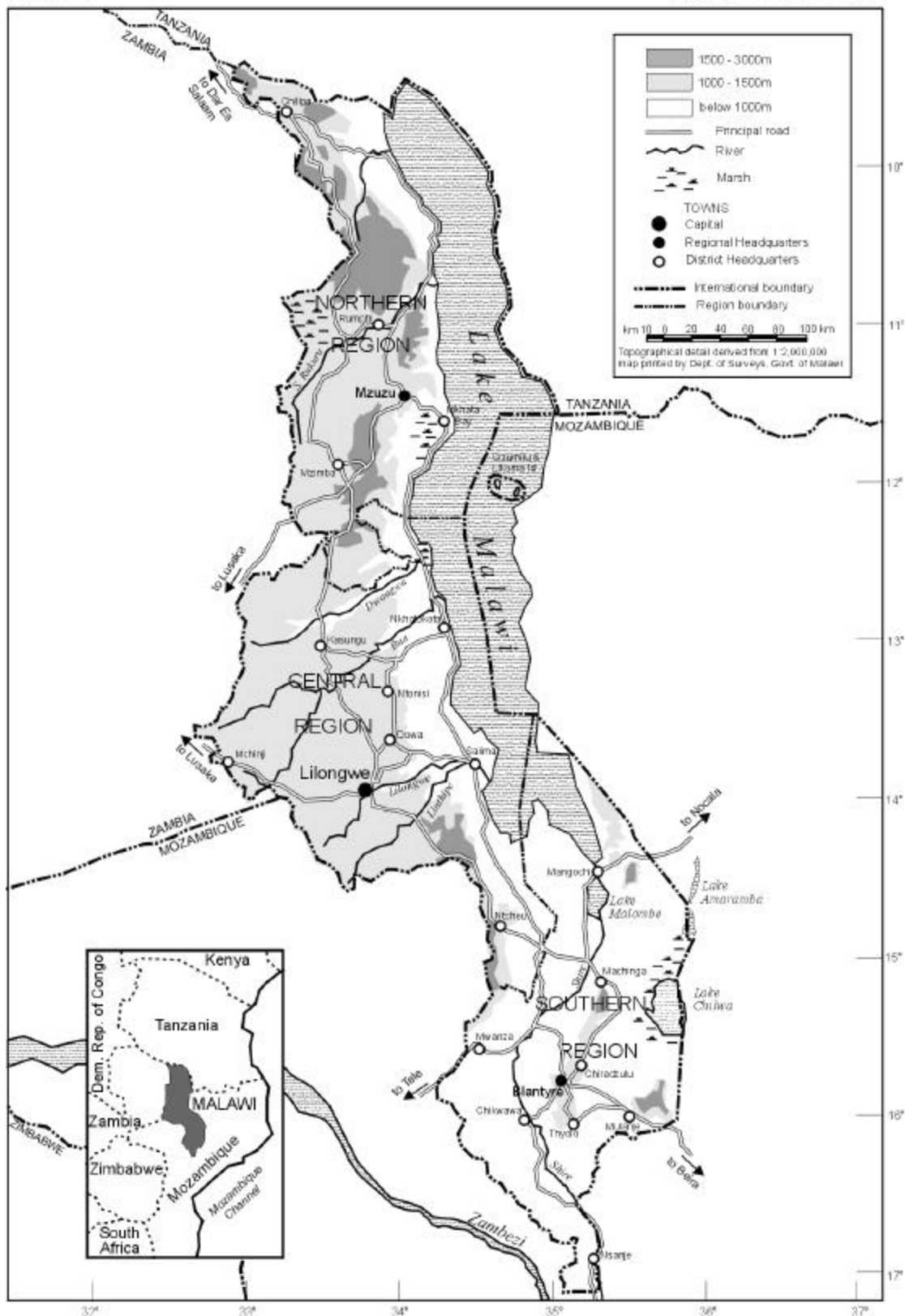
The report is based on a selective review of published literature and official documentation, as well as extensive statistical investigations, on climatic variability and its economic consequences in Southern Africa, that extends the earlier study by Benson and Clay (1998). This investigation is complemented by a review of the role of climatic forecasting in relation to Southern Africa and to Malawi more specifically, based on a review of documentation, interviews and correspondence with climatologists and actual and potential users of their forecasts. The study included visits to Malawi by Edward Clay from November 26 to December 6, 2001 and again with Louise Bohn from February 1-15, 2002. In this connection, the authors would like to thank Malawi Government officials as well as many other people in Malawi, hopefully all listed in Annex C, who generously gave their time and provided invaluable ideas and information without which this report could not have been completed. The authors would particularly like to thank Mr. D.R. Kamdonyo, Director, and Mr. J. Nkhokwe, Deputy Director Monitoring and Prediction, at the Malawi Department of Meteorological Services for their cooperation and advice. The practical assistance provided by Bunda College of Agriculture, where the team stayed during their visits, is much appreciated. Charlotte Benson and Jonathan Kydd provided invaluable advice, Alice Baker edited a summary version of this report, Jim Dempster prepared the maps and Mavis Clay assisted with the preparation of the report.

The study team also extends its thanks to Mr. Darius Mans, Country Director, and members of the World Bank's Malawi country team for support and collaboration on the study.

There is scope for further work on this subject in Malawi and Southern Africa more generally, and it is hoped that this report will provoke discussion on both analytic and policy issues and also stimulate others to undertake further investigations. The authors of course accept full responsibility for all errors and omissions in this report.

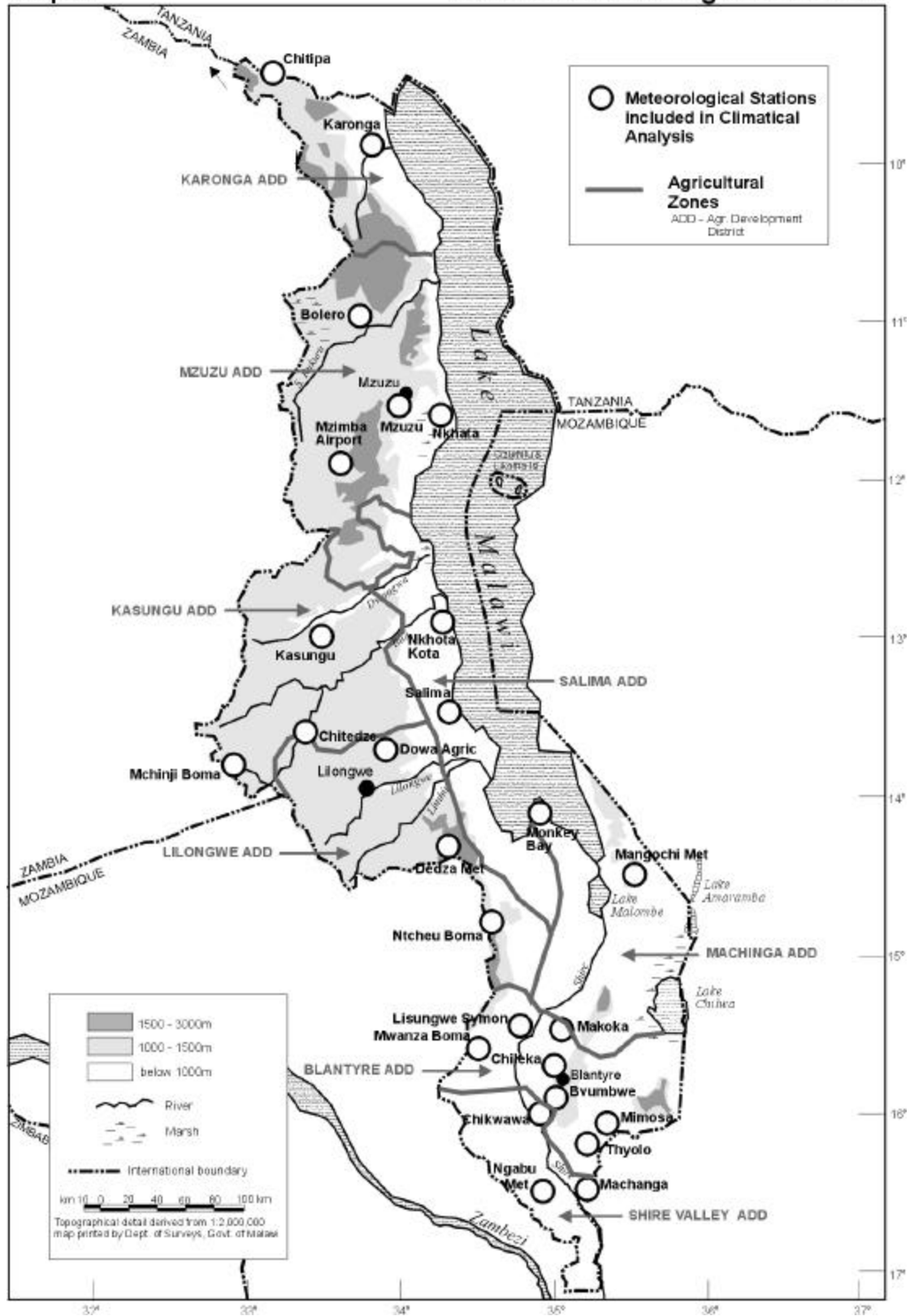
Map 1

Malawi - General



Map 2

Malawi - Meteorological Stations



Executive Summary

This study taking the 2002 food crisis in Malawi as its context and using evidence up to 2001: reassesses the economic consequences in Malawi and Southern Africa more generally of climatic variability in the light of experience such as the El Niño event in 1997/98; and takes stock of the current capacity of climatic forecasting and progress in research to review the range of potentially useful outcomes; and the institutional capacity and financing issues which arise if effective use is to be made of strengthened forecasting ability.

Malawi is a small, land-locked country in Southern Africa, with an estimated population in 2000 of 10.8 million. It is one of the poorest countries in Africa with around 65% of the population below the national poverty line and 28% in extreme poverty. Health and social indicators are also among the lowest in Africa. Infant mortality in 2000 was 134 per 1000, compared with an average of 92 for sub-Saharan Africa, and average life expectancy (now 37 at birth) is declining as a result of HIV/AIDS, which in 1999 affected 16% of the adult population and 31% of women in ante-natal care. Adult literacy is under 60% and only 78% of children attend school. Agriculture accounted for some 40% of GDP in 2000 and its share of GDP has been increasing since the early 1990s with industrial stagnation and contraction of the public service sector. Some 89% of the economically active population is classified as rural. Malawi is heavily dependent on maize, which is the main food staple and in a normal year probably accounts for about three quarters of calorie consumption for Malawi's population. Export earnings are dominated by tobacco (61%), tea (9%) and sugar (8%). This dependence on rainfed crops makes Malawi very vulnerable to variations in rainfall as well as commodity price shocks.

Malawi's 2002 food crisis – how might better climatic forecasting have helped?

The 2002 food crisis in Malawi, which was emerging during the course of the study, highlights both the important potential gains that good climatic forecasting offers in terms of managing the risks associated with climatic variability; and also the problems which need to be overcome to develop and make full, effective use of meteorological monitoring and forecasting in the region. It provides a highly relevant starting point for examining the linkages and issues at the heart of the study.

The impetus for improving drought risk management at a regional level for Southern Africa – involving regional bodies, national governments and the international community – stemmed from the droughts of 1991/92 and 1994/95. By 1997/98, a formal process for consensus-based 'long-lead' or seasonal climatic forecasting had emerged, managed through the Southern African Climatic Outlook Forum (SARCOF). Within Malawi, the Department of Meteorological Services (DMS) was providing 10 day bulletins on rainfall, temperature and sunshine for the met stations under its control. However, despite this progress, the meteorological input into anticipating and assessing the scale of the emerging crisis seems to have been quite limited. SARCOF's forecasts of most likely outcome were for above average rainfall in the region in 2000-01 and broadly average rainfall in 2001-02. Because the overriding concern in the region has traditionally focused on risks of drought, the potentially negative impacts of higher than average rainfall were not recognized. Policy decisions taken in Malawi were therefore predicated on a normal or favorable climatic outlook, and what turned out to be an over-optimistic view of the likely maize crop. In apparently favorable conditions, a poverty reduction scheme, which provided all small-scale subsistence farmers with a minimum package of seeds and fertilizer, was halved in coverage in order to reduce public expenditure. On the advice of the International Monetary Fund (IMF), and with World Bank agreement, Malawi sold two-thirds of its Strategic Grain Reserve of maize, which in 2000 was at near capacity, to reduce its debt. The decision was taken prematurely, while planting was still underway and the maize crop was uncertain. In the event both maize and tobacco yields were low, with dangerous consequences in terms of food security; and the Government had to make replacement purchases of maize which wiped out savings from the disposals.

The 2002 crisis is a result of many factors, of which climate is only one. But a better understanding of agro-meteorological relationships, reliable crop production data, and less generalized climatic forecasts to inform

economic and food security decisions would undoubtedly have helped to avoid some of the extreme consequences of the low crop yields. There was apparently little understanding of how fragile society and the economy in Malawi had become. There was insufficient appreciation of the sensitivity of the maize and tobacco crop to weather *through* the season and the damaging effect of erratic rainfall levels. There was an over-concentration throughout the region on risks of drought, leading to “undue confidence” in the light of highly generalized forecasts of average or above average rainfall. There were financial and human resource constraints, which meant that data collected from the meteorological stations within Malawi was not analyzed and interpreted to draw out the agro-meteorological linkages or permit the closer monitoring of weather on a local basis throughout the growing season. This more robust data monitoring is essential to assess and address the vulnerability of the important smallholder agricultural sector. As the 2002 crisis demonstrates, there are major benefits to be derived from strengthening climatic forecasting regionally and at a country specific level.

Climatic variability, agriculture and economic performance in Southern Africa

The droughts of 1991/2, 1994/95 and 1997/98 were all associated with the El Niño Southern Oscillation phenomenon (ENSO). Climatologists have established a highly significant relationship between ENSO and inter-annual variations in rainfall in Southern Africa. But it is not a simple canonical relationship: not every El Niño event brings low rainfall; and in some years extremely low annual rainfall is not clearly linked to El Niño events. Much less well-understood oceanic-atmospheric interactions in the Indian Ocean and Southern Atlantic are now recognized as important influences on rainfall patterns.

Cereal production, especially maize, is central to food security in Southern Africa. It is also highly sensitive to drought and climatic variation more generally. In a crisis, assuring maize supply is likely to take priority over other trade considerations and in public spending decisions. So it makes sense to look first at the impact of climate on cereal and maize production and how that in turn impacts on the economies of Southern Africa. South Africa is by far the largest agricultural producer in the region, accounting for 64% of cereals and 62% of maize production during 1993-98. Cereal production performance in South Africa and the rest of the region is correlated, generally moving in the same direction.

The relationship throughout the region between production volatility and climatic events is striking. But the pattern is more complex than that of drought caused by El Niño in turn resulting in low crop yields. Different sequences in drought impacts at country level – some ahead of ENSO linked droughts – are reflected in year-to-year changes in maize yields and agricultural GDP. In 1997/98 the risks associated with the very strong ENSO event led climatologists to forecast severe drought in Southern Africa and very low crop yields. In fact, though regional crop yields were lower than normal, the rainfall associated with oceanic activity in the Indian Ocean resulted in more favorable conditions in countries in the north of the region, and crop yields were higher than had been anticipated by scientists using only El Niño based models. Total rainfall is a better explanatory variable than El Niño in analyzing crop yield variations. Obviously there are other important factors. Nevertheless, focusing on rainfall and output provides a better understanding of the consequences of climatic variability historically and in the future – with implications for food security and economic policy.

Drought has been commonly seen as the main climate issue in the region. However, the recent disastrous floods in Mozambique and the role which the extremely high rainfall in Malawi in 2000/01 played in the lead up to the food crisis in 2002 have highlighted the risks associated with high rainfall. Plotting annual cereal and maize outputs against the south east African rainfall index suggests that outputs plateau at about 15% above the 1960-90 mean rainfall levels. Above that level there is increased probability of reduced production. A parallel analysis for Zimbabwe showed a similar pattern. However, in the case of Malawi, which is at the northern margin of the climatic region, there was no significant relationship between maize yields and either the regional rainfall index or ENSO variables. There was however a link between maize yield and country specific rainfall levels for the critical month of February rather than total annual rainfall. Our conclusion is that climatic forecasting and Early Warning Systems need to give more attention to

potentially extremely high rainfall events; and that localized monitoring and agro-meteorological interpretation of data is needed to reflect the significant variations between and within countries in the region and inform critical decisions.

Costs of climatic shocks

As is the case with most natural hazard risks, the livelihoods most affected when disaster strikes are those of the poorest in the population. The clearest impacts of drought are on cereals – especially production and trade in maize. The most extreme 1991/92 drought reduced maize production by 10 million tonnes and cost US\$ 1 billion in cereal losses at import parity prices and US\$ 500 million in actual logistical costs of importing cereal into affected Southern African countries. There were also severe wider GDP and agricultural sector impacts over 12 months of at least double this magnitude. The climatically less severe 1994/95 drought involved costs of US\$1 billion in cereal losses because of higher prices in a tighter international cereal market. The 1997/98 El Niño event also caused significant but less serious losses. The impacts of the 2002 crisis are beyond the scope of the study but as El Niño develops again, emergency cereal import costs have already exceeded losses in 1997/98. Costs of this scale require action at national, regional and international levels to prepare an economic strategy and to discuss aid policy. The value of climatic forecasting lies in offering early evidence of enhanced risk of a major shock, and in anticipating the costs and the scale of measures that may be needed at the national and regional level.

Climatic variability and the Malawi economy

Periods of below average or erratic rainfall were less extreme and less general in their impacts in the 1970s and 1980s than in the 1990s. The droughts of 1991/92 and 1993/94 impacted very severely on agriculture in Malawi, particularly the smallholder sector, which accounts for the major part of maize production. Maize production declined by around 60% in 1991/92 to the equivalent of only 45% of average production levels for the previous five years. High and well distributed rainfall, combined with policies to assist smallholders, resulted in a bumper maize crop and record tobacco crop in 1992/93. In order to avoid the producer disincentives, which might result from these very high yields, Malawi's Agricultural Development and Marketing Corporation (ADMARC) made record purchases (over 375,000 tonnes of maize), adding to financial pressures on the government. But in 1993/94, following low and erratic rainfall in key growing areas, maize production again fell sharply. In 1994/95 while South Africa and Zimbabwe were affected by lower and poorly distributed rainfall, Malawian agriculture largely recovered. These zonal differences in the pattern and timing of drought impacts during 1994 and 1995 highlight important climatic variations within the country as well as regionally. In 2000/01, maize production fell by 30% and tobacco was down 16%, following exceptionally high rainfall and widespread flooding.

The wider economic consequences of a drought in a Sub-Saharan economy such as Malawi include direct impacts on agriculture and on other productive sectors reliant on water, such as hydro-electricity. The indirect multiplier and linkage effects from the agricultural sector typically involve a lag of 6–12 months. The overall pattern of drought impacts on public finances in Malawi has been broadly consistent with standard expected patterns. Drought severely reduced agricultural production towards the end of one financial year, with financial effects in terms of relief and recovery assistance following in the next financial year. Flawed or problematic data has made it difficult to undertake in-depth sector or wider economic analysis of the effects of climatic shocks or to isolate the effects of drought. Nevertheless the evidence suggests that Malawi's economy is among the most sensitive to climatic shocks of any in the region.

Prior to the 1991/92 drought, there were signs of improvement in Malawi's economy with export revenue rising and public expenditure falling. However, in 1991 the combined effect of the refugee and trade impacts of the Mozambique conflict; increasing political difficulties within Malawi which temporarily halted non-relief development aid; and the extreme drought in 1991/92 resulted in a near chaotic budgeting situation. Public expenditure rose by 30% in real terms between 1991/92 and 1994/95, and the rate of inflation rose from 12.5% in 1990/91 to 75% in 1994/95. Fiscal measures combined with better agricultural performance led to

a temporary stabilization in 1995/96 and 1996/97. However, public finances in Malawi have continued to be very volatile. Upward pressures on expenditure have intensified in recent years. Foreign aid levels, on which development funding depends, have been influenced by political and governance issues as well as economic and humanitarian considerations, and this has also been a factor in Malawi's relatively unstable public finances.

Understanding climatic variability in Southern Africa and the links to wider climatic processes

At a general level, the effects of destabilizing climatic hazards are increasingly understood and increasingly predictable. However, there are still important gaps in our knowledge. The study has examined climate variability and links to wider global processes in the light of recent research and events in the study area.

In the predominately semi-arid Southern African region, rainfall varies significantly from year to year, with a pronounced seasonal cycle. The rainy season generally extends from October/November to April, reaching a peak between December and February. Rainfall distribution during the rainfall season is also variable, depending on the interplay between tropical and mid latitude weather systems and convective variability. As a result of increased temperatures and higher water evaporation rates, future global climate change is likely to alter short-term climate variability and to change rainfall patterns, reducing water availability. The peak of the wet season is likely to increase, but with offsetting decreases in the drier months. Both droughts and floods may become more likely, but there is greater uncertainty.

Fluctuations in seasonal rains are linked to regional sea surface temperatures and the global ENSO phenomenon. The links between ENSO and regional weather system are robust and relatively well understood. Models can predict ENSO up to a year in advance; and using ENSO, useful predictions of southern African rainfall can be made at lead times of up to five months. During El Niño events south-eastern Africa (SEA) is likely to experience a 50-60mm shift towards drier conditions. During La Niña, models show above normal rainfall in SEA for all rainy season months except February. By contrast, equatorial east Africa (EEA) is likely to experience relatively wetter periods during El Niño events, and relatively drier phases associated with La Niña events. The severity of the impacts depends on different types of El Niño pattern. Climate zones, of course, do not follow national boundaries: Malawi lies between the core zones of SEA and EEA, indicating the difficulties of climate forecasting in Malawi. Moreover, it is changes in distribution of rain during the wet season associated with El Niño events rather than total rainfall amounts which are crucial to understanding agriculture impacts. These changes are complex and difficult to predict, limiting the precision which forecasts can provide.

Of course, ENSO is not the only factor affecting rainfall in Southern Africa. Regional sea surface temperatures (SST) and topography are also important. Predictions of Indian and Pacific Oceans (SST) are used to produce seasonal forecasts for South Africa; and the South Atlantic also helps shape atmospheric circulation. Despite advances in forecasting capability, for some areas of Southern Africa predictability or the 'skill' of the forecast may still be relatively low. Certainly, there are complex relationships which go beyond the influence of El Niño and which need to be taken into account in reviewing the potential and actual roles of climatic forecasting.

As has already been noted, drought has been seen as the main climatic hazard. This is reflected in the importance accorded to drought management in macro-economic policy and in the institutional arrangements for disaster management. More recent events (including the 2002 food crisis in Malawi) have highlighted other important climate risks:

- Erratic rainfall, particularly an extended halt in rains at the critical flowering time, can considerably reduce crop yields, even if total annual or seasonal rainfall is at or near normal. Food security implications are particularly serious if there is excessive dependence on a single crop, such as maize. Further investigation is needed into the extent and frequency of the phenomenon of mid-seasonal dry spells. With increasing cultivation of marginal lands, a useful climate forecasting

product would be a probability assessment of the likelihood of an erratic rainfall pattern, with the risk of extended dry periods. Are extended dry periods at critical points in the growing season closely linked to below average overall rainfall, or are there other influences on the short-term distribution of rainfall?

- Extremely high rainfall can also reduce crop yields, either through flooding or perhaps reduced solar radiation levels as a result of extended and denser cloud cover. Cloud cover is not regularly monitored in terrestrial meteorology, so this effect can only be confirmed by correlating remote sensing and agronomic data. Excessive rainfall will also disrupt infrastructure and communications, with associated costs.

The emphasis on drought risks is understandable, given the devastating effect of drought. But it has led, for example, to a perhaps over simplified concentration on and interpretation of the impact of El Niño events on Southern Africa's climate, and an assumption that if drought is not in prospect then the agricultural season will be good. It may also be that the water management strategy was so focused on building up capacity to ensure adequate flows in the dry season, that when emergency releases from overfull reservoirs were needed in 2000 these exacerbated downstream flooding in Mozambique.

Households and national food systems are operating within increasingly narrow margins, because of socio-economic pressures – demography, the HIV/AIDS pandemic and economic adjustment. These systems are potentially more fragile and sensitive to erratic intra-seasonal distribution of rainfall, which is difficult to predict.

19. In summary, drought remains the most likely source of food crisis and climate related economic shock. Nevertheless, it is now clearer that the food system, the livelihoods of the poor majority of the largely rural population, and the wider economy are more generally sensitive to any destabilizing climate risks. In these circumstances, the value of well-resourced and well coordinated work to improve our understanding of the evolving weather situation and climate forecasting capacity for the region is clear.

Climatic forecasting

There has been considerable progress towards better integration and strengthening of meteorological systems within the South African Development Community (SADC). SARCOF now provides a formal process for consensus based 'long-lead' or seasonal climatic forecasting. The SARCOF forecasts rely heavily on forecasts from global statistical models, reflecting partly the behaviour of ENSO, with additional details from national meteorological services. They are made seasonally, in September for October to December and for January to March, with the January to March forecast re-assessed in December. SARCOF provides forecasts in three broad probability bands for below normal, near normal and above normal total rainfall for the relevant periods; and forecasts are shown for spatial zones with similar rainfall response.

The precision of SARCOF forecasts is still very limited, with probabilities more difficult to assign for zones further away from the core areas of south-eastern Africa. For example, in the 2001/02 forecasts, the assigned probabilities varied from 20-60%, with around 40-50% probability for the most likely outcome band. The forecasts are difficult to downscale and imprecise about the risks of erratic rainfall patterns that are critical to crop performance. Implicitly the focus of attention has continued to be on the risk of major drought. On the other hand, the greater attention now paid to forecasting and monitoring weather through the season ensures that scientific data on a ten daily basis is more rapidly available to inform assessment and decisions. Global climatic developments are also closely watched and assessments quickly disseminated through the internet. A real problem is that decision-makers would like very clear predictions – this climatic event will lead to this pattern of weather in the coming months – particularly when food security depends on good crop growing conditions. The reality is that the complexity of weather patterns and impacts mean that forecasts often have to reflect a lack of certainty. For example, in early 2002 forecasters identified a high probability of a relatively weak El Niño event towards the end of the year, but

there was great uncertainty about what this might mean for the 2002/03 wet season. In effect, the models are saying that decisions about an already difficult food security situation have to be taken in circumstances of more than usual uncertainty.

It is difficult to place a robust value on climatic forecasting. However, qualitatively, its usefulness is clear. Climatic forecasting work has:

- Provided a scientific consensus process;
- Integrated and strengthened meteorological systems in the region;
- Provided systems for assessing climatic risk that can feed into decision making processes;
- Established systems for closer monitoring and reporting of weather through the year;
- Identified priorities for further research to improve forecasting ability.

The study has not assembled a complete costing for forecasting work. The financial costs attributable to the whole forecasting effort for Southern Africa are around US\$ 5 million, spread across services and research institutions inside and outside the region. These costs are modest compared with the economic costs imposed by climatic variability in the region, which are estimated to be at least US\$ 1 billion a year. Regional climatic forecasting needs to be sustained as a learning process. Long-lead forecasting is still in its infancy, and climatic research is making rapid progress – for example, towards including oceanic influences of the Indian Ocean and South Atlantic into forecasting models. Importantly, the benefits are not confined to the region. The private sector, the international community of donors and financial institutions are all involved in managing the effects of climatic variability.

The ultimate test of the usefulness of information is whether and how it is used and with what results. A survey of potential and actual users of forecasts, undertaken as part of the study, has confirmed the value of forecasts. Foremost, country-specific forecasts can alert international and national agencies and NGOs to the need for precautionary measures to safeguard food security and water supplies, and to reduce the cost of potentially financially destabilizing crisis measures. But the survey also highlighted problems which at present limit the value of forecasts. For example: the spatial scale is often not detailed enough; there is insufficient detail about the distribution of rainfall within the wet season; information about the start and end of the rains is needed; there needs to be sufficient time to respond to forecasts; and users would like more information about the accuracy of past forecasts. Presently only some commercial farmers are able to respond to more specific seasonal forecasts. Smallholders lack the technical options and resources to modify significantly their choice of crop, seed variety or traditional planting practices. The use being made of climatic forecasting is promising, but it still needs considerable institutional strengthening, technical capacity building, more systematic application of current scientific knowledge and investment in data and equipment.

Conclusions and Recommendations

Climatic variability, agriculture and economic performance

Agriculture and the economies of Southern Africa are highly sensitive to climatic variability – The 2002 food crisis has underscored the vulnerability of the region, and especially the rural poor, to food insecurity resulting directly from climate instability and shocks.

The Southern African region's agricultural economy is more sensitive to climatic variability than previously appreciated – The intense impact of droughts between 1981/82 and the mid 1990s led to a too narrow preoccupation with drought rather than the broader problem of climatic variability. Agricultural performance is also sensitive to rainfall 25% or more above average, and to intra-seasonal variations in the distribution of rain. The region is likely to perform best only with annual rainfall within a 90% - 120% band of long term mean total rainfall. High rainfall as well as drought should signal the need for increased concern about regional food security.

El Niño and La Niña are both important influences – Increased risk of an extreme El Niño event should put the region on the alert against a possible drought and related food crisis, particularly in countries near the core of the south east African climatic region. However, El Niño events alone are not a good predictor of agricultural performance. The floods and poorer agricultural year 2000/01 were associated with a La Niña event. Countries to the north of the region are more sensitive to erratic intra-seasonal rainfall distribution than to relatively rare low rainfall or drought years. Climatic variability at country and sub-regional level needs closer monitoring.

Southern African agriculture is becoming more sensitive to climatic shocks - There is evidence of increasing volatility in agricultural indicators such as maize yields and macro-economic performance. Factors contributing to this fragility include:

- Non-sustainable agricultural practice: stagnation in cereal production due to failure to follow cropping patterns that sustain soil nutrient levels and increased fertilizer applications to compensate for the effects of intensified land use and environmental degradation.
- Structural change in agriculture. A shift in production to smallholders has not been accompanied by sufficiently successful attempts to establish a viable credit system, support in providing seeds etc and a supportive marketing structure for smaller producers.
- Institutional weaknesses, which constrain smallholder agriculture and contribute to food insecurity and malnutrition.
- Political instability, which has affected countries in the region.
- Foreign aid has been influenced by political and governance issues as well as directly economic and humanitarian needs. The effects of HIV/AIDS on human resources, which are insidious but so far largely unquantified.
- Climatic change - Although there is as yet no conclusive evidence that the region is becoming drier or suffering more frequent extreme climatic events, both are anticipated as consequences of global climate change.
- A fuller understanding of the environmental and socio-economic consequences of variability is needed in order to isolate the forms of climate change and their implications.

Climatic forecasting

There is an urgent need to reduce vulnerability to climate variability and the threat posed by climate change – Critical to achieving this is improving the information on which decisions at all levels are made, from smallholder to national and international bodies. What has been achieved? What is still to be done? How worthwhile are such efforts? Should climatic forecasting be a priority for international aid and the use of scarce human resources within Southern Africa?

Efforts have continued to improve regional forecasting and provide better frameworks for disseminating information. The costs of forecasting (presently estimated at around US\$ 5 million for long term forecasting for Southern Africa) are modest compared with the very high economic losses caused by climatic variability. Even a small reduction in losses through improvements to public decisions and private risk management justifies investment in strengthening forecasting. There is no doubting the usefulness of forecasting (see paragraph 21). At the same time there is some disappointment about what has been achieved so far. First, because the discovery of El Niño effects created unrealistic expectations about the power and precision of forecasting. Secondly, the full extent of increasing sensitivity of the region's agricultural economy to variability in general rather than just drought had not been appreciated. And thirdly, while users can see the value of forecasting, their ability to respond is often limited.

Increasing the usefulness of climatic forecasting information

Forecasting needs to be focused on climatic variability more broadly. This requires more research, downscaled to zonal levels and intra-seasonal timescales. More specific information on the evolving

weather situation would be of use to specific groups such as water system managers, commercial farmers and the public institutions and NGOs working with small farmers.

Greater agronomic - meteorological collaboration is needed to help national and international institutions make more effective use of forecast information in their decisions, including decisions on food security and agricultural support.

More rapid reporting of variability would help secure more rapid responses to an evolving situation.

More systematic research is needed into the relationship between erratic rainfall, and also very high rainfall and crop performance.

Information and public action

Weaknesses in statistical data – meteorological, agricultural and economic – have hampered this study. These deficiencies have become more serious during an extended period of near budgetary chaos in Malawi and underfunding of statistical and scientific information systems. The HIV/AIDS epidemic may also be eroding the human resources needed for this work. Poor quality information has been an important contributory factor to the 2002 food crisis in Malawi and perhaps more generally in Southern Africa.

Good quality, trustworthy data is a necessary condition for effective natural disaster risk management and all areas of public action. Strengthening and sustaining information systems as a public good in low-income countries has to be an international priority. As soon as there is evidence of an enhanced risk of an extreme event, the international community as well as SADC countries need to use the available information to prepare for aid policy discussions and to develop economic strategies for the countries involved. Experience of the 1991/92 drought led to greater efforts to ensure food security, assess the need for humanitarian aid and prepare for wider economic and financial consequences. However, as the 2002 crisis has again demonstrated, there is much to be done to make better use of climate information in public policy at country, regional and international levels.

Chapter 1.

Introduction

1.1 Context

The extreme region-wide Southern African drought in 1991/92 was followed only two years later by drought in Malawi and Zambia in 1993/94, and then by drought in the countries further south in 1994/95. Both events were associated with the extended and intense global climatic El Niño event of 1991 – 1994. These droughts had severe agricultural and wider social and economic impacts. The concern engendered by these experiences, and awareness of the scientific evidence linking events in Southern Africa to global climatic variability and possibly climatic change, created a widespread disposition in favor of strengthening climatic forecasting, and seeking ways to promote the use of such information to support food security, agricultural and wider resource management throughout the region. It was also envisaged that climatic forecasting and information could be used to assist in increasing resilience to longer-term global climatic change, and the likely associated increase in frequency and severity of extreme events. Recognition of the severity of economic impacts of drought simultaneously raised interest in taking the risks of climatic shocks into account in the management of national economies and in undertaking structural adjustment programs (World Bank 1995a, 1995b; Benson and Clay, 1998).

The predisposition to support the development of climatic forecasting and the increase in the use of its products is reflected in the 1995 Natural Resources Institute (NRI) study on 'Drought management in Southern Africa: investigating the potential of long lead climatic forecasting...' commissioned by the UK's Overseas Development Administration (ODA), now DFID, and the World Bank (Gibberd and others, 1995). This study included an extended review of the status of meteorological institutions, the actual and potential uses of climatic forecasting, focusing particularly on Malawi, South Africa and Zimbabwe. In Malawi it provided evidence for a World Bank study of drought and food security (World Bank, 1996) and then background documentation for the subsequent project component to strengthen long lead time climatic forecasting¹ as part of the World Bank's 1998 Environment Management Project (World Bank, 1997). The NRI study therefore provides a convenient point of reference, or benchmark, for this investigation into the usefulness of climatic forecasting in Southern Africa, focusing on Malawi. The report's conclusions and recommendations reflect the broad consensus position at that time on two issues:

- The importance of drought as an issue for development policy at national and regional levels, and
- Investing in climatic forecasting offered a technical, scientific and so non-contentious way of improving both public and decentralized private economic management of risks.

The main conclusions and recommendations of the study are typical of thinking at that moment, and so find reflection in much subsequent action at a regional and, at least for Malawi, at a country level.²

First, though investigating *climatic variability*, the whole focus of attention is only on drought and abnormally low rainfall events. The study concludes that Southern Africa appears to be becoming more prone to drought. There is implicit in that conclusion a long run forecast or view on climatic change as likely to involve some combination of aridification and more extreme drought events. The focus was on the occurrence of an El Niño, which is associated with drought in the region, and little attention was given to La Niña, which is associated with higher rainfall and more intensive rainfall events.

¹ Long-lead time climatic forecasts are usually taken to mean seasonal, annual and multi-annual forecasts covering large areas in contrast to weather forecasts that cover a period of hours, days and weeks. In this report climatic forecasting is understood to mean seasonal forecasting unless otherwise indicated. See also Box 4.

² Similar conclusions were reached, for example, in the 1996 SADC and NOAA sponsored workshop on reducing climate-related vulnerability in Southern Africa (Stewart and others, 1996).

Second, a reliable indication of the quality of the next wet season is probably the most useful single item of information that could be provided for many governments.

Third, there is an optimistic presumption that ongoing climatic research is much closer than generally appreciated to being able to provide *reliable* and *timely* long time lead seasonal forecasts. However, meteorological institutions in the region lack the capacity to realize the full potential of their global links, and need investment and reform. Furthermore, if "long lead forecasts offer the prospect of *significant benefits*, these would not be fully realized without a number of concurrent developments in the economy."

The study concluded that "relatively modest investment towards improving climatic prediction and strengthening information dissemination and uptake paths could revolutionize drought risk management, enhancing economic responsibility, food security and natural resource management throughout the region." This leads to the strong recommendation that donors should recognize the important potential and seek means to ensure their broad multi-disciplinary implementation for maximum impact.

Subsequent international support for institutional development at a regional level and in Malawi for strengthening the national meteorological system were broadly in accord with these and similar recommendations. The major El Niño event in 1997/98 reinforced concerns about the social and economic consequences of climatic variability and stimulated institutional development and some donor support. These developments are discussed further in Chapter 2.

The range of potential uses and associated benefits to be achieved through strengthening climatic forecasting were conveniently and boldly summarized in the NRI study 'conceptual framework', listing uses, potential applications, the nature of the benefits and key preconditions for success (Gibberd and others 1995, p.3). A fuller version of this tabular framework is set out below in Table 3. The 1995 study and this table provide a useful checklist of issues for investigation at a regional and national level.

First, there is a need to reassess the economic consequences of climatic variability at a regional and country scale in the light of experiences such as the 1997/98 El Niño event. A reassessment for the region is undertaken in Chapter 3 and for Malawi as a country case study in Chapter 4.

Second, it is appropriate to take stock of the current status and progress in climatic research and forecasting as these relate to regional and country scales:

- To review the range of potentially useful products in the light of recent experience;
- To reexamine institutional capacity issues, especially at a national level;
- To reassess the financing issues posed by strengthening climatic forecasting.

All these issues are considered at a regional level in Chapter 5 and again for Malawi as a country case study in Chapter 6.

1.2 Methods of analysis, data and statistical problems

The relationships between climate, especially El Niño, and drought and the economies of Southern Africa were confirmed in the mid-1990s after the 1991/92 drought, and then widely reported and used to underpin the attempt to provide medium term climatic forecasts for the region, as in Gibberd and others (1995). There is a danger that a single large event can have a distorting effect, particularly on the conclusions and policy implications derived from investigations undertaken in the immediate aftermath of the event. This study therefore explores again the relationships between climatic variability, agricultural and wider economic performance in Southern Africa, and in more detail for Malawi as a case study country. It uses evidence up to the late 1990s for the region and Malawi of the relationships that were identified between global climatic processes, notably the El Niño Southern Oscillation (ENSO), climate and drought. This evidence is then used to consider the usefulness or value of medium term climatic forecasting.

This re-examination of the economic consequences includes:

- The relationships between ENSO and climatic variability in the region, known as teleconnections, since the underlying forcing mechanisms are unclear;³
- The effects of climatic variability on cereals and maize production, which the 2002 crisis has shown to still be critical for food security and stability of the rural economies of most countries in the region;
- The impacts of climatic variability on the wider economy;
- Quantification of the direct economic costs resulting from major climatic shocks.

These issues are explored using simple, relatively low cost, transparent methods of analysis. These methods can be readily and easily adopted in economic and financial investigations for developing countries, for example, if required in a crisis situation and include:

- Graphical analysis to identify qualitative relationships;
- Simple and multiple regression to including curve fitting to quantify relationships;
- Conventional project assessment for quantifying the impact of a specific climatic shock.

The analyses are undertaken after a careful review of published and grey documentation and interviews with a selection of key informants in government, private sector and international agencies, as well as other researchers. The use of structured interviews is especially important in eliciting the views of (potential) users on the applications of climatic forecasting (Bohn, forthcoming; Ward 1999).

The first two types of analysis were adopted in the preliminary study for Sub-Saharan Africa (Benson and Clay, 1998) and have been used again in each of the country case studies in this project (Benson and Clay, 2001; 2002). The use of project assessment broadly follows the approach of Mosley, Harrigan and Toye (1991) in investigating the effects of structural adjustment programs.

Initially it was envisaged that the investigation would be largely restricted to a case study for Malawi. But as the research proceeded, it was decided to broaden the investigation to include a larger regional aspect. Factors influencing the decision, as described more fully in Chapters 2 and 4, include the following:

- Medium-term climatic forecasting in Southern Africa is still large scale for zones that may include several countries and is effectively organized at a regional level;
- Malawi is in several respects a special case being at the margin of two distinct climatic zones;
- Malawi's environmental, agricultural and national accounting statistics are, as discussed below, in some respects highly problematical, so that an investigation drawing solely on Malawi evidence might reflect data errors, as well as real phenomena. In this respect, Malawi exemplifies problems that are possibly more general amongst low income countries experiencing considerable financial volatility and severe and continuing constraints on recurrent expenditure, including statistical services. There is a loss of professional capacity because of these constraints, as well as the effects of the HIV/AIDS epidemic affecting Southern Africa (Haacker, 2002). Some might also add that there are the pressures to be seen to succeed, associated with the monitoring of aid-funded development activities;

³ The indices used in this study to reflect the ENSO phenomenon are described in Annex B.

- Food crises are often regional because a climatic shock affects several countries simultaneously (covariance), as can be seen most recently in 2002, and previously in 1991/2, 1994/95 and 1997/98. Food systems are linked through intra-regional trade.

Environmental data

The environmental data used in this report are as follows:

- Three sources of rainfall data for the rainfall analyses: monthly precipitation data provided by the Malawi Department of Meteorological Services (DMS); monthly precipitation time series held by the Climatic Research Unit (CRU) of the University of East Anglia; regional time series from Hulme and others (2001);
- Malawi average lake level data since 1960, provided by the Department of Hydrology, Malawi;
- Eastern equatorial Pacific sea surface temperature (SST) anomalies from the Climate Prediction Center (NOAA, 2002). These data are from the Niño region 3.4 used to assess ENSO events (see Annex B).

As a result of problems with the Bull mini computer, on which the DMS stores its data, and lack of resources, relatively limited historical rainfall data is available. The DMS was able to provide data since 1960 for 45 stations. For some of these sites however records were incomplete. The majority of the station data from CRU are available until the late 1980s. CRU and DMS data were compared to see if any of the stations were the same and had overlapping data. 17 stations from the CRU and DMS were found to be same and the records were merged to provide runs of data from pre-1960 to post-1989 (Map 2).

The rainfall data for individual stations and the other environmental data were assessed to give an indication of their characteristics. In particular, trends were plotted for annual data and, for rainfall, the monthly distribution was analyzed. The rainfall data were also used to create rainfall indices for the Agricultural Development Divisions (ADD) of Malawi. The sea surface temperature data was used to create ENSO indices. Both the lake level data and the various rainfall time series were analyzed for any relationships with the ENSO indices.

Economic and agricultural data

Data taken from the World Bank World Development Indicators and FAO Agrostat databases up to about 1998/99 were used in statistical analyses and assessments of drought impacts and costs at a regional level.

For Malawi the agricultural and macro-economic data since 1972 were also taken from World Bank and FAO data bases. These were updated to 2000/01, using provisional World Bank macro-economic series since 1995 and Government of Malawi agricultural series. Public finance data for the period since 1980/81 are taken from Government of Malawi statistical series as published as the annual economic report (e.g. Government of Malawi, 2001a). Recent public expenditure reviews undertaken by the Government of Malawi (2000a) and the World Bank (2001) only cover the period since 1995. There are inconsistencies between different national income accounting and public finance series that are at least partially explained by problems of determining an appropriate deflator for a constant price series. There was a period of extremely high inflation during 1993-1995. In addition, there was considerable volatility in the economic aggregates, and the public finances display near chaotic behavior during the early 1990s. There were also several major changes in the reporting of the composition of public expenditure. All this occurred over the period in which there were two major climatic shocks, the drought of 1991/92 and the drought of 1993/94, which lingered in the south into 1994/95.

There is a further, possibly more serious, issue concerning agricultural production statistics for the smallholder sector since the early 1990s, when responsibility for statistical reporting was transferred from the government's National Statistical Office to the Ministry of Agriculture, supported by the FEWS NET early warning project. Subsequently, the growth in areas, yields and output of roots and tubers appears to have been systematically overestimated. At the same time the Ministry was implementing a

USAID-funded project for diversification of food staple production from maize to roots and tubers. This practice of overestimation has created serious problems for food security policy by resulting in inflated estimates of food availability in Food Balance Sheet calculations (Devereux, 2002). For example, Malawi is reported as globally one of the top twelve performers in reducing chronic food insecurity between the early and late 1990s in the State of Food Insecurity 2001 (FAO, 2002). The overestimation has also by implication been officially acknowledged, as the government has halved its provisional estimate of cassava and sweet potato production for 2001/02⁴. But the implications are also serious for macro-economic analysis. Smallholder-subsistence food production is a substantial agricultural sub-sector, and the overestimation of sector output also distorts national income accounts. The spatial distribution of poverty that is one of the underpinnings of the national poverty reduction strategy may also have to be reassessed in the light of this serious distortion in the statistics for subsistence food production (Government of Malawi, 2000; 2001b).

All these weaknesses in the available statistical data, for an extended period of economic and political instability since the time of the first drought shock in 1991/92, created a problem in isolating the economic and financial consequences of climatic variability. That problem was felt to justify restricting the analysis to relatively simple broader issues, and then complementing the Malawi study with a parallel regional analysis.

⁴ 'The Ministry of Agriculture and Irrigation revised production estimates in the third round for root and tuber crops downwards: 51% less for cassava, and 61% reduction in sweet potatoes' (WFP, 2002).

Chapter 2

Climatic Variability in Southern Africa and Links to Wider Climatic Processes

Climatic variability is now recognized as a major influence on the performance of the economy and social well-being in Malawi and Southern Africa more widely. Agriculture accounts for 40% of GDP in Malawi. The dependence of the livelihoods of 90% of the population, directly as farmers and through farm employment, and indirectly through agriculture related activities, makes the economy and the welfare of almost everyone sensitive to climatic variability. However, it is argued that economic and social policy has concentrated excessively on the phenomenon of low rainfall or drought. These conceptual and definitional issues are discussed. The nature of climatic variability in Southern Africa, especially Malawi, and the sources of this variability, including links to global climatic processes such as the El Niño phenomenon, are not well understood. Therefore the nature of variability and global linkages are discussed in the light of recent research and events.

21 More than drought

Definitions of drought

The considerable and visible consequence of drought, particularly in 1991/92 following earlier and severe droughts in the region and elsewhere in Africa, led to a focus on drought as the primary climatic hazard issue.⁵ Drought is widely seen as a meteorological phenomenon of extremely or exceptionally low rainfall. However, as an agricultural phenomenon it is an abnormal or exceptional rainfall pattern that impacts on plant growth. That exceptional pattern of rainfall may be more a departure from normal temporal patterns than an absolute reduction in total or cumulative rainfall through the cycle of the agricultural year. A drought also directly affects livestock systems through a reduction in feed and water availability.⁶ Drought can be, therefore, a hydrological event affecting water-dependent activity, most obviously hydroelectric generation and water using processes. There are also the potential effects of reduced water availability on direct human consumption and, potentially, indirectly through health effects of loss of quality of water, on diseases.

After the severe drought of 1991/92 all these effects were widely investigated and are now much better understood. This heightened awareness of drought and the increased importance accorded to drought management up to a national scale, including in macro-economic policy, is seen in the literature. It is also reflected in the focus of institutional arrangements for disaster management. Drought Monitoring Centers were established for East Africa in Nairobi and for Southern Africa in Harare. The issue of climatic variability was understood and interpreted as being in effect a problem of absolutely low rainfall, or of only the lower "tail" of the distribution pattern for annual rainfall. Was this a justifiable simplification of the issue of climatic variability – focusing attention on the key issue - or alternatively, has this led to distortions in analysis and policy?

Intra-seasonal distribution and the effects of erratic rainfall

Crop performance is highly sensitive to total rainfall and the effect that this has on soil moisture availability. However, performance is also sensitive to the intra-seasonal distribution of rainfall and there are examples that show this to be a serious issue, especially where a single rainfed crop, maize, dominates food production. In the 1991/92 drought, Zambia's main maize growing areas were most severely affected by an abnormally extended period without rainfall in February 1992, rather than extremely low total seasonal rainfall (Banda, 1993).

⁵ For example, 'Drought is the principal type of natural disaster in Africa' (Thomson and others, 1998 p1); Harrison and Graham (1998) only attempt to estimate climate forecast value for low rainfall anomalies, and so forth.

⁶ There are also indirect income and price effects on crop production and markets.

The uncertain outcomes of the 2001/02 maize crop in Malawi, and cereal production across Southern Africa more generally, highlight another aspect of climatic variability, erratic rainfall. Agriculturists in Malawi point to considerable sensitivity to intra-seasonal variability, at the scale of around 10 days, as critical to maize performance. Maize is extremely sensitive to moisture stress at the time of flowering, which widely occurs in February. An extended halt in the rains can lead to considerably reduced grain formation. This can seriously reduce maize yields, even if the total seasonal or annual rainfall is normal or near normal, that is, close to mean levels. Such dry spells are possibly more likely in Northern Malawi, which has a bimodal rainfall distribution (discussed below in Section 2.2). The mid-season dry spell can apparently extend further south and west into the main maize-growing areas. The critical importance of rainfall during February in Malawi is also supported by statistical analysis of the relationship between maize yields and rainfall discussed below (Chapter 4).⁷

Agro-climatic investigations into the extent and frequency of this phenomenon of a mid seasonal dry spell are apparently needed. The sensitivity of crop performance to departures from the 'normal rainfall pattern' has serious food security implications where, as in Malawi, there is excessive dependence on a single crop.

Drought and dryness

Drought as an abnormal occurrence is commonly confused with the phenomenon of normally low rainfall or aridity. In semi-arid or arid areas within Southern Africa or elsewhere rainfall may often in, say, two or more years out of five (40% probability) be insufficient to allow successful cultivation of maize, or even less water-demanding millet species. In such environments sustainable farming systems and rural society must adapt to dryness as a normal or highly likely condition.

The impact of extremely high rainfall

The focus on drought and extremely low rainfall may also have distracted attention from any possible negative consequences of extremely high rainfall events and the upper tail of the rainfall distribution. Certainly the literature on climatic variability for the region typically uses linear or log-linear models to explain relationships between crop performance or economic activity and rainfall.⁸ Such models are unable to capture any negative effects of abnormal wet periods. There has been a failure to explore more fully the consequences of extremely high rainfall and possible associated weather phenomena, such as longer periods of denser cloud cover. The omission may partly reflect the greater attention in the literature and policy to drought in semi-arid and arid areas, or countries with a higher proportion of semi-arid lands such as Zimbabwe and Botswana. Another factor may have been the relatively more common occurrence of extremely low rainfall years from the early 1970s to mid 1990s. The non-linear nature of crop water response relationships is, of course, universally understood, but perhaps the potential negative effects of climatic events that include excessively high rainfall are less apparent and less severe than the devastating effects of a drought.

A further consequence of the focus on drought is the attention given to El Niño events. The coincidence of major droughts in 1982/83 and again in 1991/92 and 1994/95 with El Niño events received global attention. The link between drought and El Niño was confirmed by climatological research. This widely recognized link between drought in Southern Africa and El Niño contributed to a highly asymmetrical response to climatic forecasting. For the 1997 El Niño event, for example, the presumption was that Southern Africa should be on the alert against drought. This was the interpretation in the media of a forecast of a higher risk of drought (O'Brien and others, 2000). Other forecasts, for example of average or higher than normal rainfall, are not seen as an indication of a climatic threat to agriculture in the coming season, and perhaps a certain complacency may result (Bohn, forthcoming). Experience since

⁷ February rainfall explains about 50% of the inter-year variance in national maize yields in Malawi. In contrast, regression analysis shows that the total annual and seasonal (November – April) rainfall data have very little explanatory power. In previous investigations Benson and Clay (1998) found that in Zimbabwe February rainfall in the Midlands area around Harare, which accounts for the highest proportion of the national maize crop, had more explanatory power than annual rainfall.

⁸ The author's own previous work provides examples (Benson and Clay, 1998; Benson, 1998). Another example is the widely cited Cane and others (1994) study of the association between Pacific sea surface temperatures (SST) and maize yields in Malawi.

the early 1990s indicates the need for a more complex view of the implications of climatic variability for food security and economic policy more broadly in Southern Africa.

Higher than mean rainfall may be associated with relatively poor agricultural performance. There may be flooding which destroys crops, as in Mozambique in 1999 and again in 2000, and every year in Malawi's lower Shire Valley. But there are other constraints on overall performance that may be associated with extremely high, more continuous rainfall.

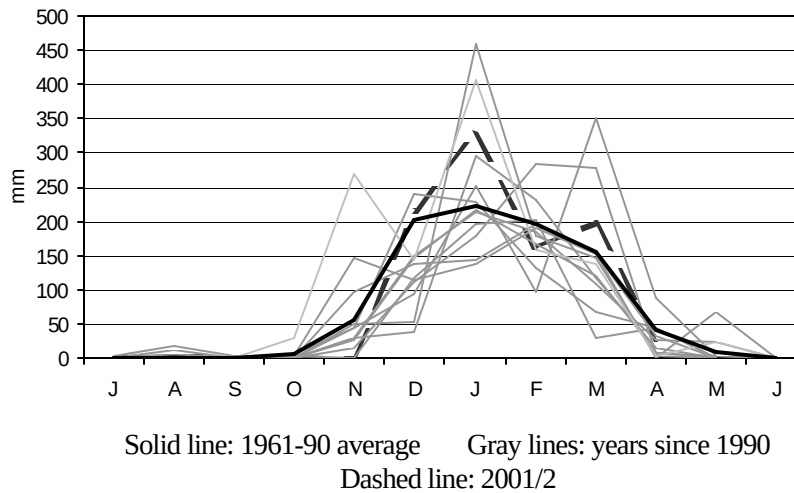
In 2000/01 in Malawi the early rains began as usual, but then persisted without the 'usual' or 'normal' pause (Nkhokwe, 2001). The first rains are called the *Chizimalupya* and are normally followed by a short dry spell before the rains start in full. Early distribution and use of seeds and fertilizer were therefore required. The Targeted Input Program (TIP), or 'Starter-Pack' Scheme had been reduced in scale, and it was also late in providing inputs, because of new problems in targeting only around 50% of households. But the eventuality of early and substantial rainfall was not anticipated. The high rainfall was nevertheless expected to ensure a normal to good crop. This assumption was reflected in early crop assessments. Later in the season there was extended and denser than usual cloud cover, and thus reduced solar radiation levels. Cloud cover reduces photosynthesis and also cuts down on evaporation, thereby contributing to waterlogging. High rainfall is also associated with increased leaching of soil nutrients. All these factors depress grain yields. However, cloud cover is not regularly monitored in terrestrial meteorology, so unless remote sensing can be correlated with agronomic data, this effect cannot be confirmed. This experience suggests that small-scale production systems and the institutions supporting them are closely adapted to usual, that is to relatively favorable conditions. Farmers tend to operate on the assumption of normal conditions (Bohn, forthcoming). Consequently any departure from this normal pattern may lead to a substantial reduction in crop performance as appears to have happened during the 2001/02 wet season (Box 1).

Box 1: The 2001/2002 Wet Season in Malawi

Forecasts for the 2001/02 wet season in Malawi were for near normal conditions. The SARCOF forecast released in September covering October-December 2001 indicated 45% and 40% probability of near normal conditions for northern and southern Malawi respectively. For January to March 2002 probabilities of near normal rainfall for northern Malawi changed to 40% and for southern Malawi 50%. The forecast produced by the National Meteorological Services also indicated that a near normal season could be expected. They did note however that episodes of dry spells associated with a normal wet season were to be expected during the forecast period. The forecast also pointed out that flooding was likely due to heavy siltation in rivers.

The total rainfall for the season was near normal, but despite this many observers have indicated that the weather conditions over the wet season may have been one of the triggers the 2002 food security crisis. This was due to the intra-seasonal variability of the rains. Such variability is characteristic of the rains in Malawi. Figure 2.1 illustrates the variable year to year distribution of the wet seasons in contrast to the average. It also shows that the most recent season was characterized by months of above and below average rainfall. According to the National Meteorological Services the onset was delayed and suppressed in most areas. Both prolonged dry spells and locally heavy rains were experienced, which adversely affected overall crop production.

The successes and weaknesses of the forecasts for the 2001/2002 season highlight many of the issues surrounding forecast application in Malawi. Whilst the forecasts predicted normal rainfall for the season, they did not include information on the distribution of the rainfall, such as the delayed onset and the intra-seasonal dry spells. Thus on the large scale the forecasts were successful but the detailed information, often required by users, was lacking.

Figure 2.1 Seasonal rainfall distribution for Mzimba

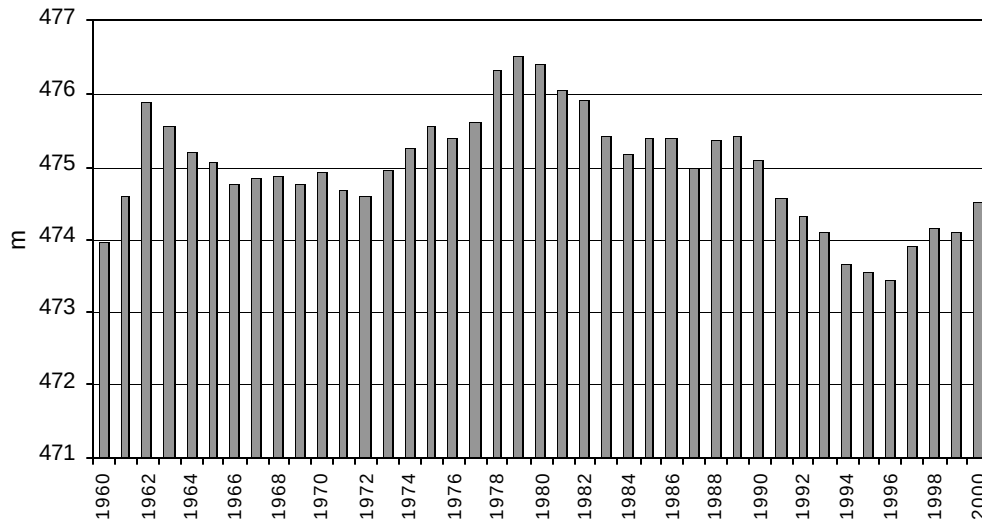
Elsewhere the determination to avoid a potential repetition of 1991/92 disruption may have led to a mini-max water management strategy for Kariba and dams on the Limpopo. Perhaps actions were subsequently geared to minimizing the possibility of inadequate dry season flows and a reduction in power supply. If so this may have contributed to the sudden emergency releases from over-full reservoirs which exacerbated downstream flooding in Mozambique in 2000.

Hydrology too has focused more on drought since 1991/92 when the Lake Kariba system that provides electricity to Zambia and Zimbabwe partially failed. The Shire Valley hydroelectric system, which depends on flow from Lake Malawi, also came close to power restrictions due to insufficient water flow. Systems had been developed following the relatively more favorable sequence of years in the 1960s and 1970s when Lake Malawi reached secular (300-400 year) record levels. In Malawi, thoughts turned to the possible need for massive investment in assuring enhanced water flow (Box 2).

Box 2: Drought and Hydropower: Lake Kariba and Lake Malawi

In 1992 the curtailment of hydroelectric power to Zambia and Zimbabwe from the Kariba Power Station is an important and well documented example of the impact of drought on the non-agricultural sector. The curtailment of electricity supply is estimated to have reduced Zimbabwe's GDP by US\$102 million, cut exports by US\$36 million and caused 3000 job losses. This disruption is attributed to basing water discharge during the 1980s and early 1990s on average intake levels attained during the previous decade, and pressures to minimise short-run costs of power generation. With intake during the 1980s substantially lower than expected, the actual off-take was 16% higher than intake, and power generation capacity was already dangerously exposed at the onset of the 1991/92 drought. Drought mitigation responses have included a more cautious water management of Lake Kariba and other dams. But did this lead for example to precipitate water release on the Limpopo in South Africa and Mozambique, disastrous for downstream areas of Mozambique in early 2000? (Christie and Hanlon, 2001)

Almost 100% of the electricity generated in Malawi comes from hydropower from the outflow of Lake Malawi. Capacity was installed based on designs made in the 1970s and 1980s (see figure 2.2) in a period when Lake Malawi reached a 400 year record level. Subsequently lake levels began to fall. This fact and the droughts in 1991/92 and 1993/94, suggested that Malawi could face a similar threat of economic disruption from a future drought that reduces water level below the critical threshold for maintaining power supplies. Is fresh large investment in assuring hydropower supplies needed? Hydro-climatic investigations are required to assess such risks including the possible consequences of environmental degradation and climatic change on Lake Malawi's outflow.

Figure 2.2 Average Lake Malawi maximum level (m above sea level)

There are also the costs of excessively high rainfall to infrastructure. There is generally increased repair and maintenance. Long periods of intensive rain and flooding expose lack of maintenance and cause major damage. There may also be disruption to communications and high transport costs from flooding and damage to infrastructure.⁹ Overall, the sectoral pattern of losses and distribution of costs are likely to be different from those associated with drought.

Does the focus on drought risk lead to complacency in food systems management, when there is apparently minimal or low risk of a drought? Following the events of 1991–1995 regular seasonal forecasting has been institutionalized at a regional level with down-scaling by national meteorological departments. These activities have been linked to the already established regional and national early warning systems, but are primarily organized around assessing the risk and anticipating the consequences of drought. The seasonal assessment largely focuses on assigning probabilities at a regional scale of rainfall falling within three broad bands or terciles - below normal including drought, normal and above normal.

The regional forecasts are down-scaled to the extent possible to provide national and sub-national zonal forecasts. It is recognized that Malawi, as well as much of Mozambique and Zambia, are on the northern margins of the South East African climatic zone, so these forecasts have typically implied lower risks of abnormally low rainfall events. Within the framework of these regional scale forecasts, if the risk of drought, primarily linked by statistical association with the ENSO phenomena, has been assessed as low, then there is a strong implication of a likely normal to good agricultural season. Then, perhaps, as in Malawi in 2000/01, seeming complacency about an apparently favorable food security situation can contribute to a crisis. Forecasts of normal to high rainfall were seen to imply a good crop. Only retrospectively did it become clear that 2000/01 was a poor year, as initially favorable assessments of maize production early in the growing season, based on favorable planting rains were downgraded in mid-season and post-harvest assessment (Devereux, 2002).

Government and parastatal grain reserve agencies are under severe financial strain from the costs of sustaining high stock levels. Managers and possibly politicians may perceive opportunities for private financial advantage, as well as reducing public budgetary pressures from the disposal of stocks and from limiting fresh purchasing. International financial institutions may also favor or use leverage to

⁹ For example, the loss of a bridge on the Nkhotakota-Salima-Mangochi road caused major disruption to north-south traffic in Malawi in 2001/02 (Map 1).

encourage governments to give higher priority to financial stabilization— reducing stocks (and related costs) and accruing revenue from disposal. This issue is discussed further in Section 6.4 below, in relation to the 2002 food crisis in Malawi.

Population pressure

Under population pressure subsistence and small-scale commercial farmers are also being forced into more high-risk food production strategies. First, there is a contraction in farm size, which makes households more vulnerable to production variability.¹⁰ There has been a reduction in soil fertility, especially in micro-nutrients. There is more extensive cultivation of marginal lands, and increasing settlement of relatively more drought-prone areas.¹¹ At the micro-level lands which are marginal in terms of soils, slope and elevation are being brought into use and more frequently cultivated. Sensitivity to less favorable conditions and what are perceived to be abnormal rainfall patterns may be increasing. In these circumstances a useful climatic forecasting product would be a probability assessment of the likelihood of an erratic rainfall pattern, with the risk of extended dry periods. This poses the question – are extended dry periods at critical points in the growing season closely linked to below average overall rainfall, or are there other influences on the short-term distribution of rainfall? This issue is examined in Section 2.2.

Households and the national food system are operating within increasingly narrow margins, because of socio-economic pressures – demography, the HIV/AIDS pandemic and economic adjustment. These systems are therefore potentially more fragile and sensitive to erratic, intra-seasonal distribution of rainfall, which is difficult to predict. These considerations make the assurance of food security at both household and national levels more difficult.

2.2 Sources of variability and linkages to global climatic phenomena

Southern Africa is a predominately semiarid region with high inter-annual rainfall variability and a pronounced seasonal cycle (Tyson, 1987). The rainy season in Southern Africa generally extends from October or November to April, reaching a peak between December and February. The distribution of rainfall within the six month rainy season is quite variable and depends on the interplay between tropical and mid latitude weather systems, as well as convective variability (Garanganga, 1998; Joubert and Hewitson, 1997).

As well as current climate variability, the region is facing the threat of adverse impacts from future climate change. Climate change is likely to alter short-term climate variability and have a major effect on the hydrological cycle, changing precipitation patterns and river runoff regimes and causing excessive evaporation rates (IPCC, 2001). In particular, increased temperatures and higher evapo-transpiration is likely to result in reduced potential water availability. However the peak of the wet season is likely to increase, although this will be offset by decreases in the drier months. Thus both droughts and floods may become more likely, but there is great uncertainty involved (Hulme and others, 1996a).

El Niño and the southern oscillation (ENSO)

Fluctuations in Southern Africa's seasonal rains are linked to regional sea surface temperatures and the global ENSO phenomenon (Jury, 1999). The swings in rainfall associated with ENSO contribute to a large fraction of the inter-annual variability in the tropics (Bradley and others, 1987). Understanding ENSO and how it affects climate around the globe is a key element to providing an effective means of response to climate related anomalies (Glantz and others, 1997).

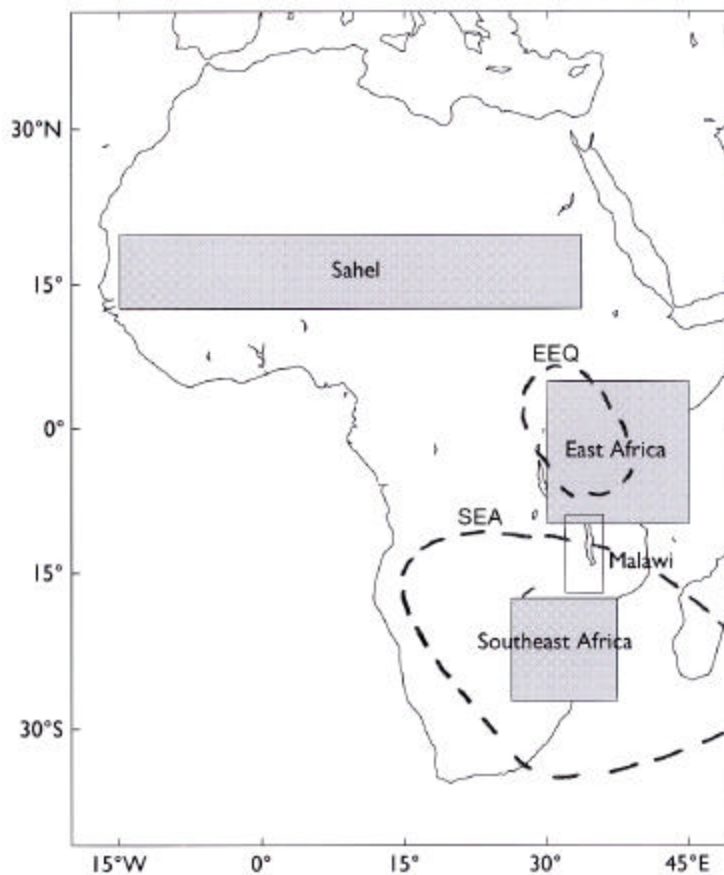
¹⁰ In the mid 1970s 75% of farming households had access to 1.5ha or more. By the late 1990s 75% had access to less than 1ha and in southern districts to under 0.75ha. When a household had 1.3ha, with a maize yield of 1/4t/ha, the average in the late 1970s, they could suffer a 50% reduction in yield because of adverse weather and still have enough to feed an average-sized family for a year. But now, with only 0.6ha and an average yield of 0.9t/ha, a 25-50% reduction in yield spells disaster. This quantitative illustration of increased food insecurity was provided by Stephen Carr.

¹¹ An example is the Ntcheu area in central Malawi that is severely affected in the 2002 food crisis – see Map 1 (Stephen Carr personal communication).

The links between ENSO and regional weather systems are robust and relatively well understood (Jury, 1996). Models can predict ENSO up to a year in advance (Kirtman and others, 2000).¹² Mason (1998) notes that by using ENSO, predictions for southern African rainfall may be made for lead times of up to five months, with a high degree of confidence. Recent studies have highlighted observed links between tropical Pacific Ocean sea surface temperature variability (ENSO) and the prevalent atmospheric circulation over Southern Africa (e.g. Vanheeren and others, 1988; Halpert and Ropelewski, 1992; Allan, 1996; Engelbrecht and Rautenbach 1999). ENSO's influence over Southern African rainfall is strongest in the peak austral summer months (December-March), when the event has reached maturity and the Inter Tropical Convergence Zone is furthest south (Mason, 1996).

Ropelewski and Halpert (1987, 1989) suggested two areas of ENSO related precipitation effects: equatorial eastern Africa (EEQ) and south-eastern Africa (SEA) – see Figure 2.3. In contrast the influence of El Niño on northerly and western areas of the continent is less clear including the highly drought vulnerable Sahel Zone (Hulme and others, 2001).

Figure 2.3 Defined rainfall regions in relation to Malawi.



Shaded boxes: Hulme and others (2001)
Dashed line: Ropelewski and Halpert (1987)
Clear box: Malawi

During El Niño events south-eastern Africa is likely to experience a 50-60mm shift towards drier conditions, with the strongest impact in November to May.¹³ During La Niña, Ropelewski and Halpert's south-eastern Africa (SEA) composite shows above normal precipitation for all of the rainy season

¹² Cane and others (1994) found a correlation coefficient of 0.61 between predicted and observed sea surface temperatures for the period up to and including the 1991/92 drought.

¹³ Research undertaken at the regional Drought Monitoring Center confirms that Southern Africa tends to experience below normal rainfall for March to May during El Niño (Atheru, 1994).

months, except February (Figure 2.3). The equatorial east African zone (EEQ) is, in contrast, likely to experience relatively wetter periods during El Niño events and relatively drier phases associated with La Niña events. Researchers such as Bohn (2000) have indicated that it is the *changes in distribution within* the wet season caused by ENSO rather than the total rainfall amount, which are crucial when impacts on agriculture are considered. Furthermore, the climatic zones do not correspond precisely with geo-political boundaries. So, for example, Malawi is positioned between the two core zones of SEA and EEQ and lies in the transition zone between two different climate regimes to the south and north. (Figure 2.3).

Further research has suggested more complex relationships involving both different types of El Niño patterns and other influences on rainfall within the region. Although the analysis is limited by data availability, ENSO impacts on Southern Africa fall into two types.¹⁴ A Type I pattern is a 'moving event', with the main trajectory of drought conditions moving across the continent from Namibia to Malawi. The 1987 and 1995 El Niño events are included in this category. Type II events do not move so much, with a core area near the borders of southern Zimbabwe, southern Mozambique and north eastern South Africa which grows irregularly throughout the event. Type II events include 1982 and 1991 and tend to be the more severe, possibly due to their stationary nature (Eastman and others, 1996).

Other climatic influences on Southern Africa

Although most of the predictability of equatorial sea surface temperatures is associated with ENSO (Landman and Tennant, 1999), it is important to note that ENSO is not the only factor affecting rainfall in Southern Africa. Other influences include regional sea surface temperatures (SST) and topography (Ropelewski and Halpert, 1989). The oceans surrounding the subcontinent act as an important control on seasonal rainfall in this region (Hulme and others, 1996). Indeed, the occasional break in the association between ENSO and southern African rainfall may be because that subcontinent is also influenced by SST fluctuations in the tropical Indian Ocean (Walker, 1990; Mason and others, 1996). The South African Weather Bureau uses both predictions of equatorial Pacific and Indian Ocean SST to produce its seasonal forecasts (Landman and Tennant, 1999). Although the Indian Ocean is partly responsible for transmitting the ENSO signal, this region can experience warm events independently which can complicate the signal and either enhance or reduce the ENSO effect (Mason, 1996).

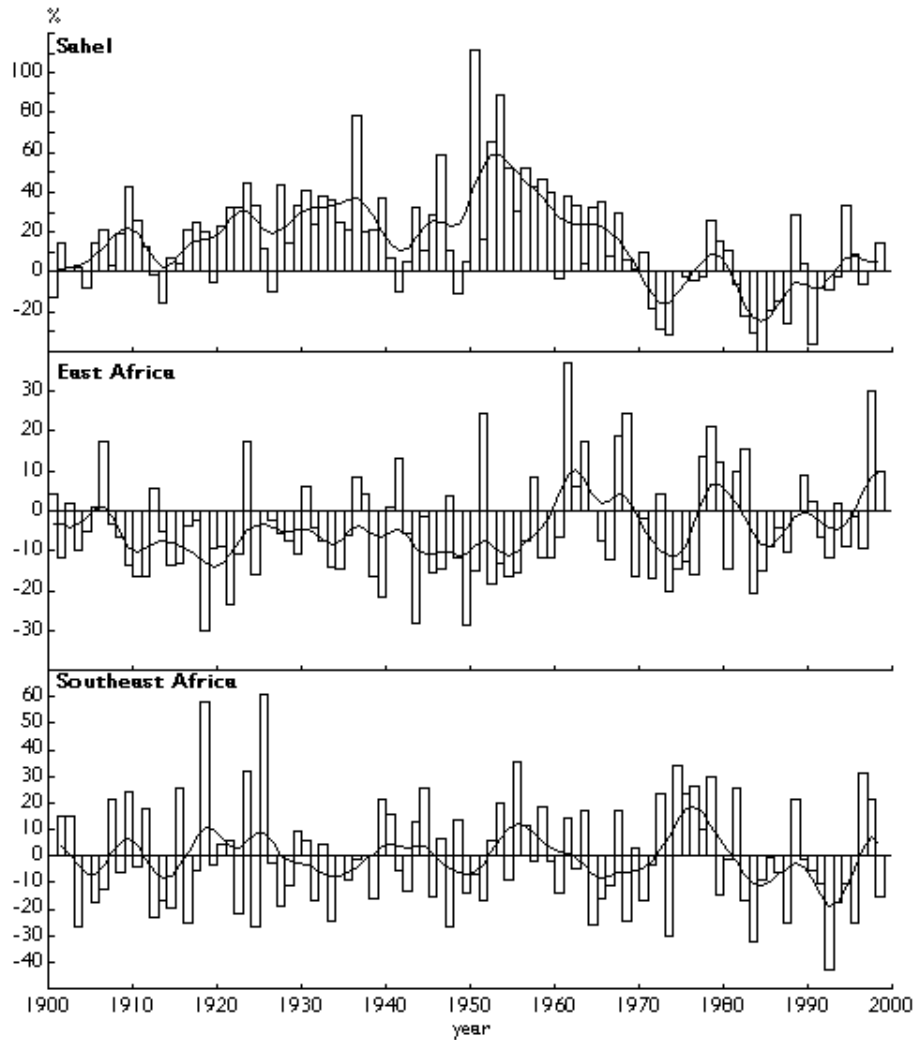
It is not only the Indian Ocean that acts as an influence. The southern Atlantic, for example, may play an important part in shaping the atmospheric circulation (Mason, 1996). Nicholson and Entekabi (1986) suggest that the high persistence of rainfall anomalies over much of Southern Africa, may be due to the influence of Atlantic SST normally only associated with the Sahelian region. Engelbrecht and Rautenbach (1999) also note that the inclusion of extra-tropical SST anomalies into models increases their ability to stimulate anomalous summer rainfall over the region.

Despite advances in forecasting capability Mason has noted that for some areas of Southern Africa the predictability may be decreasing due to changes in the influences of the oceans. For example Landman and Mason (1999) illustrated that the influence of the Indian Ocean on Southern African rainfall has been changing, which will be an inherent problem to virtually any statistical forecasting method.

Longer-term annual rainfall patterns

Hulme and others (2001) show that there are contrasting rainfall characteristics between the major climatic regions shown in Figure 2.3 in terms of annual rainfall. The Sahel has experienced patterns of variability and drying that extend over many decades (Figure 2.4). East Africa appears to be relatively stable with some evidence of long term increase in precipitation. In south-east Africa there is a stable regime with marked interdecadal variability (i.e. of around ten years) – the quasi cycles identified by Tyson (1987). The pattern of interdecadal variability is similar in recent decades for east and south-east Africa. However, the timing of the negative (drier) periods in the 1980s and 1990s is not the same. Only rainfall in the Sahel displays a significant trend, which is negative and the result of drying in recent decades (Nicholson and Palao, 1993).

¹⁴ Researchers at Clark Laboratories (Eastman and others, 1996) used a satellite-derived vegetation index to map the spatial characteristics of ENSO events over Africa.

Figure 2.4 Regional rainfall trends

Annual total rainfall expressed as anomalies that is deviation from 1961-90 mean. The filtered curve shows variations on timescales greater than 10 years from Hulme and others. (2001)

When these regional time series for annual rainfall are correlated with ENSO SST indices, the signal is strongest for Southeast Africa. The correlations between the SST in January, February, March and April with the Southeast African rainfall index (SEARI) are all significant at the 0.01 level. The correlation is *negative* and the strongest signal with March ENSO indicators ($r = 0.46$) provide some degree of predictability. This relationship highlights the need for forecasts to incorporate ENSO information, but also indicates that other predictors are necessary to account for the unexplained variability in rainfall in this region. East Africa experiences *significant positive* correlations between October, November and December SST and annual rainfall at the 0.05 confidence level. Thus positive SST anomalies (El Niño) are associated with positive rainfall anomalies.

Both the clear relationship between El Niño and rainfall and the complexities caused by other influences are apparent in Figure 2.5. This chart shows the annual rainfall index for Southeast Africa (SEARI) and also a rainfall index for Malawi, as well as major El Niño events since 1970. The five driest years, in which the SEARI fell below 80% of the long run 1961-90 mean rainfall – (1972/3, 1982/3, 1986/7, 1991/2 and 1994/5) were all El Niño years. However, in 1997/8 there was a less extreme rainfall anomaly and the 1976/7 El Niño event, which occurred within a relatively wetter period, had reduced but above average rainfall.

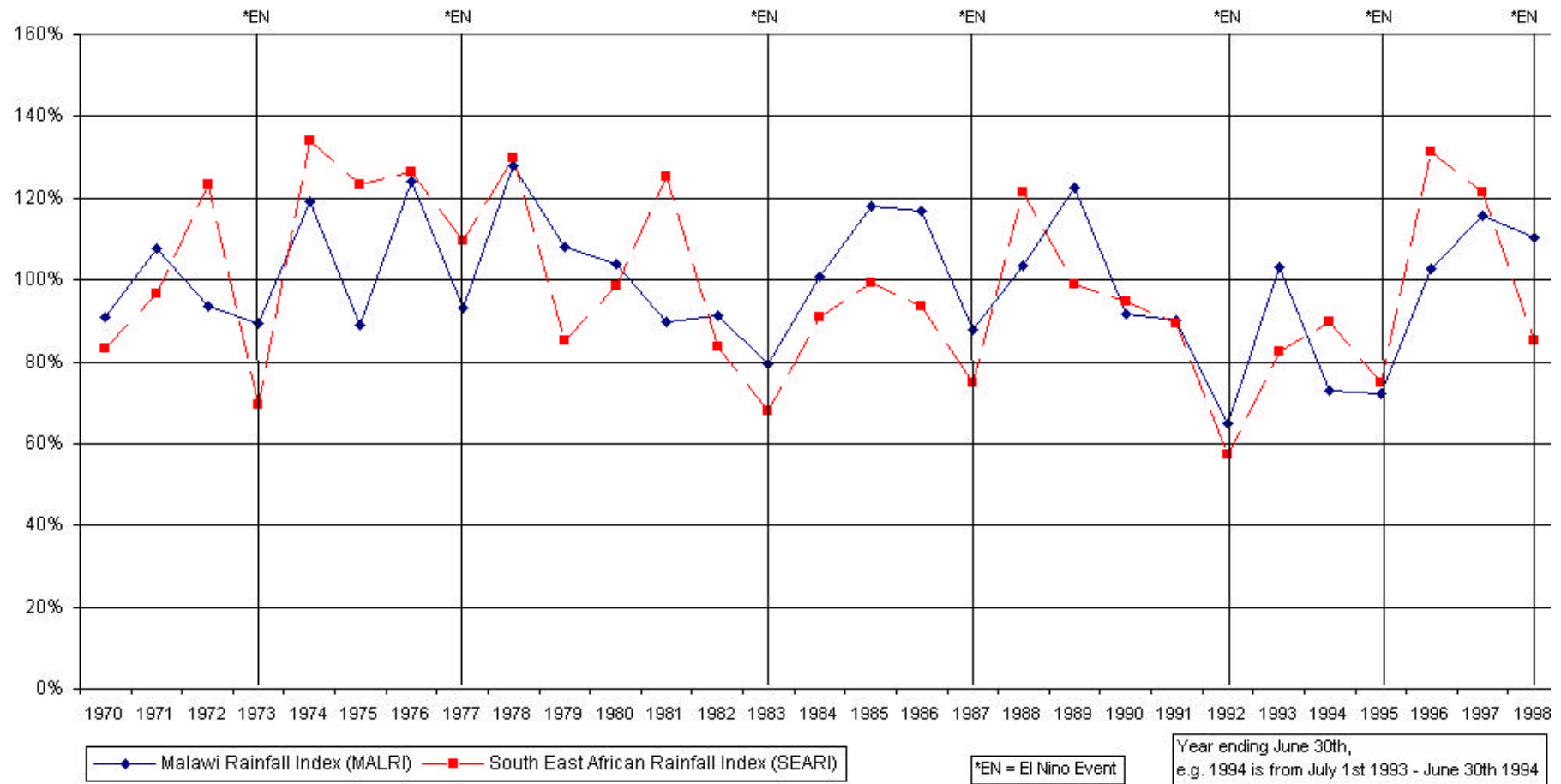
The transitional position of Malawi is also indicated by the less-close relationship between El Niño and drier years. 1980-1983 was a relatively drier period and, as discussed further below, drought came in 1994 before the regional drought in 1995, whilst in 1997/8 there was no drought because of other influences. Malawi's location between these two core regions, with their differences in ENSO - rainfall associations, indicates the difficulties facing climate forecasting in Malawi (see below Chapter 6).

23 Issues for further investigation

Drought remains the most likely source of food crisis and a severe climatically induced economic shock. Nevertheless, it is now clearer that the food system, the livelihoods of the poor majority of largely rural people and the wider economy are more generally sensitive to any climatic variability. The rural economy is perhaps more delicately balanced, more fragile than previously. Its stability is threatened by climatic variability and any widespread departure from an increasing narrow band of normal, that is favorable, rainy season growing conditions. The relationships between climatic variability, agriculture and wider economic performance need to be re-examined, focusing not only on drought, but on climate extremes in general.

There is an important role for climatic forecasting in Southern Africa more generally and specifically in Malawi, because of considerable climatic variability. However, the brief review of the sources of climatic variability has also shown that there are complex relationships that go beyond the influence of El Niño as a forcing mechanism behind drought. So that in reviewing in a realistic way the potential and actual roles of climatic forecasting, these complexities need to be taken into account (see Chapters 5 and 6).

Fig. 2.5 Rainfall Indexes for South East Africa and Malawi and El Nino Events, 1970 - 1998



Climatic Variability, Agriculture and Economic Performance in Southern Africa

This chapter includes a regional analysis of evidence of the relationship between climatic variability and cereal and maize production. Maize is the major food staple and is largely grown in rainfed conditions during the austral summer rainy season. There is widespread concern that the impacts of climatic variability on food security and wider economic performance at a country level is worsened by a high degree of co-variance in annual production levels across the region. The strong teleconnections between global El Niño events, rainfall variability and extreme drought events in particular has also been recognized at a regional level (Chapter 2). These relationships between the El Niño Southern Oscillation (ENSO) phenomenon, rainfall variability and cereal production are all explored statistically at a regional level, using quantitative and graphical analysis. This exploration of relationships is then complemented by an estimation of the apparent cost of major drought events in terms of maize production losses, using commonly adopted evaluation or assessment methods.

3.1 Reassessing the impacts of drought on cereal production

The drought in 1991/92 demonstrated beyond dispute the serious impacts that climatic variability can have on the economies and societies of the Southern African region. There were subsequently many reported estimates of these impacts, often taken from assessments made during the drought, or the period of recovery. Since then there have been two more widespread drought events. There was a rapid onset of drought in 1993/94 in the more northerly countries, especially Malawi, Mozambique and Zambia, and this drought subsequently more severely impacted South Africa, Zimbabwe and other more southerly countries in 1994/95. That event heightened awareness and led to initiatives to strengthen forecasting and drought preparedness. There was a less severe drought in 1997/98. All three droughts were associated with El Niño events or warmer phases of the Pacific Southern Oscillation (Bohn, 2002). Then in 1999/2000 and 2000/01 the disastrous floods, affecting especially Mozambique, drew attention to the possibly negative socio-economic consequences of extremely high rainfall. In the light of these experiences and the reassessment of the issues of drought and wider climatic variability in Chapter 2, it was considered appropriate to re-examine the relationships between climatic variability and economic performance. The methods of assessment adopted are those used in the previous preliminary examination of drought and economic performance (Benson and Clay, 1998). The analysis is conducted at a regional and country level and is based on data up to and including the most recent El Niño event of 1997/98.

Climatic regions

The analysis has been restricted to a region including nine countries – Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe – which are climatically all largely within the south east Africa rainfall zone, dominated by a single peaked austral summer rainy season. Northern Malawi and probably north Mozambique, for which there has been apparently little reported research due to conflict, are at the limit of this zone, displaying a bimodal rainfall pattern, with a definite gap in the rainy season, more similar to Tanzania and Uganda in East Africa.

Southern African countries have established regional institutions, which extend northwards to include the Democratic Republic of Congo, Tanzania and the island states of Mauritius and Seychelles, but not Comoros or Madagascar. These northern SADC states are excluded from the analysis because they fall

outside the south-east Africa rainfall zone. Angola is also excluded because conflict has so severely affected the economy and limited the collection of climatic or agricultural statistics.¹⁵

ENSO and regional rainfall patterns

Climatologists have demonstrated that there is a highly significant relationship between the ENSO phenomenon and inter-annual variations in rainfall in Southern Africa (Chapter 2).¹⁶ However, it is notable that there is not a simple canonical relationship – not every El Niño event is necessarily associated with extremely low annual rainfall, and some years with low rainfall are not clearly and directly associated with El Niño events. There are other forcing mechanisms influencing rainfall patterns in particular, as is now more widely recognized, the less well understood oceanic-atmospheric interactions in both the Indian Ocean south of Madagascar and the Southern Atlantic. Indeed the limitations to forecasting production are being recognized. These issues are discussed further in the background paper by Bohn (2002).

3.2 Rainfall, ENSO and cereal production

Production of cereals, and especially maize as the main food staple for the majority of rural and lower income urban households, is central to food security in Southern Africa. The rural poor in countries such as Malawi, Zambia and Zimbabwe depend heavily for their food security on maize cultivation for own consumption and as well as their capacity to acquire food through markets. Maize dominates agricultural production in some economies. Furthermore, most production and nearly all smallholder cultivation is rainfed and grown during the southern (austral) summer rainy season between October and March. Maize is therefore highly sensitive to drought and, as the analysis presented below indicates, to climatic variability more generally. This has major poverty and food security implications: climatic variability is likely to impact more adversely on the poorest in the population.

There is substantial intra-regional trade, largely involving exports from South Africa and, until recently, Zimbabwe, with occasional surpluses, for example in Malawi. Trade in maize overland involves high transport costs and logistical problems. These were respectively increased and intensified because of conflict in Mozambique, and so there is a large gap between export parity and import parity prices of the landlocked countries such as Malawi and Zambia. A further trade issue is the strong consumer preference for white maize, grown regionally, over the yellow maize typically exported by the US and France. This preference is reflected in a substantial premium in white maize prices and the pattern of imports. Because of the central importance of maize and the priority to assure supplies and avoid price hikes that jeopardize access by poorer consumers and threaten political stability, maize has historically been closely managed through national parastatal marketing boards such as ADMARC in Malawi. However, the role of these bodies has been modified and in some cases considerably reduced in the process of market liberalization during the 1990s.

In a crisis, as the events of 2002 have reconfirmed, assuring the supply of maize is likely to take priority over other trade considerations and in public spending decisions. For all the above reasons international involvement in crisis management in the region has also tended to focus on maize, including the financing of imports. So, for example, in assessing the balance of payments implications of the droughts in 1991/92 the IMF focused on what it saw as the core problem of financing maize imports. There are, therefore, well-grounded arguments for focusing in the first instance on cereals and maize in looking at the implications of climatic variability for the economies of Southern Africa.

¹⁵ Preliminary statistical investigations also indicated that Angola was not strongly influenced by climatic events affecting the rest of southern Africa.

¹⁶ This relationship is clearly shown if discrete El Niño events are superimposed in a chart of the rainfall index for south-east Africa (SEARI), constructed and developed at CRU by Mike Hulme and others (Figure 2.3). There is also a significant correlation between rainfall and the El Niño Southern Oscillation phenomenon, based on sea surface temperatures (SST) represented as a continuous index.

The widely assumed relationship between El Niño and drought is apparent when cereal and maize production are plotted and discrete El Niño events are superimposed (represented by vertical lines) in Figure 3.1.

There is little apparent long term trend in regional production. Recognizing that cereal and maize production will be affected by other factors, such as changes in planted area, new technologies and inputs, the relationship between the considerable volatility in production and climatic events is striking. There was a sharp decline in 1972/73, but this event is not considered further, being at the limit of the period for which there is comparable statistical data across the region. The association is clearest for the major droughts of 1982/83, 1991/92 and 1994/95. There is also a less pronounced apparent link between events and reduced production in 1986/87 and 1997/98 at a regional level, although at a national level there were significant decreases in some of the countries in these years.

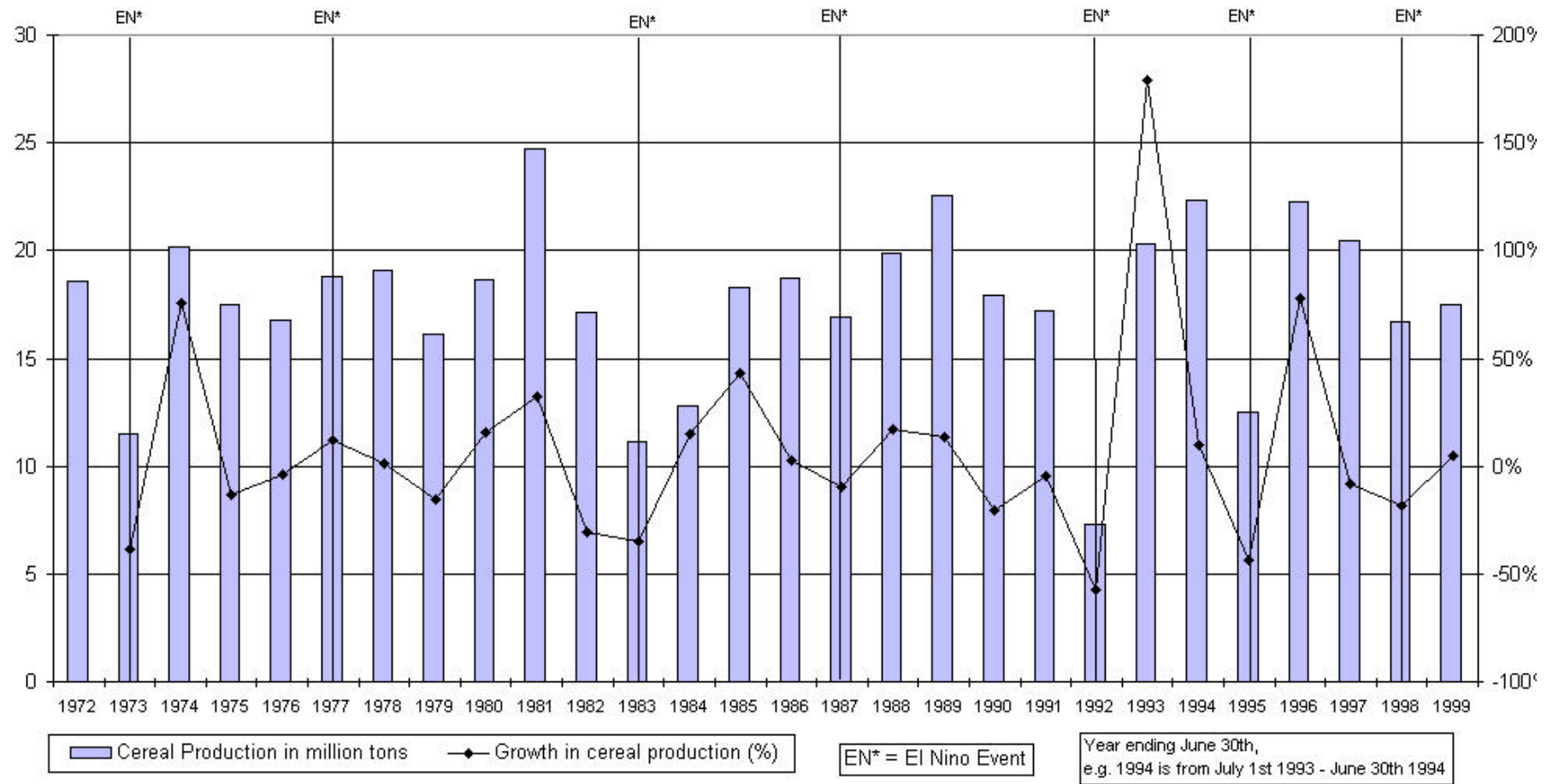
A closer inspection of the time series for cereal and maize output (Figure 3.1) also shows a somewhat more complex pattern than that of drought being caused by El Niño, and this is confirmed by country level information. For example, there was low rainfall and an onset of drought in parts of the region in 1990/91 (Lesotho and Zimbabwe) before the drought of 1991/2 and also in 1993/94 (Zambia, Malawi and Mozambique) before the ENSO-linked drought in 1994/95. These different sequences in drought impacts at a country level are reflected in year to year changes in maize yields and agricultural GDP (Appendix A Table 3.1).

The very strong 1997/98 event is especially worth noting. In South America and South East Asia there were widespread losses from extreme weather (Van Aalst and others, 1999; Vosti, 1999). In contrast, there is now a quite widespread perception in Southern Africa, encountered during this study, that there was no widespread drought in 1997/98. Consequently, by pointing to a high risk of drought in 1997, the climatologists and others who drew attention to the possible effects of an El Niño event were thought to have been crying wolf. In fact, there was regionally a relatively poor maize crop, some 2.5–3.0 million tonnes below normal, as is confirmed in the analysis of drought impacts below (Table 1). However, rainfall associated with oceanic activity in the Indian Ocean resulted in more favorable conditions in northern and central zones, including Malawi and Mozambique, than had initially been anticipated by climatologists relying on El Niño based statistical models.

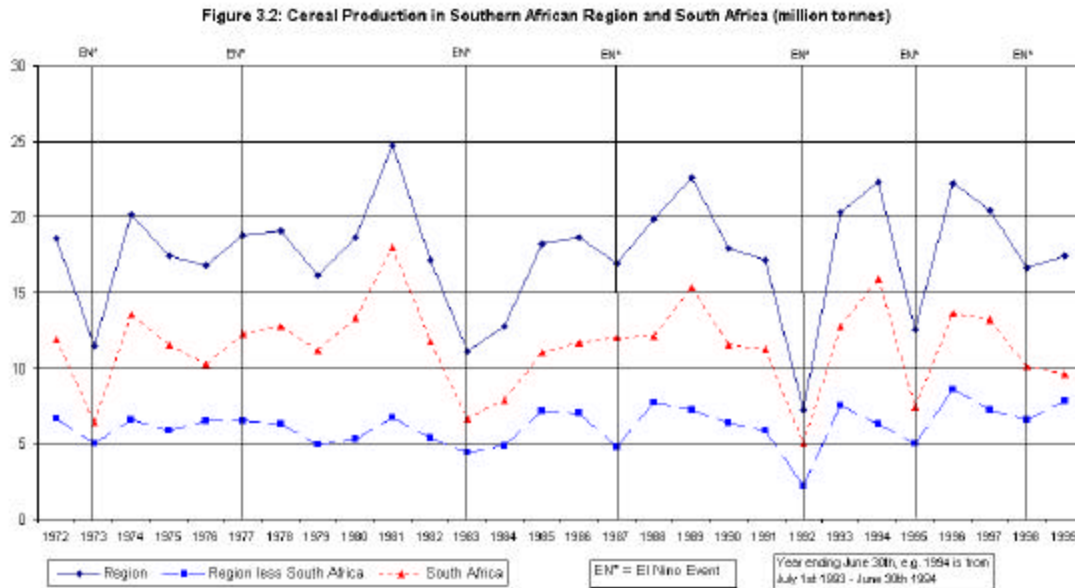
The quantification by regression analysis of the relationship between production variability, annual rainfall and ENSO confirms the graphical analysis, and also supports an intuitively plausible set of relationships (Annex A Table 3.2). There is a statistically significant association between maize (and cereals) production and ENSO, measured as a series of discrete events (shocks), or as a continuous index. Nevertheless, there is a closer statistical relationship at a regional level between total rainfall and production.¹⁷ This is to be expected because there are other influences besides ENSO teleconnections on rainfall variability in Southern Africa. This finding is important because of a widely cited study for Zimbabwe, suggesting the contrary – that the El Niño SST is a better explanatory variable than rainfall in analyzing maize yield variations (Cane and others, 1994).

¹⁷ This hierarchy of explanatory power is further confirmed in looking at country level production and yield data. At a country level country-specific rather than regional rainfall indices provide a higher level of explanation, especially in moving towards the periphery, as in Malawi (See below).

Figure 3.1: Southern Africa (exc. Angola and Tanzania), cereal production, 1972 - 1999 (in million tonnes)



The relationship between annual rainfall and aggregate output is obviously a considerable simplification of the influences that determine crop performance. Focusing on yields, the distribution of rainfall within the season from the onset of the rains and, as experience in 2001/02 has highlighted, possible dry periods at critical points in the growing cycle may have a negative effect. Nevertheless, as further statistical exploration shows, focusing on rainfall and output and rainfall and yield relationships provides a better understanding of the consequences of climatic variability rather than El Niño, in terms of what has happened and may happen, and the implications for food security and economic policy. There are also other influences on production that determine profitability, such as international grain prices, input prices and availability, and more country specific factors.¹⁸



The covariance issue

Climatic variables are significant determinants of aggregate cereal and maize production at a regional level. However, production is driven by South Africa, which is by far the largest agricultural producer, accounting for 64% of cereals and 62% of maize production in the region during 1993–1998. However, production in South Africa and production in the rest of the region are closely correlated, mostly moving in the same direction during almost three decades since 1972, with only occasional divergent movements, notably in the late 1980s (Figure 3.2).¹⁹ The food security problem of covariance would be amplified if there were a significant risk that one poor year would follow another. But, as climatologists have demonstrated, there is no significant level of autocorrelation within annual rainfall patterns for the region. Statistical analysis for Southern Africa also shows neither significant autocorrelation between cereal production in subsequent years or a lagged relationship between production and rainfall in a previous year. In contrast, in the Sahel there is a well established pattern of prolonged periods of drought (1971-74, 1982-84) and of more favorable rainfall (1950s and since the late 1980s).

¹⁸ The possible sensitivity of production to international market conditions was tested using lagged US export prices for maize and wheat, without establishing any significant relationship. This is possibly because for most of the period under study internal marketing controls insulated domestic producers from international conditions. Total use of fertilizers in various forms was also tested, but it proved insignificant at this level of aggregation.

¹⁹ The correlation coefficients between production in South Africa and the rest of the region are 0.61 for cereals and 0.60 for maize. The degree of explanation provided by rainfall and ENSO variables is also similar for South Africa and the rest of the region, underlining the food security issue posed by highly covariant production movements.

There is evidence of a different, but still potentially difficult to manage quasi-cyclical rainfall pattern in Southern Africa. The region has experienced periods of around a decade of relatively higher rainfall and, as between 1982 and the mid 1990s, lower rainfall (Hulme and others, 2001).

At a regional level, the absence of an upwards trend in cereals and maize production since the early 1980s may partly reflect the impact of relatively drier conditions that is counteracting the effect of any yield increasing technical changes and more intensive input use.²⁰ The possible effect that cyclical patterns in rainfall might have on investment and management of water systems was highlighted by Benson and Clay (1998) and is discussed further for Malawi in Box 2.

Climatic extremes and cereal production

The problem of climatic variability is commonly simplified into an issue of drought, the consequence of extremely low rainfall. The recent disastrous floods in Mozambique and the events leading to a food crisis in Malawi in 2002 have drawn attention to the possible negative impacts of extremely high rainfall and other associated climatic phenomena, such as leaching of nutrients and denser and more extended cloud cover reducing solar radiation, which restrict plant growth. Partly to indicate the possible avenues for further investigations, the form of the relationship between rainfall and cereal production was explored a little more fully. There is a universally recognized non-linear parabolic relationship between plant growth (an inverted U) and available moisture, since moisture stress and excessive watering both inhibit growth. Both charting production against annual rainfall and a complementary regression analysis suggest that this relationship is reflected in national yield and output and regional output of cereals and more specifically maize.

Figure 3.3 is a scatogram for aggregate regional cereal output, plotted against the south east African rainfall index (SEARI): the implied relationship is non-linear. Recalling the absence of a significant time trend, annual production levels appear to peak at close to the mean rainfall level for 1961 – 1990. Curve fitting suggests that cereals and maize output plateau at approximately 15% above 1960 – 1990 mean rainfall levels, and that above that level there is increasing probability of reduced production. Non-linear, in particular parabolic relationships give an impressively close fit, better than other functional forms,²¹ accounting for around 60% of inter-year variance in maize and cereal production (Annex A Table 3.2). Recognizing other factors that are influencing production, this is a high degree of explanation at a regional level.

²⁰ Some agronomists suggest that higher applications of fertilizer are barely compensating for reduced fertility associated with more intensive land use by smallholders on plots of shrinking size.

²¹ The functional forms fitted are described in the notes to Tables 3.2 and 4.1

Figure 3.3: Southern Africa Cereal Production/ Rainfall Scatter

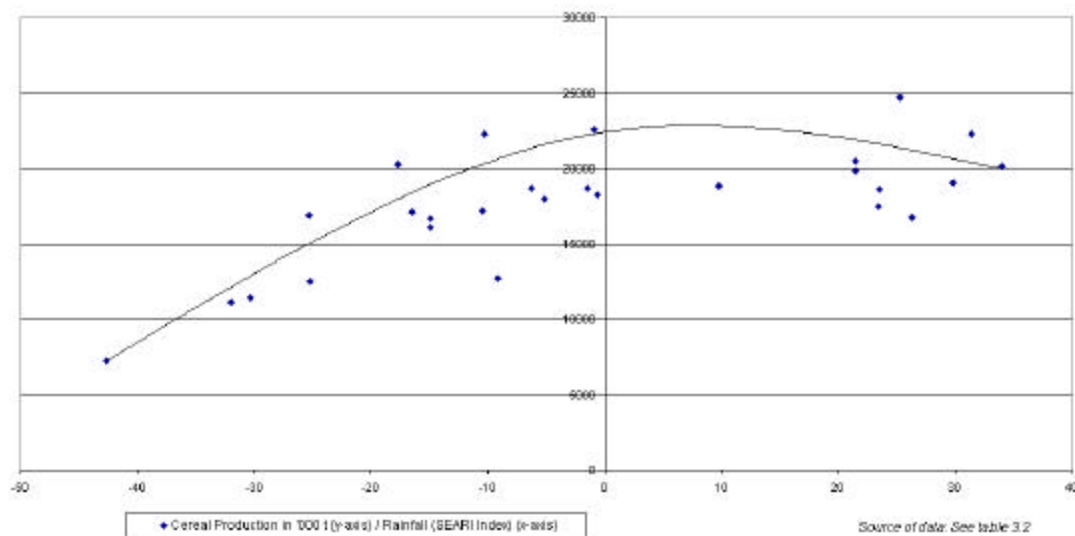
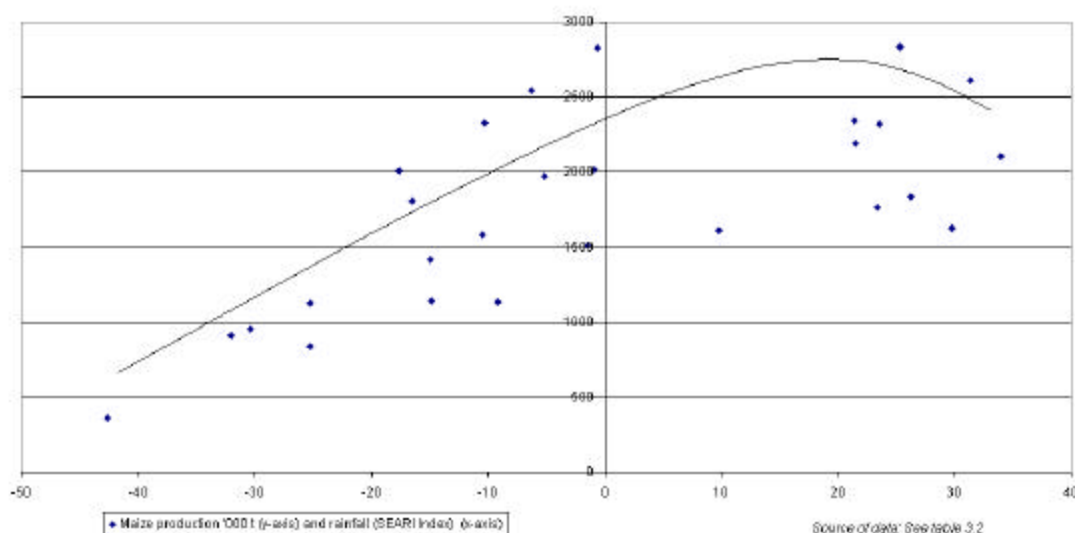


Figure 3.4: Zimbabwe - Maize Production / Rainfall Scatter



To confirm the robustness of this apparent non-linear relationship, similar graphical and regression analyses were undertaken for maize production and maize yields in Zimbabwe and Malawi. The analysis uses appropriate rainfall indices for these countries, SEARI for Zimbabwe and, after confirming the low explanatory power of the regional index for Malawi, a specially constructed national index, weighted to reflect the distribution of maize plantings.

Zimbabwe was selected because of relatively good data up to 1997/98, prior to the recent politically induced disruption to the agricultural sector, and because it is at the center of the zone whose weather patterns are reflected in the south east African rainfall index. The statistical results for both aggregate maize production and maize yields (the ratio of total production and land area) are very similar to those for the region dominated by production in South Africa (Figure 3.4).

For Malawi, the consequences of climatic variability for agriculture and the wider economy are considered in more detail below (Chapter 4). But it is informative to examine the maize-rainfall relationship for this still

strongly subsistence economy, in which maize is the dominant crop. Confirming that Malawi is at the northern margin of the south east African climatic region, no significant relationships were found between aggregate maize production or yield and either the regional rainfall index (SEARI) or ENSO variables (Annex A Tables 3.1 and 4.1). Drought seriously affected maize production in 1994 and not in 1995, and again 1997 was a poor year rather than 1998. Looking instead at links between rainfall patterns within country and maize yields, again, after much statistical exploration a non-linear relationship was found to exist, but for the critical month of February in a country-specific weighted index, rather than the total annual rainfall (Figure 4.3 and Table 4.1).²²

There are several interesting implications of this finding for the region confirmed in two country analyses about the non-linear form of the rainfall-production relationship. First, overall regional production appears to be quite well adapted to the expected annual rainfall, which is in fact around 5% above the 1961-1990 average.²³ Second, although rainfall in the upper tail of the distribution as experienced in the last 30 years is unlikely to have a severe regional negative impact, nevertheless, the intra-regional spatial distribution of production may cause problems. There are some areas in which production may be constrained by drought stress in a low to average year. There are also likely to be other areas where the combination of climatic conditions associated with abnormally high rainfall may depress output substantially. These findings suggest that climatic forecasting and Early Warning Systems need, as discussed further in Chapters 5 and 6, to give more attention to the potentially extremely high rainfall events.

The non-linear form of the relationship between rainfall and cereal production and yields also helps to explain why Benson and Clay, in investigating the wider economic consequences of drought, found that maize yields, rather than national rainfall or ENSO climatic variables, were more useful indicators of climatic variability (Benson, 1998; Benson and Clay, 1998). After again exploring the relationship between rainfall and climatic indicator variables and maize yields the latter are used to update the quantitative analysis of the impacts of drought on Southern African economies.

3.3 Country-level economic impacts of climatic variability

After demonstrating the significant impacts that climatic variability has on cereal production in Southern Africa, it is appropriate to explore the wider economic consequences of variability, particularly drought shocks, at a country level. As Benson and Clay (1998) and others have indicated, the effects of these shocks are likely to be differentiated in form and severity depending on differences in economic structure and the immediate wider economic situation (Box 3).

In exploring these wider consequences of climatic variability, Benson (1998) suggests three relatively simple approaches:

- to examine qualitatively with charts the association between the behavior of economic or other aggregates and discrete variables to reflect extreme natural events such as El Niño episodes;
- to measure these relationships quantitatively by estimating the explanatory power of these same discrete events as dummy variables;

²² In Malawi, as agriculturalists suggested, the intra-seasonal distribution of rainfall and its erratic pattern, rather than cumulative rainfall during the main growing season is more critical for maize production. Personal communications from Stephen Carr, Harry Potter and Elizabeth Minofu Sibale.

²³ The mean annual rainfall in Southeast Africa since 1900 is approximately 5% above the 1960-90 average that includes two decades of relatively drier conditions (Hulme and others, 2001). Maximum cereal and maize production are implied at rainfall levels about 10-15% above the 1961-90 average level according to the non linear equations in Tables 3.2 and 4.1. The elasticity of production with respect to total rainfall is low with the range 90% -120% of the 1961-90 average rainfall levels.

- to measure relationships for climatic variability, using proxy variables such as cereals or maize yields to reflect the effects of weather on agriculture.

Cereal and maize yields

To understand the consequences of employing these potentially complementary approaches, the relationships were examined between cereal and maize yields at country level and climatic variables. These variables included those already considered, the categorical variable of El Niño events, SST and SEARI and, in addition, a variable based on the country specific list of extreme drought events, contained in the World Bank Development Indicators 2000 (World Bank, 2000).

At a country level the ENSO variable had limited explanatory power, but importantly more so in South Africa and Zimbabwe (Blanco de Armas and Clay, 2002). For other countries in the region, even when there was a statistically significant relationship, this lacked explanatory power (a low r^2). The World Bank Drought variable, which is country specific, explained more of the variability in cereal and maize yields for more countries, but still did not prove very useful.

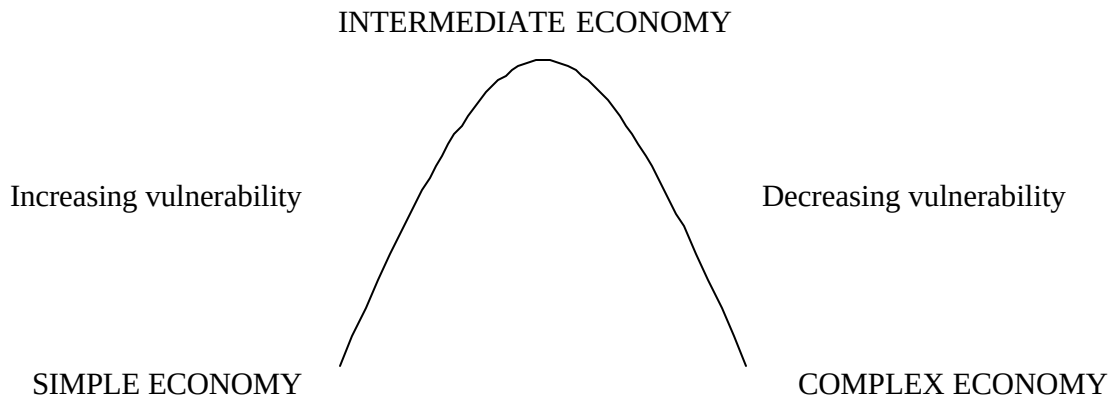
In the light of the findings of the regional analysis for cereal and maize production these results are unsurprising for a number of reasons. First, the rainfall-maize yield relationships are non-linear, and the ENSO variable influences only one tail of the distribution – low rainfall. Second, the 'climatic signal' is also apparently weaker as one moves away from the Transvaal – Zimbabwe heart of South East African climatic zone. Third, the World Bank drought variable reflects an assessment of events in individual countries. There are also other confounding factors such as conflict up to the early 1990s in Mozambique and, throughout the study period, in Angola. Further exploration of these climatic-crop performance relationships would need to be down-scaled to intra-country zonal level, if rainfall and reliable crop production statistics were available.

Climate and national economic aggregates

The wider, macro-economic significance of climatic variability, especially extreme drought events, which impact as an economic shock, is broadly confirmed by the two forms of complementary analyses, the charting of macro-economic aggregates (GDP, Agricultural and Non-Agricultural Sector Product) on to which events are superimposed, and regression analysis, in which maize yields are used as an explanatory variable as a proxy for climatic variability. These analyses also broadly support the importance of differences in economic structure and the "inverted U" hypothesis of Benson and Clay (1998) about the interacting roles of economic structure and development on vulnerability to climatic shocks (Box 3).

Box 3: Economic Development Increases Vulnerability to Climatic Shocks

The economic development of a country may actually increase its macro-economic vulnerability to climatic shock. The intuitively plausible linear relationship is that vulnerability decreases as an economy diversifies away from dominance of the agricultural sector. Instead it is hypothesized that the impact of a shock such as drought or extremely high rainfall and associated flooding may increase during the early stages of development. This is because of the extending and deepening forward and backward linkages between the water-intensive and other sectors of the economy. But then, as development continues, relative vulnerability declines in an “inverted U” relationship.



A largely subsistence economy effectively contains the macro economic impacts of a disaster shock. As the manufacturing sector develops, initial dependence on raw material processing makes it highly sensitive to a shock to the agricultural sector, with substantial multiplier effects on agricultural incomes and on domestic demand. Parts of the service sector such as an infant tourist industry may be sensitive too. In a dualistic mineral exporting economy, such as diamond producing Botswana, the non-agricultural sectors may be largely insulated from the effects of a climatic shock by weak linkages and a low share of agriculture in GDP.

Malawi is in the transitional phase between a simple and intermediate economy. In a volatile economy investors may also eschew expenditure on disaster proofing in favor of higher returns. The processes of market integration and liberalization, which have been associated since the 1980s with structural adjustment, may also temporarily increase sensitivity to a shock as production, incomes and investments are no longer shielded from shocks by weak linkages and highly-regulated markets and policies. Eventually economic development through structural changes will increase diversification and the emergence of risk-spreading financial arrangements will make the economy more resilient to disaster shocks.

Source: Benson and Clay, 1998 and World Bank, 1996

The impact of drought and climatic variability is larger for the simple, predominantly agricultural economies (Malawi and Mozambique) and an intermediate economy (Zimbabwe). The impacts are better absorbed by a more complex economy (South Africa). There is less impact on the rest of the economy in dualistic mineral exporting economies (Botswana, Namibia and Zambia, before the rapid decline in its copper industry during the 1980s). The association between fluctuations in economic aggregates and El Niño events and especially country specific droughts (World Bank variable) is shown for a representative selection of countries – Malawi, South Africa, Zambia and Zimbabwe (Appendix A, Figures 1.1 – 1.4).

The relationship between climatic shocks or variability is strongest for the climate-linked agricultural sector product.²⁴ Nevertheless, GDP and non-agricultural GDP are also affected where there are strong linkages to agriculture and where there are other water use related effects on hydro-electricity generation (Zimbabwe). The effects of climatic variability are less clear for the smaller economies of Lesotho and Swaziland. Perhaps the former displays small state erraticism with widely fluctuating performance, reflecting high sensitivity to a range of factors. Largely agrarian Swaziland's agricultural sector is clearly sensitive to climatic variability, but the effects are not reflected in the rest of the economy, where factors such as aid and remittances may hide or compensate for drought impacts. Agricultural trade, and especially imports, appear to be sensitive to climatic factors, perhaps because most are net importers of food staples except in the most favorable years. However, exports were significantly affected only in a few countries.²⁵

The country specificity of the effects of climatic variability are apparent from a careful inspection of Annex A Table 3.1, which shows growth rates for GDP, Agricultural Sector Product, Agricultural Imports and cereal yields during the 1990s. More northerly Malawi, Mozambique, Zambia and also Tanzania were affected by drought in the crop season 1993/94, whereas countries further south were affected in 1994/95, the El Niño year. The 1997/98 El Niño event is associated with a poor year regionally, but a mixed outcome at country level. These differences contributed to the perception of unnecessary alarm, especially in countries where Indian Ocean weather events were more dominant, Malawi and Mozambique.

Other interesting factors emerge from this country-level analysis. Some countries have experienced increased variability in cereal crop yields and agricultural sector performance during the 1990s, notably Malawi and Zambia.²⁶ The relative increase in variability could be explained by changes in the structure of production (commercial versus peasant farmers). There was also the disruption caused by structural adjustment programs in several key areas of the agricultural sector (price mechanisms, subsidies on fertilizers) that may have had an impact on the way farmers grow crops (Harrigan, 2001). These effects again would then filter through to the agricultural GDP. There is some evidence of an increase in the variability of cereal and maize production at a regional level.²⁷

Aid and climatic variability

The sensitivity of aid flows to disasters was also examined at a country level. There are no overall patterns of response for total ODA or for food aid. There is, however, some sensitivity of both ODA and food aid to the 1991/92 drought. Beyond that, there is no clear evidence of aid response sensitivity to drought events or, with a few exceptions, of crisis-related food aid substituting for development aid. There are other important factors influencing aid, such as conflict in Mozambique, democratization in South Africa and Malawi.

²⁴ The regression results are summarized in Background Paper 2 Tables D4.1-11 (Blanco de Armas and Clay, 2002).

²⁵ This issue needs further investigation. Factors making exports less sensitive to drought include -more drought-resistant crops, especially tobacco, and commercial farmers having irrigation, e.g. for sugarcane. South Africa's agricultural exports are largely from the Cape region that has a distinct Mediterranean climate.

²⁶ "When the apparent changes in variability of yields and agricultural sector product were subject to Chow tests, these indicated a significant increase in variability in the 1990s cereal and maize yields in Malawi, Namibia and Zambia and of agricultural sector product in Malawi and Zambia." (Blanco de Armas and Clay, 2002).

²⁷ "To expand the analysis on variability undertaken above we have plotted the residuals of regressing the first differences of log aggregated cereal and maize production (for the region as a whole, excluding Angola and Tanzania) on a time trend, to test whether there is any increase in its standard variation. Again we have used a Chow test to explore whether there is a structural break in the square of these residuals in 1988 and we failed to find one. We repeated the test, taking 1990 as the dividing point, and we did find a structural break in the square of the residuals in that year." (Blanco de Armas and Clay, 2002)

Overall, Malawi emerges as one of the countries most sensitive to climatic variability in terms of the range of economic and agricultural sector aggregates considered, GDP, agricultural sector product (GDP), agricultural trade including both exports and imports. There is some evidence of increasing variability (instability) in these aggregates. However, the relationships between wider climatic forces, particularly the ENSO phenomenon, are less clear than in countries to the south. These comparative findings are sufficient justification for exploring these issues more fully through a Malawi country case study (Chapter 4).

3.4 The cost of major droughts

Methods of assessment

Climatic variability, especially severe drought, has significant impacts on economic performance in Southern Africa. A more difficult issue is to quantify those effects in ways that would be useful to development policy. Broadly, what is the scale of costs that is likely to result from a major drought at a country and regional level? The fuller and systematic exploration of these complex issues requires an investigation of the growth patterns of economies that incorporates the impacts of climatic variability as one form of exogenous shock. Such an investigation is beyond the scope of this study, as it would require a substantial investment of human resources and time into simulations with a computable general equilibrium (CGE) model.²⁸

Nevertheless, an approximation of the costs of a discrete extreme event is possible, by applying the conventional methods of project evaluation and assessment to available macro-economic data. The usefulness of this simpler approach has already been demonstrated in analyzing the impacts of external shocks and policy changes on smaller relatively open economies of the Southern African region, such as Malawi (Mosley, Harrigan and Toye, 1991; Harrigan, 2001). Furthermore, some variation of this evaluation approach is widely adopted in the immediate, and frequently the only, attempt to assess the financial cost of a disaster. It is worthwhile therefore to find out if such very simple analysis can be strengthened by taking into account agro-climatic relationships such as those suggested in this study.

Broadly, the approach adopted in evaluation analysis is to compare what actually happened to the chosen variable with one or more of three alternative methods which compare *before* and *after* the event, *with* and *without* the event and the *actual* and *planned* outcomes.

Formally these methods can be set out as follows:

Before and After: this method compares actual outcomes after a disaster event with the outcomes for the previous period. In the simplest formulations the cost of disaster impact on the variable Y_i is:

$$\Delta Y_{it} = Y_{it} - Y_{it-1} \quad (3.1)$$

where for example Y_{it} is the value in US dollars of 'real' agricultural sector product measured in constant prices (GDP) in the drought affected year (t) and Y_{it-1} the value in the preceding year.

With –Without: this method compares actual outcomes after a disaster event with a counterfactual estimate, which might have been most likely to happen in the absence of a disaster. Formally the impact of a disaster event, assuming again that these effects are limited to one year, is:

$$\Delta Y_{it} = Y_{it} - Y_t \quad (3.2)$$

²⁸ Benson and Clay (1998) draw attention to some earlier attempts to investigate the impacts of drought for South Africa and Zimbabwe. Freeman and others (2001) undertake exploratory investigations into the use of the World Bank's RIMSIM models to assess the impact of natural disasters on capital stock.

where $\bar{Y}_t$ is the expected value of Y_{it} . The estimation of the expected value is potentially a complex issue, but a relatively simple formulation explored in this investigation is to estimate the trend value for a variable such as the GDP growth rate and calculate the effect of the drought as the deviation from this trend value. Where, as in the case of regional maize production, there is no apparent long term trend, but there is considerable inter-year fluctuation in level, the expected value might be approximated by the easily calculated average or mean value of Y_i over say the previous five years.

Actual versus Plan: the actual outcome in the disaster year is compared with the envisaged outcome associated with specific policy interventions. Formally this comparison is defined as

$$\Delta Y_{it} = Y_{it} - Y_{it}^* \quad (3.3)$$

where Y_{it}^* is the envisaged policy influenced outcome. For example, this planned value might be the level of output envisaged under a sectoral or structural adjustment program, which is intended to move outcomes away from those of unchanged policies, reflected in trend values. More commonly it is simply government forecasts that are used for planned values. Such forecasts may not be associated with any specific policy change, but are 'normative' in contrast to 'without' values that are empirically derived. This formulation is not attempted here, as (practically) a comparison of planned and actual values requires country case studies of government annual economic plans to examine planned outcomes for the region, which is beyond the scope of this study. Such a comparison was done, for example, in the preceding country case study for Bangladesh in examining the impacts of the 1998 flood (Benson and Clay, 2002) and in the earlier study for Zimbabwe (Benson, 1998).

The *before* and *after* approach is most commonly adopted in assessing the direct impact of a disaster in terms of physical damage and loss of capital stock, including inventory. This approach is more problematic in assessing impacts of a shock on flow variables such as production of specific crops, sector product or GDP. The previous year's level of activity may be unsatisfactory as a counterfactual predictor of what would have happened in the disaster affected year, because of so many other possible changes in circumstances. For example, basing a cross-sectional comparison of the effects of a discrete climatic event such as the regional drought in 1991/92 on a *before* and *after* calculation potentially understates the effects of the drought. Some countries such as Lesotho and Zimbabwe had already experienced a relatively poor agricultural year in 1990/91.

The assumption that impacts are confined to a single year is also a serious simplification if, as in the case of non-agricultural sectors, the effects are delayed but longer lasting (Benson, 1998). However, the consequences of this simplification are perhaps less serious for largely rainfed production in Southern Africa, where the agricultural cycle is dominated by a unimodal rainfall pattern for the summer rainy season.²⁹

Two cost estimation exercises are attempted, applying for purposes of comparison both a *before* and *after* method and forms of the *with-without* method which seemed most appropriate. Many similar calculations were made by international financial institutions and bilateral aid agencies, particularly for the droughts in 1991/2 and 1994/5 to determine likely additional levels of food import requirements and possible need for external assistance.

²⁹ This simplification is more dubious in the case of Botswana, where livestock production dominates. That may explain why even agricultural GDP is apparently not seriously disturbed by drought events or cereal production variability. The assumption is also unsatisfactory when there is a multi-year event such as the Sahel droughts of the early 1970s and 1980s. A sudden impact event such as the 1991 cyclone in Bangladesh, which occurred near the end of the agricultural and financial year (Benson and Clay, 2002) also has effects that spill over in to the next year.

Impacts of El Niño -related droughts on maize production

In the first exercise there is an assessment of the impacts of four El Niño related droughts in 1982/83, 1991/92, 1994/95 and 1997/8 on cereal and maize production, perhaps the least contentious impact of these events (Table 1).

Table 1: Southern Africa – Losses in Maize Production Caused by the Main Droughts

	Maize					
	Method. I		Method. II		Method. III	
	Volume	Value	Volume	Value	Volume	Value
1983	-5.2	-0.8	-7.3	-1.1	-7.2	-1.1
1992	-8.4	-1.0	-9.4	-1.1	-10.3	-1.2
1995	-9.5	-1.4	-4.5	-0.7	-6.3	-0.9
1998	-3.0	-0.3	-2.5	-0.3	-2.4	-0.3

** VOLUME is total volume of losses measured in million tonnes

** VALUE is physical losses measured in billion US\$ according to annual CIF price for early delivery of US yellow maize delivered to European port (Rotterdam)

The *before* and *after* calculation is computed as in equation 3.1 (Method 1). The *with-without* impact of the drought (equation 3.2) is calculated in two different ways. First, as there is no apparent trend in the production series, expected output is simply calculated as the level of production in the preceding 5 years (Method 2). Second, it is calculated as the difference between the actual drought-affected level of regional cereal or maize production and the expected value that is associated with the long term (1961 – 1990) mean level of rainfall (Method 3). The preceding analysis of climatic variability suggests that this is possibly a superior formulation of expected production.³⁰

The calculations in Table 1 provide an approximate estimate of the losses incurred solely in maize production during the major regional droughts of the 1980s and 1990s. Method 1 shows the year on year reduction in maize production. The *with-without* drought calculations show the reduction in production compared with the previous five years (method 2) and the departure from expected production associated with the long-run mean rainfall. The *with-without* calculations are relatively consistent, indicating overall losses of around 10 million tonnes in the most severe 1991/92 drought, over 7 million tonnes in 1982/83, 5-6 million tonnes in 1994/95 and over 2.5 million tonnes in 1997/98. The year on year (*before* and *after*) estimates, often used in headline estimates of drought impact, are more variable. This approach probably exaggerates the impacts in 1994/95 and 1997/98, which followed favorable conditions in previous years, and probably understates the severity of the 1982/83 and 1991/92 droughts that were preceded by relatively dry years.

The financial cost of these drought shocks is even more difficult to estimate with any precision, because of several factors. Nevertheless, it is interesting to note that calculations of potential losses in terms of import costs of maize cluster around US\$1 billion for the three major droughts and US\$300 million for the less severe 1997/98 event. A number of factors make the calculation more difficult. There are large differences between export parity prices and import parity prices, especially for landlocked countries such as Zimbabwe and Malawi. Another factor is the difference in prices between white maize, grown and preferred in the region which trades at a premium, and yellow maize, especially from the USA, that has typically filled a large proportion of the deficit in drought years. Imports of other cereals, especially wheat, increase in drought

³⁰ The expected level of production is calculated using the best-fit quadratic form of the relationship between production and the SEARI (Table 3.2). The use of this equation to calculate expected cereal or maize production is justified because there is no apparent trend in production. Furthermore, the probability of an extreme climatic event in Southern Africa is, according to climatological evidence, unaffected by what happened in the preceding year (Hulme and others, 2001).

years. But to provide an approximate sense of the overall costs, the financial loss was estimated, valuing production losses at the readily available annual average CIF price for US yellow maize to Europe. These calculations suggest that the direct import equivalent costs of major droughts were at least US\$1 billion.³¹ The cost of the 1994/95 drought was made worse by this being a relatively tight year in international grain markets. In contrast, 1992 and 1998 were years when markets were weak and there were substantial stocks of US maize available as food aid and on concessional credit terms.

If these production losses and associated import requirements are calculated on a country by country basis, this would provide an approximate estimate of the minimum additional import financing that would be required to sustain maize distribution systems in the severely affected countries. That was the approach adopted by the IMF in computing the continued requirement for food aid and additional import support during the 1991/92 and 1994/95 droughts (Clay and others, 1995).

Impacts of the 1991/92 drought on macro-economic performance

In the second exercise, the impacts on macro-economic performance of the most extreme 1991/92 event are estimated for each country in the region. In this case year on year differences in growth rates are compared with deviations from trend growth rate during the preceding decade (Annex A Table 3.3). These exercises are intended to provide an approximate measure of the likely costs of immediate economic impacts and severe regional drought. These costs provide the context within which to assess disaster reduction benefits that could be achieved through climatic forecasting at regional and country levels.

The scale of the impact on agricultural sector performance is apparent from the contrast between both the simple 10 year average and trend growth rates during the 1980s and actual growth during the period 1991-93. Some countries, notably Lesotho, Mozambique and Zimbabwe, were already performing poorly in 1991, largely due to low and erratic rainfall.

Regionally, the drought resulted in a decline in agricultural sector GDP of over 25%, compared to 3.5% growth in 1991, an implied reduction of close to 30% (Table 2). The implied reduction in value of agricultural GDP was some US\$ 2.6 billion for the region, and US\$ 0.8 billion for all countries, excluding South Africa. If the comparison were with what might have been expected with favorably distributed rainfall close to mean levels, then losses for the region were around US\$3 billion in terms of departure from 1980s trend growth rates in agricultural sector GDP. The losses were \$ 1 billion for maize alone (Table 1).

The agricultural sector then recovered rapidly in 1993, with favorable rains and programs to assist recovery. In all countries, apart from South Africa, these programs also received considerable international support. Nevertheless, agricultural sector GDP only recovered to around 1991 levels, implying that the losses in 1992 were not immediately made good by higher growth in the recovery year.

The impacts on GDP in 1992 are, as would be expected, relatively more extreme in the largely agricultural economies such as Malawi and Mozambique (Annex A Table 3.1). The impacts were less severe, but more prolonged in the more diverse economies of South Africa and Zimbabwe. The implied regional impact, bearing in mind the other influences on economic performance, was an actual reduction in regional GDP of US\$ 3.0 billion in 1992 – a decline of 2.3% in South Africa and 2.2% in the rest of the region, broadly equivalent to the reduction in agricultural GDP. The recovery in 1993 was largely driven by resilient

³¹ There are in addition, the logistical costs of shipping commodities within the region that should be added to the CIF price to provide the full import cost. These will vary considerably according to the circumstances. In 1992/3 the overall costs of the emergency operations were some US\$440 million, equivalent to around a further \$80 a tonne (SADC, 1993). Where imports are planned well in advance, rather than on a crisis basis requiring delivery at any cost, then the logistical costs can be substantially less, as apparently was the case in 1994/95 and 1997/98. In 2002 the pressures to bring in food quickly again obliged the Malawi government to use some road transport routes, with costs of around US\$80 a tonne, to ship maize from South Africa.

agricultural performance, but only just brought GDP back to 1991 levels, implying a loss broadly equivalent to two years of average GDP growth in the 1980s.³²

Table 2: Southern Africa: the 1991/92 Drought and Macro-economic Performance

Region (a)		1990	1991	1992	1993
GDP	(\$ bn)	133.8	133.6	130.6	132.8
	growth	0.0%	-0.1%	-2.3%	1.7%
Agriculture	(\$ bn)	10.0	10.3	7.7	9.8
	growth	-4.1%	3.5%	-25.1%	26.1%

South Africa		1990	1991	1992	1993
GDP	(\$ bn)	114.1	113.0	110.4	112.0
	growth	-0.5%	-0.9%	-2.3%	1.4%
Agriculture	(\$bn)	6.4	6.6	4.8	6.0
	growth	-7.1%	4.5%	-27.3%	24.0%

Region excluding South Africa (a)		1990	1991	1992	1993
GDP	(\$bn)	19.7	20.6	20.1	20.8
	growth	3.2%	4.6%	-2.2%	3.2%
Agriculture	(\$bn)	3.6	3.7	2.9	3.8
	growth	1.7%	1.8%	-21.1%	29.5%

Source: World Development Indicators 2000, World Bank

Note: (a) Region includes Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe, but excludes other SADC members, Angola, Tanzania, Mauritius and Seychelles

A close inspection of performance, as undertaken by Benson and Clay (1998) suggests that the typical pattern is for a major drought to impact directly on agriculture, as in 1991/92. While the wider economic impact resulting largely from multiplier and linkage effects is felt in the following year, with a lag of about 6–12 months. This is again the pattern of impacts observed for Malawi when affected by a sequence of droughts in 1991/2 and 1993/4, as described in Chapter 4.

What are the implications for climatic forecasting? The direct economic costs are large, but also unavoidable so long as most of agriculture is rainfed, and also continues to account for a substantial part of GDP. From a macroeconomic perspective the value of climatic forecasting is therefore more in anticipating these costs and indicating the scale of mitigation and counter-cyclical economic measures that may be needed at national and regional level. The most immediate costs will be the financing of additional imports to compensate for losses in cereal production. These costs could be reduced by caution in the management of public stocks and in making import/export decisions from the moment that the risk of a climatic shock becomes apparent until the next main harvest. This period extends for almost a year from around May/June preceding the planting of the main maize crop in November until immediately after harvest in the following April. This is firstly because forecasts on the likely intensity of an El Niño event are extremely uncertain until around the middle of the calendar year (Chapter 5). Secondly, because of the sensitivity of maize to erratic

³² In 1993 GDP was US\$112 billion in South Africa compared with US\$113 billion in 1991, and US\$20.8 million in the rest of the region compared with US\$20.6 million.

rainfall, the likely harvest is also highly uncertain until it is brought in. Thirdly, because there is also a risk of a relatively poor maize crop with above average rainfall, perhaps there is a need for continuing vigilance about the food security situation in every year.

The economic costs of an extreme climatic event for the region– most likely to be a severe drought – will be a reduction in maize production of around US\$ 1.0 billion and agricultural sector product of around US\$ 3.0 billion. South Africa is likely to bear the brunt of the impact. However about one third to half of these costs are likely to be spread according to the precise pattern of the drought amongst the other countries in the region. These are severe impacts that the international community as well as SADC countries need to take into account in preparing for country level economic strategy and aid policy discussions, as soon as there is evidence of the enhanced risk of a major shock. Because of the complex relationship between rainfall and agricultural production both then need to be carefully monitored through the agricultural cycle. Agro-meteorological assessments that monitored closely the evolving rainy season at regional, country and within country zonal level could be made to contribute usefully to that process.

Chapter 4.

Climatic Variability and the Malawi Economy

In this chapter the apparent impacts for Malawi of climatic variability, especially major droughts are examined in terms of agricultural performance and the wider economy. The methods used are similar to those used at a regional level – graphical analysis, quantification by regression analysis and an assessment of costs of major events using conventional evaluation techniques. At a country level it is easier to introduce into the exploration of climatic effects other more specific factors that may influence outcomes – issues of economic structure, prevailing economic conditions and the changing policy environment. The objective is to provide an approximation to the economic and financial costs of extreme events that could be anticipated by climatic forecasting.

4.1 Background

Malawi is a small land-locked country in Southern Africa with a land area of 118,000 km² (Map 1). The country had an estimated population of 10.8 million in 2000, growing at 2.6% a year in the 1990s. It is classified as a low income country, one of the poorest in Africa, whether ranked according to GDP per capita (US\$170 in 2000), or the UNDP Human Development Index, ranking. Around 65% of the population are below the national poverty line and 28% in extreme poverty (Government of Malawi, 2001b).

Health and social indicators are amongst the lowest in Africa. In 2000 infant mortality was 134 per 1000, compared to an average of 92 for Sub-Saharan Africa, while under five mortality was over 250 per 1000. Malawians then had an average life expectancy at birth of 37, declining from 43 in 1996 because of HIV/AIDS. Malawi is one of the countries most severely affected by HIV/AIDS, with reported prevalence in 1999 of 16% amongst adults and 31% amongst women in ante-natal care. The epidemic, if unchecked, will further erode life expectancy and other social gains of the past 30 years. The loss of human capital and ill health amongst the economically active population is probably making Malawi more disaster prone (Haacker, 2002). Adult literacy is under 60%, and under 44% for women. Although the government began providing free primary education for all in 1994, only 78% of children attend school.

Malawi is still a largely rural economy and society, with 78% of people and 89% of the economically active population classified as rural. Agriculture accounted for some 40% of GDP in 2000 and this share had increased since the early 1990s, with industrial stagnation and contraction in the public service sectors. Export earnings are dominated by tobacco (61%), tea (9%) and sugar (8%) – percentages as in 2000. This economic dependence on rainfed crops, tobacco and tea, again makes Malawi potentially very vulnerable to climatic variability and commodity price shocks.

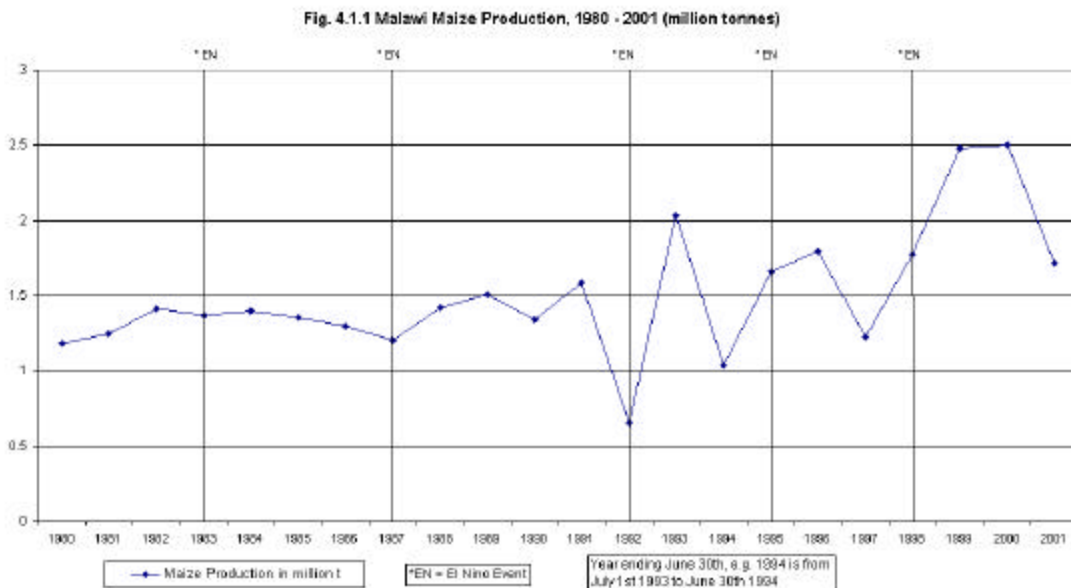
Malawi's landlocked situation imposes high overland transport costs and has made the country vulnerable to disruption in, and security of, transport because of conflict in neighboring Mozambique, and more recently political instability in Zimbabwe. Amongst the food security consequences of this locational disadvantage is, typically, a substantial gap between export and import prices of cereals, and uncertainties of organizing food import logistics, as demonstrated in 2001-02.

4.2 Climatic variability and agriculture

The droughts in 1991/2 and, only two years later, in 1993/94 are widely recognized to have impacted severely on agriculture, especially the smallholder sector, which accounts for the greater part of maize production, the main food staple (93% in 2000/01). This sector is also highly dependent upon maize for self-

provisioning and includes many who normally produce only part of their maize for own consumption. Otherwise, these poorer households depend on other sources of income, primarily labor, paid in cash or kind, to acquire food (World Bank, 1990, Government of Malawi, 2000b). Maize, in a normal year, probably accounts for around three quarters of calorie consumption, especially for low income households.³³

Production of maize declined by around 60% in 1991/92 to the equivalent of only 45% of average production during the previous five years (Figure 4.1.1). The food security effects are well documented (e.g. World Bank, 1996). There were more limited impacts on the relatively more drought resistant tobacco crop. However, the categories of tobacco in which smaller producers are most represented were more severely affected: – total tobacco production declined by 12%, but yields of burley tobacco fell by 15% and of SDDF tobacco by 34% (Tchale, 2002). Tea production, mostly estate-grown in the south, declined by 31% (Figure 4.1.2). Agriculture quickly recovered from the drought – demonstrating both a high sensitivity and resilience common to most of Africa (Benson and Clay, 1998).

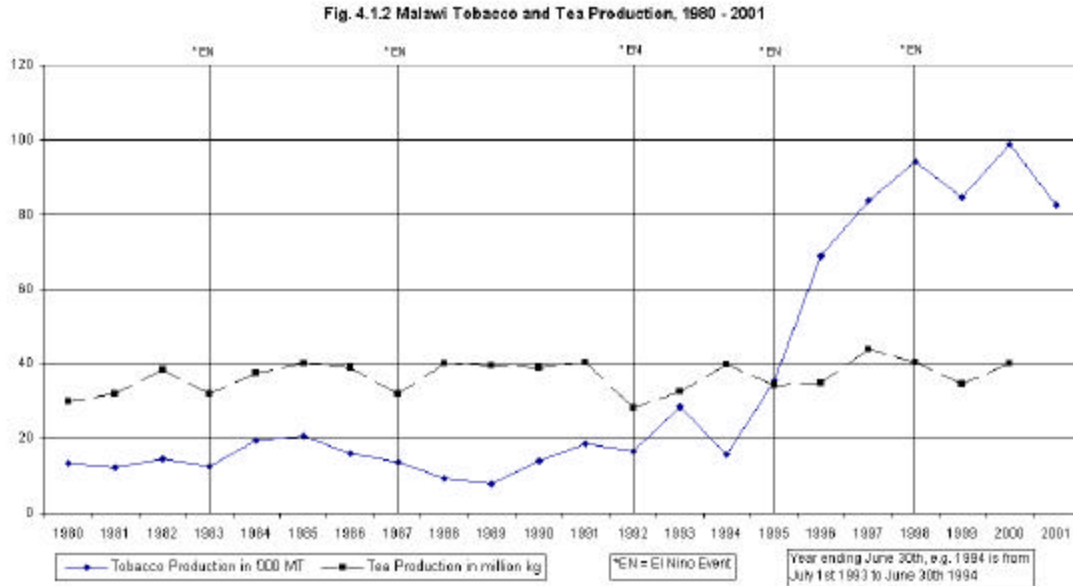


There was a bumper maize crop in 1992/93, favored by high and well-distributed rainfall, and great efforts to provide smallholders with inputs. There was also a record tobacco crop as smallholders were given more freedom to grow the crop. These good harvests also coincided with the massive inflow of emergency food aid planned in 1992 but which continued through 1992/3 (SADC, 1993). Threatened with producer disincentives, the parastatal ADMARC engaged in record purchases of over 375,000 tonnes of maize, adding to financial pressures on government discussed further in Section 4.4.

Then in 1993/94 agriculture was again affected by low and erratic rainfall, in northern and most importantly central areas of key importance in maize and tobacco growing. Maize production again fell sharply to only 58% of the 1987–1991 average level. Tobacco production also contracted by 45%. There was a sharp reduction in area, with especially poor performance by the smallholders, and yields down by 20–33% for the types they grow. Tea, concentrated in the southern highlands was less affected. In 1994/95, when major economies to the south, South Africa and Zimbabwe, were affected by lower and poorly distributed rainfall, Malawian agriculture, excepting tea, recovered. These zonal differences in the pattern and timing of drought

³³ As already discussed in Chapter 1, food production and consumption statistics are in confusion. FEWS NET estimated maize as accounting for 67% of apparent calorie consumption in 2000/01. However, this figure reflects the considerably inflated estimates of roots and tubers, confirmed by the Ministry of Agriculture when it halved its unit and estimate of cassava and sweet potato production in 2001/02 in the final crop assessment.

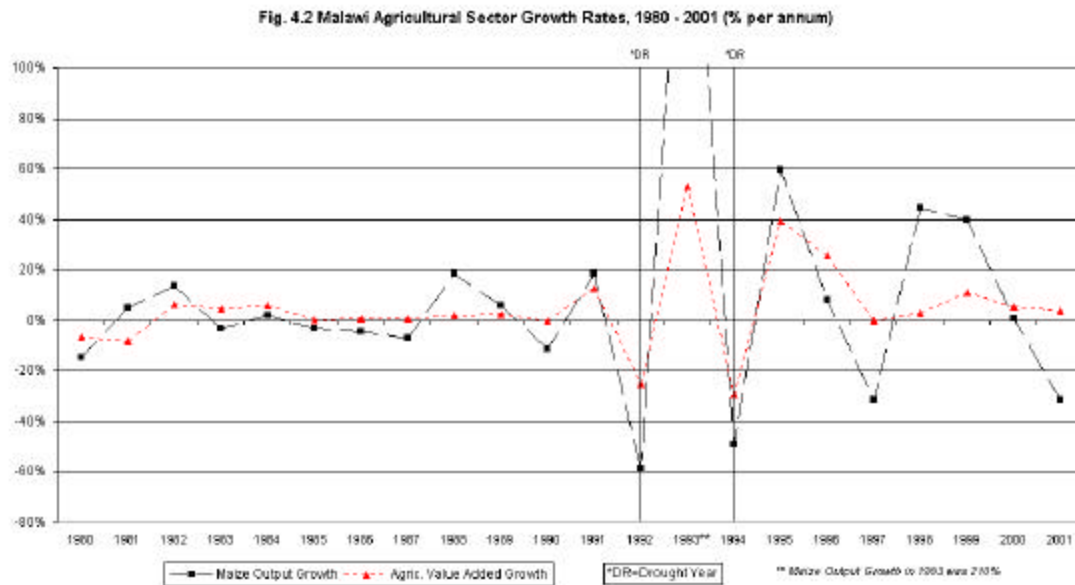
impacts during 1994 and 1995 highlight the internal differences in climate, which have made nation-wide drought a rare occurrence (See below).



Irrigated production is also sensitive to low rainfall, especially several seasons of below normal rainfall. Sugar cane production contracted by about 10% in 1992, then low rainfall in 1993/94 and 1994/96 was a factor in a sharp reduction in planted area and production in 1995-96 (Tchale, 2002).

The effects of earlier periods of erratic or below average rainfall in the 1970s and 1980s were less extreme and less general in their impacts. The 1972 El Niño event had little impact. There was a poor year in 1979. Some areas experienced low harvests, but there was not a nationally poor maize crop in either 1981 or 1982. There was also a contraction in maize production in 1985/86 and 1986/87, but this is widely attributed to problems of unsatisfactory management of the internal market and lack of incentives and inputs, rather than climatic factors (World Bank, 1995; Harrigan, 2001). The last major failure in food production was the famine year of 1949 (Vaughan, 1987).

In 2000/01, there was a poor maize crop, production declining by over 30%. Tobacco production was also down by 16%. This was a year of exceptionally high rainfall and widespread flooding, indicating that agricultural production is also sensitive to the combination of weather and hydrological conditions associated with abnormally high rainfall. This pattern of impacts is consistent with some sensitivity to both extremes of the rainfall distribution as identified at a regional level.

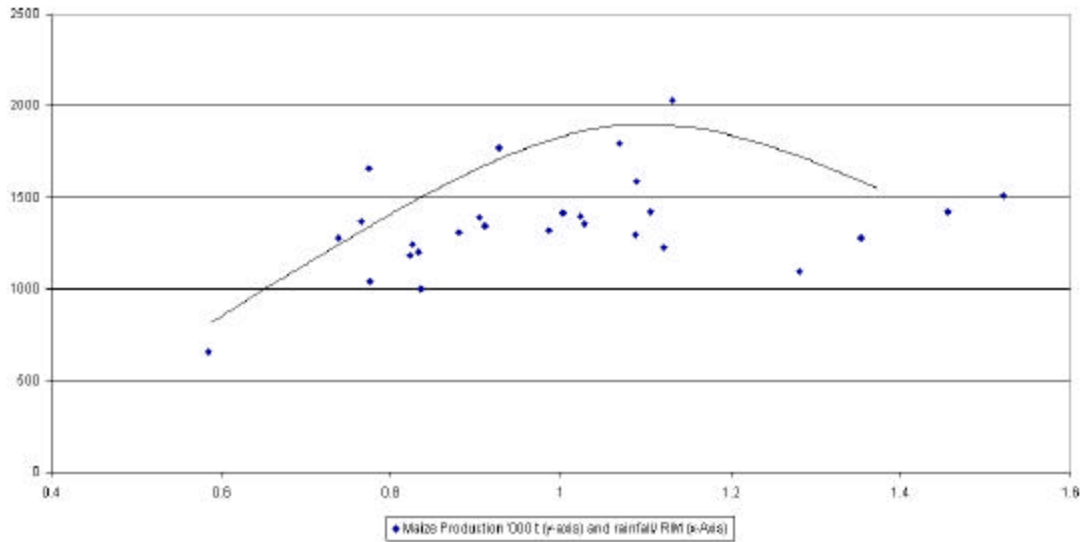


The impacts of the 1991/92 and 1993/94 droughts are readily apparent in terms of maize yields and output and the wider performance of the agricultural sector (Figure 4.2).

The investigation of the relationship between maize sector performance and rainfall failure confirms a statistically significant relationship at national level. However it fails to reveal powerful associations between either total rainfall or ENSO climatic variables in yield or output that explain a substantial proportion of the variance— comparable to those found at a regional level or for Zimbabwe (Chapter 3). Intensive statistical investigation of rainfall and crop performance showed that the best statistical associations at a national level are between rainfall in the month of February as a weighted index and maize yields (Figure 4.3 and Appendix A, Table 4.1). Again as in the regional and Zimbabwe analyses, the best-fit relationship is non-linear – a quadratic form explains about 50% of annual variance in yields.³⁴

³⁴ There is considerable variation within Malawi in annual, seasonal and the monthly distribution of rainfall (Box 1). The investigation revealed only a significant association between rainfall for individual meteorological stations and crop performance, with little explanatory power (Tchale, 2002). A rainfall index was then constructed, with station values weighted according to the geographical distribution of maize planted area (Annex A Table 4.3). This index is significantly correlated with extreme El Niño events, but not with either the SST index or the regional rainfall index (SEARI).

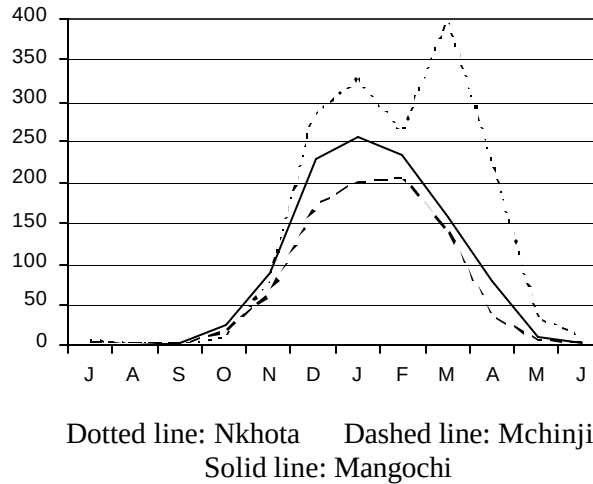
Fig. 4.3 Malawi Maize Production/Rainfall Scatter



There are a number of factors that may account for the still relatively weak and complex relationship between rainfall and performance of the main, rainfed crops. First, the production statistics for major crops are of uncertain reliability. In earlier decades, the 1960s and 1970s, production of maize, then regarded as primarily a subsistence crop were indirectly based on the maize-dependent rural population. Then more reliable agricultural statistical survey methods were introduced. But more recently in the 1990s there are uncertainties, because agricultural assessment was re-assigned from the government statistical service to agricultural extension staff who are also responsible for crop improvement programs, including food crop diversification.³⁵

Second, and critically, there is considerable difference in inter-annual and intra-seasonal distribution of rainfall between stations in different parts of Malawi. Figure 4.4 shows the mean monthly distribution for three representative meteorological stations. Nkhota is typical of the stations showing a slight bimodal distribution. Mangochi is representative of the majority of the stations with a peak in January while Mchinji peaks one month later.

³⁵ A controversial issue, beyond the scope of this investigation, is the reliability of recent agricultural production statistics. There was an apparently large but disputed increase in cassava and sweet potato production during the 1990s. This implied a substantial improvement in calorie intake and diversification in sources of rural food. The growth in largely subsistence root crops also apparently boosted agricultural sector product growth shown in Figure 4.2. These growth rates have been questioned (Devereux, 2002) and are likely to be revised downwards now that the Ministry of Agriculture has halved its initial estimate of root crop production for 2001/02 (see above Section 1.2)

Figure 4.4 Seasonal distribution of three Malawi sites.

As Bohn (2002) explains, these micro variations in weather patterns are associated with Malawi's location in the overlapping area of two climatic zones and also caused by the localized effects of Lake Malawi. As most of Malawi receives a mean annual rainfall in excess of 750 mm, the intra-seasonal distribution of rainfall rather than total rainfall is the critical determinant of yields.³⁶ This micro-diversity is consistent with the statistical findings about maize production-rainfall relationships, that an index for February rainfall, weighted by zonal sown area is a better explanatory variable than total or seasonal rainfall, or an unweighted index.

Third, there are other confounding factors which have significantly influenced food production and, since the early 1990s, export crops, in this resource-poor smallholder economy. Agricultural policy as a cause of production variability in recent years may override or amplify purely weather-related influences. As already noted, maize production declined by around 20% in 1986/87, but weather was only one factor. Other important constraints were the pricing and availability of inputs and the policies of the parastatal, ADMARC, responsible for marketing and managing national food security stocks (Harrigan, 2001). Similarly, the sharp contraction in maize in 1993/94 was also made worse by policy-related factors. There were massive cereal imports in response to the drought in 1991/92.³⁷ The related enormous build up of stocks by ADMARC in 1993 created a situation less favorable to maize growers, reflected in a contraction in crop area that coincided with the unfavorable rainfall, which subsequently impacted on yields.

In the late 1990s the Targeted Input Program (TIP), or Starter Pack, scheme provided a minimum package of seeds and fertilizer for all small-scale subsistence producers as a social safety net. This program of free input distribution probably contributed to reported record levels of maize production of around 2.5 million tonnes in 1999/2000. The attempt to reduce expenditure and target only half of smallholders curtailed the scheme in 2000/01, which then encountered distribution difficulties. These problems were then exacerbated by the early onset and unusually sustained rains, so that distribution was in many places late and incomplete (Levy and Barahona, 2001; Nkhokwe, 2001).

³⁶ There is an agro-ecological zone across central Malawi where the combination of relatively lower mean rainfall and soil types makes these more marginal areas of maize cultivation more regularly threatened by moisture stress (Ntcheu District – see Map 1). Population pressure is leading to increased settlement and subsistence food production in this area, which has been severely affected by the 2002 food crisis. Other relatively drier areas with mean rainfall below 750mm are the Shire Valley and parts of the north western Mzimba District in Mzuzu Agricultural Development Division (Map 2).

³⁷ Food imports were organized in 1992 for domestic consumption and to replenish grain reserves. These amounted to US\$175 million arriving in 1992/93, and in addition there were imports of US\$55 million for non-Malawian refugees.

Another controversial issue is the consequence of radical institutional change in agricultural marketing, with the partial dismantling of the formerly dominant ADMARC. Liberalization of agricultural markets has coincided with considerable continued volatility in production (Dorwood, Kydd and others, 2001).

The closer examination of agricultural performance in Malawi is beyond the scope of this study. Nevertheless, the examples mentioned show how a better understanding of the complex of influences on Malawi's resource-poor, fragile smallholder rural economy is required in isolating the effects of climatic variability. Something of this complexity is more apparent in looking at the wider economic consequences of climatic variability.

4.3 Economy-wide impacts

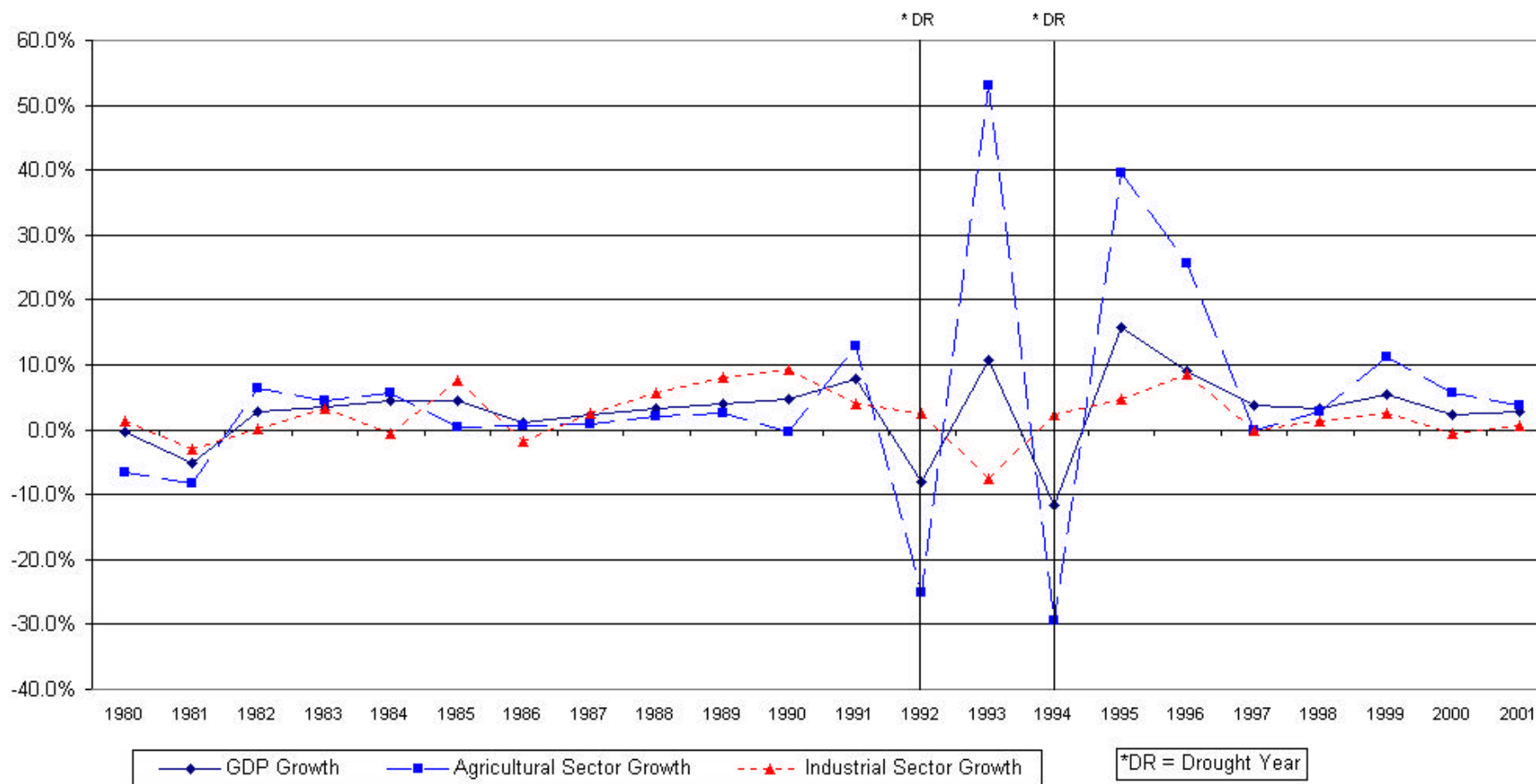
The potential wider economic consequences of a drought in a Sub-Saharan economy such as Malawi include directly negative impacts on the agricultural sector production and, depending on water use, other productive sectors, most obviously hydro-electricity, during the drought-affected period. The overall impact on GDP would depend on these direct disruptive effects, and on multiplier relationships, which reflect the structure of the economy. For a still largely rural economy such as Malawi, wide macro-economic effects were likely to be transmitted by relatively weak inter-sectoral linkages (Box 3). The overall effect of the drought as an economic shock might be reduced by compensating public actions and private remittances. As the two major droughts of 1991/92 and 1993/94 show, other influences make it difficult to isolate the impact of these shocks in a partial analysis.

In 1991/92 agricultural sector product declined by 25%, equivalent to a 10% decline in GDP (Figure 4.5). However, GDP actually declined by 8%, equivalent to US\$ 100 million in constant 1994 prices because, as explained below, the shock to the rest of the economy largely came the following year. In terms of the departure from trend rates of growth, the decline in agricultural sector product was closer to 30% and 12% in GDP (US\$151 million). The losses were concentrated in maize production and the small farmer-subsistence sectors, with apparently limited multiplier effects.

The industrial sector's growth was checked in 1991/2, and it then declined in 1992/93, suggesting a lagged impact of the drought on agricultural incomes, and so consumer expenditure and investment. This is because the loss in agricultural production occurs towards the end of the financial year and the wide effects are felt in the following months. The service sector's short-term behavior was similar – a check to growth in 1991/92, followed by a decline in 1992/93.

Despite the decline in industry and services, the economy subsequently recovered quickly in 1992/93, partly because of a good maize harvest. The relaxation of restrictions on smallholder tobacco growing also contributed to the recovery, with a 46% expansion in area and a 72% rise in production. Export earnings reflected agricultural sector performance, recovering strongly in 1993. Imports reflected the massive food imports, mostly funded as food aid. But overall GDP growth was constrained by the weakness of the non-agricultural economy. Gross domestic investment declined sharply in 1992 and showed no signs of recovery in 1993.

Fig. 4.5 Malawi GDP growth rates, 1980 - 2001 (% per annum)



The drought-related downturn in 1994 was even more severe than in 1991/92. Agricultural GDP declined by 29% and GDP by 11.6%. This time a reduction in maize planting by 8%, as well as a yield reduction of 33%, contributed to sharply reduced output and agricultural sector product. There had been a switch in development strategy from estate sector led agricultural growth to promoting smallholder production.³⁸ However, without accompanying institutional support, including credit and inputs, as well as efficient marketing arrangements, this change may have made agriculture more sensitive to climatic variability. The uncertain political and economic environment is reflected in the chaotic public finance situation, and accelerating inflation (see below). In this uncertain economic environment the estate sector was not performing well and the smallholder sector was vulnerable and volatile.

These apparently large impacts suggest that Malawi's economy was among the most sensitive to drought shocks of any in the region. There were widespread concerns also about the food security implications. These concerns gave impetus to strengthening of Early Warning Systems and raised interest in the potential benefits from medium term climatic forecasting of drought (World Bank, 1996).

The droughts of 1991/2 and 1993/4 also reduced water flow from Lake Malawi perilously close to levels that would have necessitated a reduction in electricity generation. As had happened in Zambia and Zimbabwe in 1991/92, when the power supply from Lake Kariba was curtailed. A re-examination of the need to invest in proofing hydroelectricity generation against falling levels of Lake Malawi following a drought was begun (Box 2). The influences on the hydrology of the lake are extremely complex and more research is needed on meteorological-hydrological relationships. However, such investigations have been hampered by the under-funding and institutional weakness of the national meteorological system that are only now being addressed (see below Box 5)

4.4 Drought and the public finances

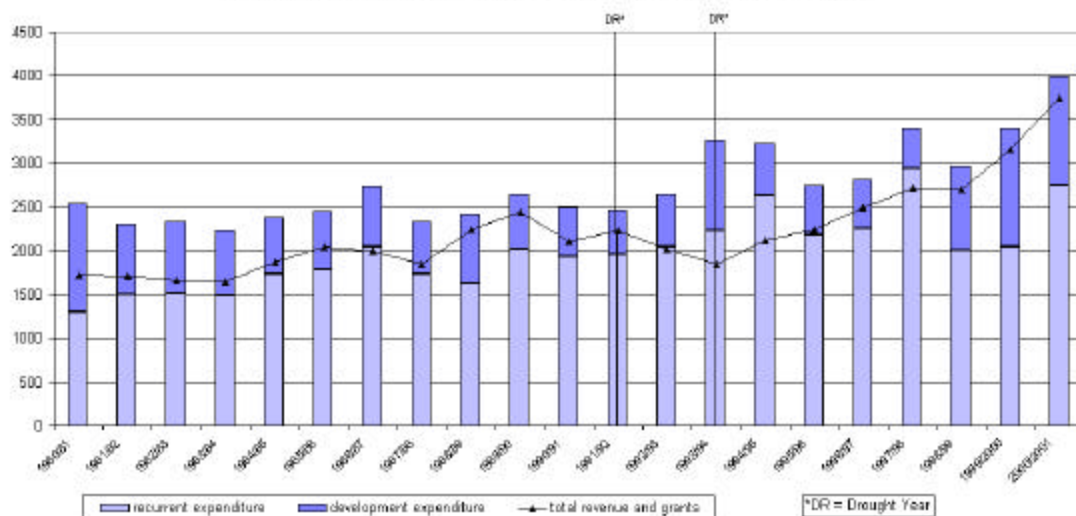
A drought shock is likely to impact adversely on the budgetary balance. Tax revenue will probably be reduced via a decline in income, employment and export earnings. The revenue of parastatals will also be adversely affected. Utilities will be affected by income impacts of the shock-induced recession on effective demand and increased non-payment. The government is likely to be confronted with increased expenditure on relief, social welfare, health and water supplies, consumption related subsidies on food distribution and logistical costs of drought-related imports. There are also pressures to increase subsidies to affected productive sectors, especially to assist recovery in the case of agriculture and to meet the additional deficits of parastatals (Benson and Clay, 1998).

The overall behavior of public finances during the period 1992-1995 is broadly consistent with the suggested ways in which drought is likely to impact on both revenue and expenditure. The impact of a drought severely reduces agricultural production (April-May) towards the end of the financial year in June. The financial effects in terms of relief and recovery assistance arise largely in the following financial year, July-June.

Prior to the drought in 1991/92 the government had been engaged in a third structural adjustment program that had shown signs of relative success. Macro-economic performance was stronger with rising export revenues. Measures to achieve a sustainable budgetary balance were reflected in public expenditure declining in both absolute terms and as a percentage of GDP. The public finances were then affected by three adverse developments.

³⁸ There is a parallel with Zimbabwe, where the major sector's performance became more volatile as production shifted from large scale estates to smallholder farmers from the mid 1990s onwards (Benson, 1998).

Fig 4.6 Malawi - Main Fiscal Aggregates, 1981 - 2001 (million K, constant prices)



First, the final difficult phase of the Mozambique conflict caused disruptions and higher costs of trade, and an associated exodus of refugees in 1991 caused unforeseen budgetary difficulties. Second, there were increasing political difficulties, with growing opposition to the gradually weakening Banda dictatorship. Bilateral donors responded to the political situation by halting non-relief development aid, so that grant aid fell by 60% between 1989 and 1992. The political crisis intensified until there were elections and the emergence of a new democratically elected government in 1994. Thirdly, the 1991/92 and 1993/4 droughts impacted on the economy with severe public financial implications in a period of increasingly chaotic budgeting (Figure 4.6).

Public expenditure grew rapidly, up 30% in real terms between 1991/92 and 1994/95 (Annex A Table 4.2).³⁹ This unsustainable growth was reversed in 1995/96 under the terms of an agreement with the IMF. The growth in total expenditure was driven largely by increased recurrent expenditure (up 34%). It was associated not only with the drought, but influenced also by electoral considerations and then the actions of the incoming democratically elected government to honor its commitments, notably to provide immediate universal free primary education in 1994/95. The composition of expenditure also shows the share of social and community development expenditure expanding sharply at the expense of economic services, a large proportion of which is support to agriculture. These increases in expenditure were unsustainable and under external pressure there was a sharp contraction in public expenditure in 1995/6.

The revenue side of the budget shows the effects of drought, probably accentuated by fiscal laxity in the election year. Revenue declined by 9% in 1992/93 and again by 11% in real terms in 1993/94. Parastatals also got into more severe financial difficulties.⁴⁰ The outcome was a soaring deficit, which increased by over 230% between 1991/92 and 1994/95. The overall deficit (including grant aid) as a proportion of expenditure rose from 23% in 1991/92 to 36% in 1994/95. The consequences were extremely inflationary borrowing from the Central Bank. The rate of inflation went from 12.5% in 1990/91 to 36% in 1992/93, rising to 66% in 1993/94 and 75% in 1994/95. The combination of fiscal measures and more favorable agricultural performance led to temporary stabilization in 1995/96 and 1996/97.

³⁹ The high rates of inflation in the 1990s and changes in the composition of expenditure make it difficult to apply appropriate deflators to budgetary aggregates. Public expenditure reviews (PER) have focused on the shares of public expenditure in GDP and relative shares of different components within total expenditure – see for example the PERs by the Government of Malawi (2000a) and the World Bank (2001).

⁴⁰ ESCOM, the electricity provider suffered from a failure of tariffs to rise in pace with inflation and non payments peaked in 1992. ADMARC deficits burgeoned because of subsidies on sales and expanded purchases in response to the good harvest in 1993/94.

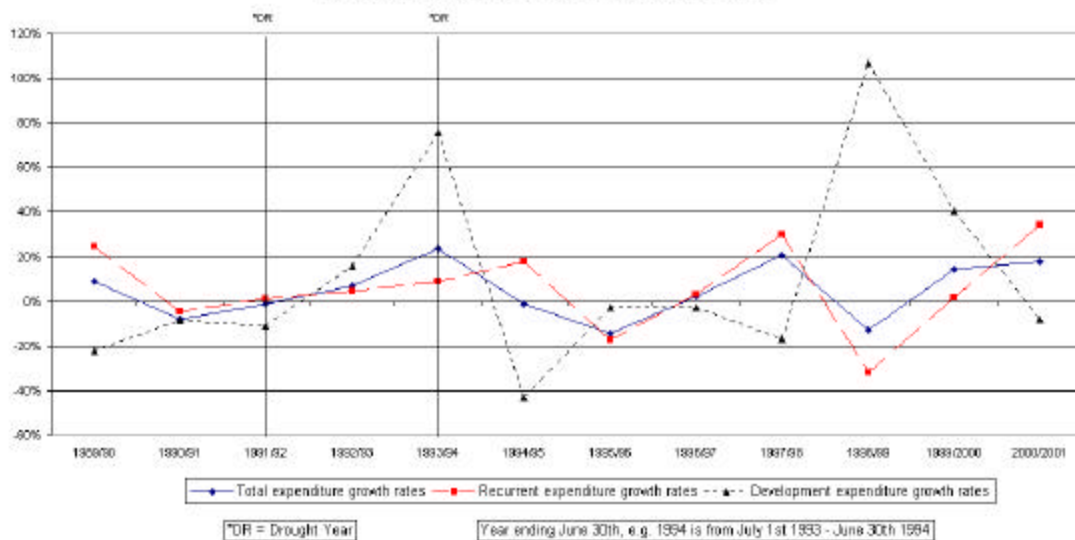
The fiscal picture is further complicated by the behavior of external donors during the transition to a democratically elected government that coincided with the two droughts. Grant aid, including relief, declined by 66% between 1989 and 1991/92, because bilateral donors had halted development aid for governance reasons. Although international lending was sustained, this obliged the government to meet the financial consequences of the 1991/92 drought to a greater extent through monetary expansion and domestic borrowing. Donors responded to democratization by massively increasing both grant and loan assistance in 1994/95. However, this increase in external funding was insufficient to cover the budgetary deficit, as expenditure rose unsustainably and revenue was adversely affected by the drought's impact on the economy.

Even at this admittedly superficial level of discussion, it is apparent that it is extremely difficult to isolate the budgetary implications of drought. The drought was only one major factor contributing to a near chaotic budgeting situation that resulted in hyperinflation and indirect negative consequences for the whole economy, with severe social costs.

Since the continued impact of these severe drought shocks that coincided with democratization, the public finances in Malawi have continued to be extremely volatile. Temporary periods of stabilization have been followed by a relaxation of budgetary discipline, which coincides with the election cycle. After stabilization in 1995/96, there was a loosening of fiscal constraints in 1996/97 and 1997/98 preceding another election. There was then a severe contraction in total expenditure in 1998/99 under external financial pressure. Total and recurrent expenditure again began to rise in 1999/2000 and was provisionally budgeted to expand in 2000/01 in expectation of benefits from the Highly Indebted Poor Countries (HIPC) debt relief. Upward pressures were amplified in 2000/01 by a poor agricultural year and doubtless will be exacerbated again by the food crisis in 2002.

There were also very large movements both between development and recurrent spending (Figure 4.7) and within these spending categories (Figure 4.8 and Annex A Tables 4.2.1 and 4.2.2). There was, as already noted, a shift in priority to social sectors, especially education, going on whilst government also provided additional relief and support through social safety nets in the drought affected years. Economic services, particularly agriculture, declined in importance from the late 1980s. There was a temporary increase in each of the drought years with special programs of assistance (Figure 4.8) there was then a small recovery in the late 1990s, partly because of the TIP (Annex A Table 4.2.3).

Fig 4.7: Malawi Volatility of public expenditure, 1990 - 2001

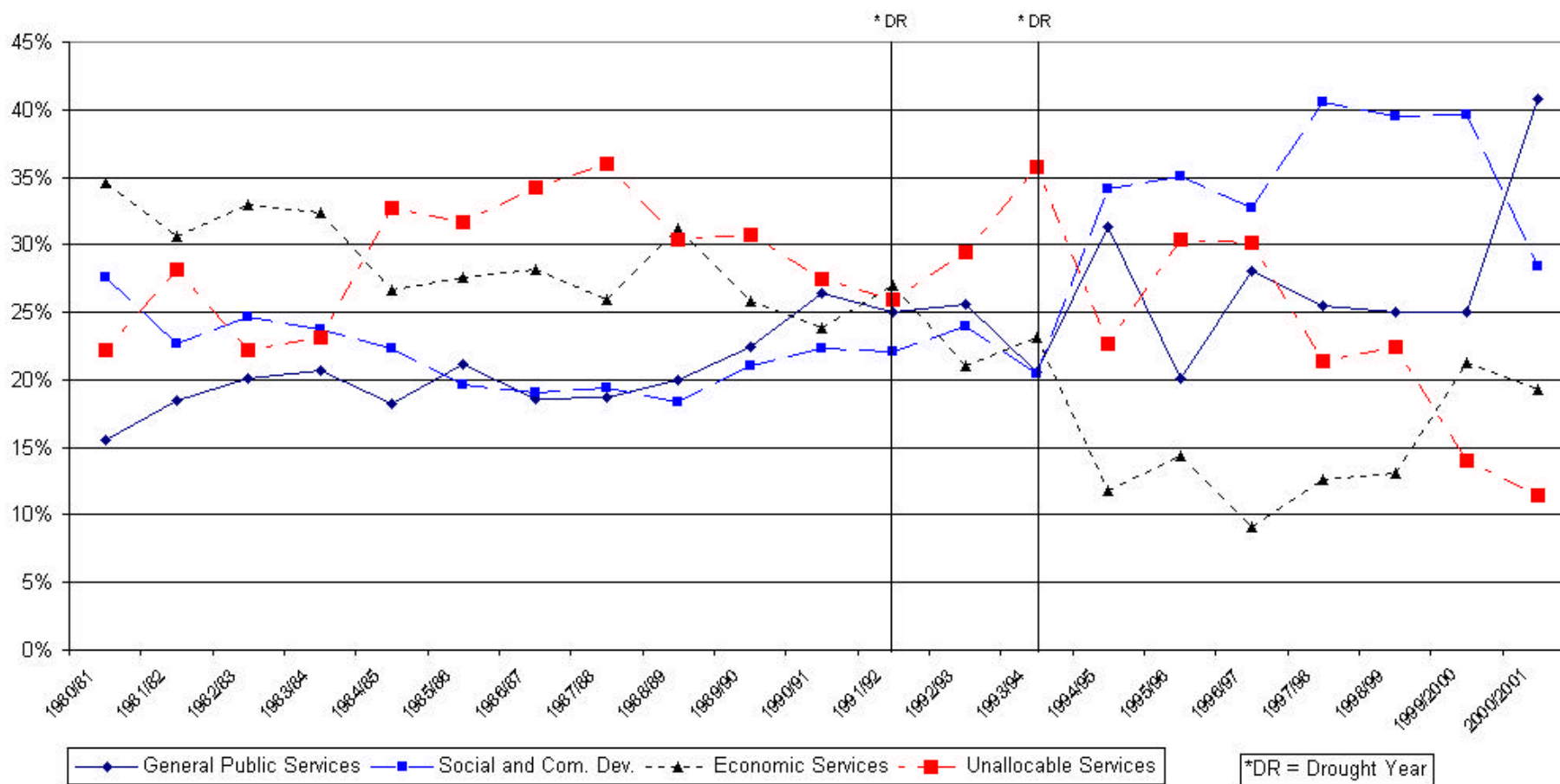


However, part of the shifting balance between development and recurrent expenditure is formal rather than substantive. There was a reclassification of expenditure in 1998/99: much social expenditure was reclassified as developmental, doubling the apparent level of development expenditure, making comparisons over time more difficult⁴¹. Also as one economist in the Ministry of Finance put it: "The distinction between recurrent and development expenditure is largely one of sources". Development is largely aid funded, and includes a large element of budgetary support. The short-term behavior of external aid, which has been influenced by political and governance issues as well as directly economic and humanitarian considerations, has also been an important factor in the volatile public finances of Malawi.

The droughts of 1991/92 and 1993/94 were major factors contributing to an extended period of macro instability and chaotic public finances. However, because of coincident timing, it is difficult to separate these fiscal impacts of drought from the effects of other political, governance influences, including donor actions. The public finances have continued to be very volatile, with upward pressures on expenditure and apparently increasing sensitivity to agricultural sector performance. Comparative analysis of real levels of expenditure are made more difficult by high levels of inflation and reclassification of spending. The 2000-2001 public expenditure review focused on changes in the share of public expenditure in GDP and the composition of expenditure (Government of Malawi, 2000; World Bank, 2001). There is apparently considerable short-term reallocation within and between expenditure categories and so the assessment of the fuller impact of shocks, interrelated expenditure surges and then, under external donor influence, subsequent contractions (Benson and Clay, 2002).

⁴¹ Figure 4.8 and Annex A Table 4.2.3 show the movements within total expenditure by broad category. The increased expenditure on economic services (agriculture) in drought years and the switch to social sectors through the 1990s are more clearly revealed at this level of aggregation. Annex A Table 4.2.2 shows that leap in development expenditure, but total expenditure on social sectors, including both recurrent and development expenditure, is little changed (Figure 4.8 and Annex A Table 4.2.3).

Fig. 4.8: Malawi Structure of public expenditure by category 1981 - 2001



Chapter 5.

Long-Lead Climatic Forecasting and Southern Africa

At a regional level the impetus for forecast development came from the 1991/2 and 1994/5 droughts. As a result of these events, the Southern African Regional Climate Outlook Forum (SARCOF) was initiated. SARCOF produces consensus probabilistic seasonal rainfall forecasts for the Southern Africa region. For the 2001/2002 season the forecasts were broadly in line with the observed outcome on the large scale. However, the precision or quality of the forecasts is limited on the smaller scale and downscaling is a problem. The focus in the region is often on forecasts of below normal rainfall, with insufficient appreciation that above normal rainfall can be costly. After the 1997 El Niño event the Southern African region was partly influenced by La Niña. By early 2002 a new El Niño was forecast. Models suggested a weak to moderate El Niño but with considerable uncertainty about its impacts. This forecast reinforces concerns about food security into 2003. Whilst a precise and robust valuation of the forecast process at a regional level is impossible, there is no doubting its usefulness. Costing of climate forecasts value is also difficult, but an estimate of around US\$5 million a year may be realistic.

5.1 Background: the usefulness of climatic forecasting

The investigations in Chapters 3 and 4 confirm that climatic variability results in substantial economic costs for the countries of Southern Africa generally, and specifically for Malawi. The direct costs associated with fluctuating and erratic rainfall in terms of reduced production of rainfed cereals, and especially maize, are easiest to establish and broadly to quantify. Similar analysis for export crops such as tobacco, tea and coffee would also be relatively straightforward to quantify, probably by focusing on rainfall variability for the more restricted areas where these crops are extensively cultivated. Impacts on larger scale commercial agriculture are relatively easier to measure (Bohn, forthcoming). Previous investigations also quantified the effects of extreme drought, especially in 1991/92, on water-using industries, particularly hydro-electricity generation (Box 2).

The wider economic consequences of climatic variability are readily apparent, but more difficult to quantify precisely, because of other influences on economic performance. The impacts of climatic factors change from event to event, depending on the pattern and severity of each climatic anomaly, which has distinctive features. The scale and form of impacts also depend on the structure of the affected economy and on the changing political and economic environment. This specificity of impacts is most clear at a country level, as reflected in the brief review of Malawi's economic performance (Chapter 4).

The obstacles to quantification of the value of climatic forecasting are formidable. Nevertheless, it is clear that climatic shocks have considerable negative impact on the countries of Southern Africa. Only the readily discernible impacts, as reflected in changes in the levels of activities in agricultural production and national income accounts are examined in Chapters 3 and 4. These suggest that the minimum costs of only the three major droughts of the 1990s were in excess of US\$ 2 billion for maize production alone. The impacts of the 1991/2 drought suggest possibly two to three times that sum in terms of reduced agricultural sector GDP and impacts on the wider economy. No attempt has been made to quantify the costs of extremely high rainfall events and associated flooding. But the analysis in Chapters 3 and 4 of cereal production and rainfall relationships suggests large agricultural impacts as well as flood damage and disruption. There were also additional costs of climatic shocks in terms of reduced investment, including in human capital. A wider social assessment, taking into account evidence from social and health assessments for specific shocks, suggests that each event represented a setback to poverty reduction goals and caused considerable suffering and distress. A lower limit estimate of the social costs of extreme events, based largely on the direct costs of the major droughts is around US\$10 billion during the 1990s implying annualized costs of

over US\$1 billion. So even a modest reduction of say 1% in such economic costs and social damage would be of considerable value at a regional level.

Efforts to quantify the potential value of forecasts have juxtaposed evidence of considerable drought-associated costs with suggested ways in which forecasting could reduce these losses. There may be specific cases of decisions that could have been improved with better information. For example, the poor management of grain reserves in Zimbabwe in 1991, is an experience that has uncomfortable parallels to what happened in Malawi in 2002 (see below Section 6.4).⁴² A survey of potential users may also indicate a wide range of possible cost savings that can be incorporated into a complex model (Harrison and Graham, 1998). Others have simply listed such potential benefits (Gibberd and others, 1995). A difficulty in realizing these benefits is that in most circumstances making available probability information about weather prospects may not be sufficiently persuasive to alter decisions that reflect many influences. Nevertheless, it might be argued that such information is a necessary condition for improved decision making. The difficulty lies in demonstrating that that such benefits are resulting from the initial efforts at climatic forecasting, or are realizable.

These conclusions imply that there is a formidable task in providing an overall framework within which the usefulness of climatic information, and more specifically the value of forecasting, can be assessed. As others have previously recognized, climatic information has a potentially useful role in reducing the considerable costs associated with climatic variability.⁴³ Such benefits could arise in three ways. First, seasonal climatic forecasting could improve decisions that *anticipate* the consequences and so reduce the costs of extreme events. The build up and draw down of public stocks of grain is the obvious example. Second, information made available as events in real time unfold could improve management of responses by ensuring that those directly affected, such as farmers and managers of water systems, know in a more precise and timely way about what is happening to weather, growing conditions and hydrology. Such timely information also assists government and international organizations in responding to emergency situations. Thirdly, investment decisions for water-dependent systems, including both design and possibly retrofitting, should incorporate an assessment of the probabilities of climatic anomalies. Eventually, multi-year forecasts may become available that could also assist production and investment decisions. The practicality of achieving these benefits requires a careful assessment of both the potential and specific actual uses of climatic information at a regional and country level, as well as the constraints on applications.

5.2 Regional level climatic forecasting

At a regional level the droughts of 1991/92 and 1994/95 gave impetus to wider attempts to improve drought risk management, involving regional institutions, national governments and the international community. Then there was considerable progress towards better integration and strengthening of meteorological systems within SADC. The regional Drought Monitoring Center was established. The issue of drought risk management was considered in several Consultative Group meetings in Paris in early 1995. These country reviews were part of the international response to the drought that had affected Malawi, Mozambique and Zambia in 1994, and which was then affecting countries further south, especially Zimbabwe, in 1995. These

⁴² In calendar year 1991 Zimbabwe, already affected by localised drought, nevertheless exported 407,000 tonnes, equivalent to 2/3rd of its opening stocks. These exports included 124,000 tonnes in July-December, when there were already strong indications of a severe regional drought associated with the intense El Niño event. In early 1992, with almost exhausted maize stocks, Zimbabwe was obliged to import commercially at additional costs of at least US\$ 15 million more than proceeds from the grain exports in the second half of 1991. Afterwards, concessional finance and food aid were used for further imports. The government export decisions were made in the context of beginning to implement a structural adjustment agreement, and political considerations – making and honouring agreements that assisted neighbouring Zambia and Malawi (Glantz, 1998; SADC, 1993).

⁴³ See for example Van Aalst and others (1999) and the earlier works cited by them, as well as Gibberd and others (1995) and Harrison and Graham (1998).

reviews were initiated by the (then) Southern African Department within the World Bank, seeking to learn lessons for economic policy and international development cooperation from the 1991/92 drought. The reviews highlighted the need to strengthen climatic monitoring, ensuring rapid and sound assessments of an evolving drought (World Bank, 1995a; 1995b).

A formal process for consensus, based on 'long-lead' or seasonal climatic forecasting, emerged during the 1997/98 El Niño alert, the Southern African Regional Climatic Outlook Forum (SARCOF). This *ad hoc* body links national meteorological departments in the SADC countries with wider global expertise, including the international institutions and national centers such as the World Meteorological Organization (WMO), the National Oceanic and Atmospheric Administration (NOAA), the UK Hadley Center and the International Research Institute for Climate Prediction (IRI), which were taking the lead in climatic modeling and long-lead forecasting.⁴⁴ The main features of these different but complementary forms of forecasting are explained in Box 4 as a background to considering what is done specifically for Southern Africa.

Box 4: Climate Forecasts

Climate forecasts are the prediction of various aspects of the climate of a region during some future period of time. Climate predictions are generally in the form of probabilities of anomalies of climate variables (e.g. temperature, precipitation), with lead times up to several seasons (AMS, 2000). As a projection of future climate, climate forecasts can include information on the expected average, on the frequency of extremes or the timing of a seasonal event such as the onset of the rains. Seasonal forecasts tend to refer to the nature of a specified season - in this instance the wet season. Seasonal rainfall forecasts most commonly refer to expected rainfall anomalies - that is deviations from the mean/average conditions, as well as containing information about specific events. The time period between a forecast being produced and the period forecasts is known as the lead time.

Climate forecasts can be derived from either statistical or numerical models:

- Statistical forecast techniques use historical data to predict the climate. Univariate methods use historical rainfall data whilst multivariate forecasts are made using other variables that appear to correlate with rainfall, such as sea surface temperature or pressure. Statistical models depend on correlations between predictors (such as sea surface temperatures) and the predictands (such as rainfall).
- Numerical models work by predicting the evolution of the interaction between the surface and the atmosphere. Data are collected about the conditions at the surface - e.g. sea surface temperatures, and atmospheric conditions. These data are combined to give an indication of the current state of the ocean-atmosphere system. A computer model of this system is then run using these conditions as a start point. As the model runs it gives an indication of the possible state of the system for a future period - the forecasts. The model is run a number of times to give all the possible outcomes and give an indication of the uncertainty surrounding the forecast.

The SARCOF forecasts are made seasonally, prior to the summer rainy season, in September for October - December and for January - March. In December, after the rains have usually begun, the January - March forecast is reassessed. The climatologists have chosen to provide forecasts in terms of three broad

⁴⁴ The SARCOF was initially supported by NOAA as part of a wider global initiative for strengthening regional climatic forecasting in response to the threat of weather-related damage from the 1997 El Niño event (IRI, 2001).

probability bands (terciles) for below normal; near normal; and above normal total rainfall for the period forecast. The forecasts include all SADC countries and are divided spatially into zones of similar rainfall response. The number of zones and their spatial form change with each forecast. The regional forecasts rely heavily on forecasts coming from global statistical models that reflect particularly the behavior of ENSO, with additional detail from forecasts made by the National Meteorological Services.⁴⁵ The zonal forecasts take into account what is known about up-to-date information on air mass movements, especially the Inter-Tropical Convergence Zone (ITCZ), and changes in local and global SST. An example of the SARCOF forecasts, that for 2001-2002, is shown in Figure 5.1.

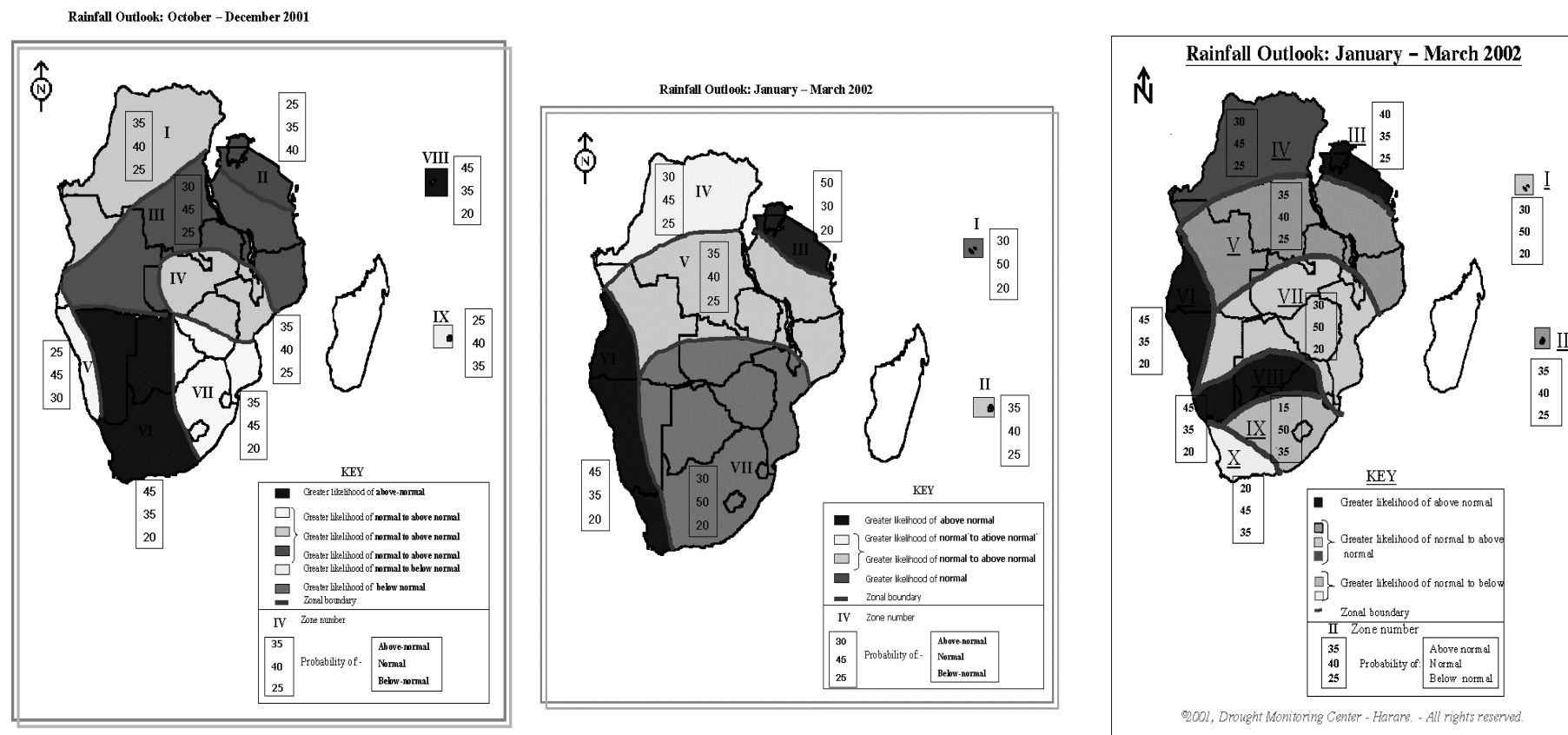
Seasonal forecasts for 2001-2002 with special reference to Malawi

The initial forecast in September 2001 comprised five zones on the mainland of Southern Africa in two periods, October - December 2001 and January - March 2002. Malawi overlapped two zones, with the greatest probability for both zones being near normal for both periods. The seasonal probability assessment was accompanied by a caution about short-term erratic rainfall. The revised forecast released in December for January – March 2002 included eight mainland zones, with the forecast for Malawi again split between two zones exactly as before, and no change in probabilities. The outcome specifically for Malawi was broadly in line with forecasts: total rainfall at DMS stations ranged between 80% and 110% of the long-term average level (DMS, 2002). However, the intra-seasonal distribution at some stations, and so in some areas, was less than optimal with dry periods during the critical period for maize grain formation in February (Box 1).

The precision or quality of the SARCOF forecasts is still very limited. The probabilities are also more difficult to assign for zones further away from the core area of southern east Africa. For example, in the 2001/02 forecast the assigned probabilities vary from 20-60%, with around 40-50% probability for the most likely outcome band (Figure 5.1). The forecasts are difficult to downscale and imprecise about the risks of erratic rainfall patterns that are critical to crop performance. Implicitly the focus of attention has continued to be on the big question – is there likely to be a major drought? – the risk of widespread, abnormally low rainfall that statistically is likely to be associated with a severe El Niño event.

⁴⁵ For example, NOAA produces regional forecasts for Sub-Saharan Africa, using a statistical model (Thiaw and others, 1999).

Figure 5.1 SARCOF forecasts



October - December 2001 (Left) January-March 2002 (middle) and January-March 2002 updated (right)

El Niño and Uncertainty

Both the usefulness and limitations of the statistical models underpinning forecasts and the process, as it has evolved so far, are indicated by experience since 1997/98.⁴⁶ In early 1997 there was a global weather alert because of the extreme El Niño event that rapidly developed. Climatologists adopted a model for a consensus approach to making risk assessments in the light of widespread concern within the region, fed by information from international sources and media speculation. The meteorologists in what became known as SARCOF-1 were broadly correct in emphasizing that the 1997 El Niño event did not necessarily imply a severe regional drought, but that the risk was sufficiently high to justify widespread drought preparedness measures. In the event, conditions in the Indian Ocean became dominant later in the season, causing extensive and near normal rainfall in northern and eastern zones, including Malawi and Mozambique.

Many users of forecasts such as commercial farmers felt and still think that the meteorologists were 'crying wolf,' or exaggerating the drought risk in 1997/98. This is despite the fact that, as shown in Figure 3.1 and Table 1, there was a drought in 1998, if less severe than 1994/95. Part of the difficulty faced by forecasters is the widespread dissemination of alarmist reports through the media about the 1997 El Niño (Thomson and others, 1998).

The twice yearly SARCOF meetings in the three subsequent years, 1998/99, 1999/2000 and 2000/01, assigned and then reconfirmed high probabilities of normal or normal to high rainfall, due in part to the La Niña event then underway (Figure 5.2). The forecasts were broadly correct, but imprecise. Perhaps, more importantly, there was insufficient appreciation across the region that above normal rainfall levels could be costly – causing life-threatening and damaging floods and also some reduction in agricultural output.⁴⁷

The 2001/02 season further highlighted the limitations of the long-lead climatic forecasting process as developed so far. Initial indications, including the absence of a severe ENSO anomaly (either El Niño or La Niña), were interpreted in September 2001 as implying a high probability of a relatively normal year. There was little evidence to the contrary at the review in December 2001, but as the season evolved it was characterized by erratic rather than low rainfall in some areas. However, the scale of this variability is below that of the broad zones for which probabilities were assigned.

Positively, the greater attention now paid to forecasting and monitoring weather through the season ensures that scientific data on a ten daily basis is more rapidly available to inform assessment and decisions. Global climatic developments are also watched closely and assessments are quickly disseminated through the Internet.

⁴⁶ The SARCOF seasonal risk assessments since September 1997 in summary forms are all reported on the regional DMC web-site <www.dmc.co.zw/> .

⁴⁷ The important exception was Mozambique, where there was concern that the SARCOF forecasts were underestimating the risk of extremely high rainfall and associated floods. It was suggested that the forecasters were being too cautious in anticipating an extreme event because of reactions to what had happened in 1997/98 (Christie and Hanlon, 2001).

Figure 5.2: Eastern equatorial Pacific SST Anomaly 1998-2002 from the last El Niño to current conditions.

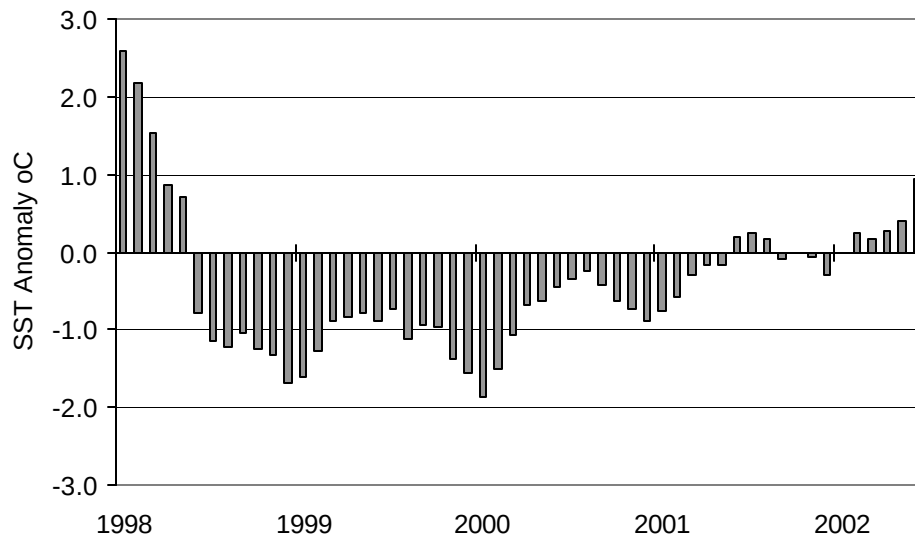
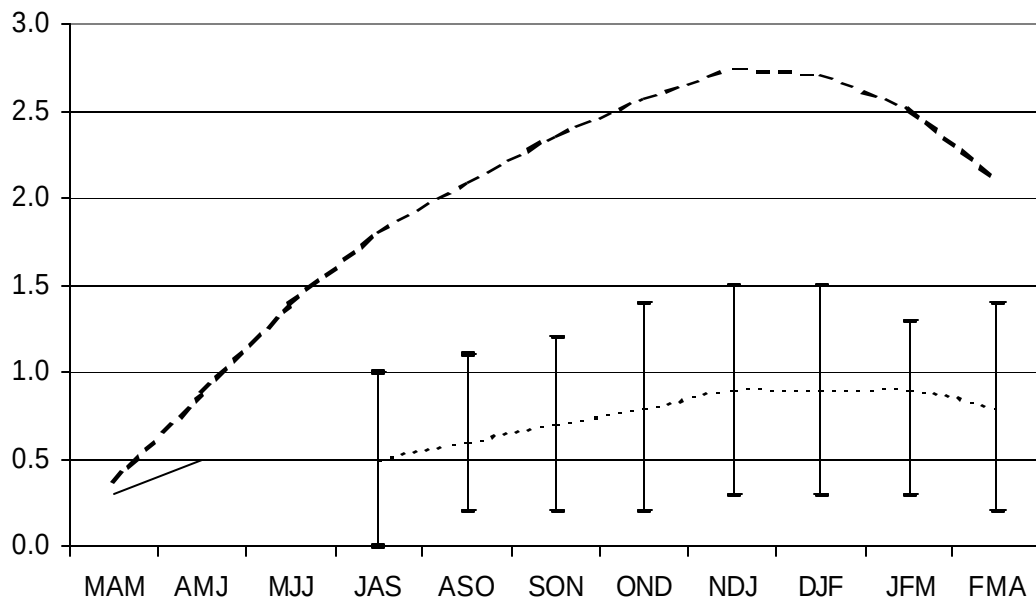


Figure 5.3: Summary of SST anomaly forecasts for the eastern equatorial Pacific March,-May 2002 to February -April 2003.



Dotted line- average of forecast models with error bars indicating the range of forecasts;
Solid line- actual conditions; Dashed line- actual conditions for the 1997-98 El Niño.

Since the 1997/98 El Niño the Southern African region has been partly influenced by a particular long-lived La Niña event, often associated with above average rainfall (see Annex B). As shown in Figure 5.2 SST in the eastern equatorial Pacific were cooler than average until the start of 2002 when there were initial indications that an El Niño event might be developing.

Figure 5.3 shows how forecasts for the eastern Pacific are used to monitor El Niño.⁴⁸ As can be seen, the consensus, or average of no less than 9 numerical forecasting and 6 statistical models in May-June 2002 was that conditions were moving towards warmer temperatures in that region (Box 4). This indicated that there was a high probability of an El Niño event occurring at the end of 2002. However the error bars, showing the maximum and minimum forecasts for each month, also indicate the uncertainty that surrounded this prediction. The models suggested a weak to moderate El Niño event, which is illustrated when the forecasts are compared with the last strong El Niño in 1997/98. A weaker event is more likely to be associated with less severe impacts on weather in Southern Africa.

The fact that the developing El Niño event was likely to be weak complicated the seasonal forecasting issue. While El Niño is generally considered to have a negative impact on seasonal rainfall amounts in the region, the impacts of each event are different. The two most recent El Niño events, 1991-94 and 1997, were both unusual in terms of their longevity and strength respectively. Therefore it is likely that there is a skewed impression of what an El Niño might mean for this region.

Thus the uncertainty surrounding the forecast of El Niño itself, coupled with the uncertainty of how an event might impact, was a severe limitation on predicting what El Niño might mean for the 2002/2003 wet season. There was also the additional complication of how other influences on the rainfall, such as the Indian Ocean, were evolving.⁴⁹

The uncertainty about the agro-climatic situation within the region in 2002 enhanced the significance of the internationally organized national crop assessments undertaken during April-May 2002, in response to an apparently poor and rapidly deteriorating food security situation in several countries. Uncertainty, including the possible increase in the risk of an El Niño related rainfall abnormality in 2002/03, reinforced concerns about food security into the next year. What decision-makers would like is a canonical prediction – this climatic event will lead to this pattern of weather in the coming months (Thomson and others 1998; van Aalst and others, 1999). Instead the forecast models were saying that decisions in the coming months about an already difficult food security situation had to be made in circumstances of more than usual uncertainty.

5.3 The value of regional forecasting

It is impossible at present to place a robust and precise value on the climatic forecasting process as it has evolved so far at a regional level. Forecasting has become an integral component of the wider network of information systems that support regional and international level institutions involved in managing the economic and social consequences of climatic variability. However, the precise contribution of forecasting cannot be readily isolated. Nevertheless, a qualitative assessment of its usefulness is possible.

- The existence of a scientific consensus process for climatic risk assessment is necessary, because of the rapid diffusion of often incomplete, misleading accounts of global developments through the media, including satellite and global television.

⁴⁸ Forecasts from nine numerical models and six statistical models are indicated. The data are taken from http://iri.columbia.edu/climate/ENSO/currentinfo/SST_table.html.

⁴⁹ This uncertainty has been reflected in reports on the web-sites of IRI, NOAA and those such as SADC's DMC that draw upon the findings of global research centers.

- The SARCOF process has provided a vehicle for the reintegration and strengthening of meteorological expertise within the region. The meteorological capacity created in the colonial era had been fragmented following independence and cooperation was obstructed by conflict in Angola, Mozambique, Namibia, Zimbabwe and, until the early 1990s, by the isolation of South Africa.
- There is now an established annual cycle for focusing on climatic variability and assessing drought risk, which feeds into wider decision processes in the public and private sectors.
- The evolving weather situation during the annual agricultural cycle is now monitored more closely and reported in a more comprehensive way within the region.
- Regional climatic forecasting has so far been a learning process: each year juxtaposing formal risk assessment and actual outcomes draws attention to further complexities in the climatic system and has suggested ways to refine the assessment.

At the same time there is some sense of disappointment. First, the discovery of El Niño teleconnections with weather and agricultural performance in Southern Africa created unrealistic expectations in the mid-1990s about the power and precision of climatic forecasting. That is apparent at a national level in Malawi, where an optimistic assessment of the potential contribution that could be made by long term forecasting was premature (Gibberd and others 1995; World Bank, 1996). Secondly, the full extent of the increasing sensitivity of the region's agricultural economy and the vulnerability of the population and infrastructure to flood, not just drought, and to climatic variability more generally had not been appreciated.

Forecasting costs

The costs of maintaining the regional process are modest, especially because of advances in telecommunications and information technology. These costs include the small regional secretariat of the Drought Monitoring Center (DMC) and the funding of the SARCOF consultative process. However, its viability also presupposes that national meteorological services have the human resources and funding to contribute to the process. There are also implied training costs to ensure that the products can be utilized within the region.

The costing of climatic forecasts for Southern Africa is difficult because these are only one of the products of a global infrastructure of meteorological institutions. 'The climatic forums are a small tip on a large iceberg of supporting institutional infrastructure, and the direct costs of the forum meetings are only part of the total costs of implementing them' (Dilley, 2001).

In undertaking this study it was not possible to assemble a complete set of costs. But the approximate scale is indicated by the following selected set of annual costs. The direct costs of SARCOF are of the order of US\$ 100,000 currently, with individual meetings costing US\$ 20,000 – 40,000 (Dilley, 2001). At an international level the approximate global forecasting costs of IRI are US\$ 1.5 million and of the UK Met Office's Hadley Center, US\$ 500,000 annually. The South African Weather Bureau costs for Southern Africa alone are US\$ 1 million. However, only a small part of the costs outside South Africa could be directly attributed to forecasting specifically for Southern African (Bohn, forthcoming).

Costs at a country level are illustrated by the relatively small Malawi Department of Meteorological Services (DMS), which had approved annual recurrent costs of only US\$ 400,000 in 1997/98 (26% of the amount requested). Only about 5% of the budget was directly attributed to climatology (DMS, 1999). The World Bank project for strengthening DMS represented some US\$ 500,000 over 4 years (See Box 5). Each country in the region has its own meteorological services, with probably a similar cost structure to Malawi, apart from the much bigger South African service. There is also the regional DMC, with relatively modest costs, funded by SADC. Overall, and taking these figures into account, the estimate of total costs of US\$ 5 million a year by Harrison and Graham (1998) for climate forecasting in Southern Africa would seem to be realistic.

These costs are modest, but largely recurrent, and so pose an issue of sustainability. So far the costs of developing forecasting capacity have been, apart from South Africa, largely funded by grants from a limited number of agencies, primarily USAID and NOAA. (Dilley, 2001). There are, in addition, at a country level, the costs of developing and maintaining a capacity to utilize forecasts and ensure that the necessary complementary meteorological activities are undertaken. At a national level, meteorological services have received regular support under UNDP/WMO country projects, and other international projects, as well as bilateral assistance from many donors for equipment and training.

To summarize, the economic costs inflicted on Southern Africa by climatic variability are considerable. Quantification of only direct costs in terms of cereal production losses and associated cereal imports suggests a lower limit for total cost equivalent to at least US\$1 billion a year. Climatic forecasting has become a still modest, but necessary part of the network of information systems that supports public action to minimize the social costs of climatic variability. The financial cost that can be attributed to the whole forecasting effort for Southern Africa is around US\$5 million, small in comparison with the economic costs of climatic variability. These financial costs are also spread across meteorological services and research institutions inside and outside the region. The SARCOF process is therefore needed to ensure that all these contributing institutions are linked together to ensure the continuing viability of regional forecasting.

It is important that regional climatic forecasting is sustained as a learning process, closely linked into global research. Long-lead forecasting is still in its infancy, and climatic research is making rapid progress. For example, research being undertaken in Southern Africa and elsewhere will eventually allow the fuller inclusion of oceanic influences from the Indian Ocean and the South Atlantic into forecasting models (Landman and Mason, 1999).

Climatic monitoring and forecasting is clearly a regional and, practically, an international public good. Forecasts and up to date reports on recent weather as a form of knowledge are 'non-excludable' and 'non-rival', the necessary characteristics of public goods.⁵⁰ The benefits are not just confined to the region. The private sector outside the region can use information, for example in agricultural trade. The international community of donors and financial institutions is also drawn into managing the effects of climatic variability. The associated expenditure is potentially very large and could be reduced through forward planning of risk management, as discussed in relation to Malawi in Chapter 6.

⁵⁰ Non-excludable implies that once provided nobody in the world could be prevented from consuming or benefiting from the existence of a public good. Non-rival means that consumption or use by one person does not reduce the amount available for the use by others (Cornes and Sandler, 1996).

Chapter 6.

Climatic Forecasting in Malawi

Efforts are being made to strengthen long term forecasting capacity within Malawi and overcome weaknesses caused by almost a decade of inadequate funding of meteorological services. The potential applications of seasonal and intra-seasonal forecasting include many fields, but the possible benefits, preconditions for and constraints on use need to be carefully considered. While forecasts have considerable potential value, users often note that their application is limited by features of the forecasts and also users ability to respond. The 2002 food crisis highlights both possibilities and current problems in effectively utilizing forecasts.

6.1 Strengthening national forecasting capacity

A recurrent conclusion of reviews about the uses of climatic information has been the difficulty in quantifying more precisely the value or benefits of climatic forecasting (Dilley 2001). Potential benefits from improved management of drought and, more recently since the Mozambique floods of 1999 and 2000, of climatic variability, are considerable. The measurement of either potential benefits or the actual benefits achieved so far from investment in strengthening climatic information systems is more problematic. The most recent review also concluded that increasing the usefulness of climatic forecasting in particular would depend critically on the strengthening of African national meteorological systems in their climatic monitoring and research work, as well as in dissemination (IRI, 2001).

In Malawi the potential benefits of 'strengthening the information base for drought risk management' were specifically recognized in the review of the 1991/92 and 1993/94 droughts and their wider implications :

'There is an overwhelming case for investing in improving the spatial and temporal reliability of these (seasonal and within season) forecasts, and for establishing the necessary dissemination systems to ensure that these forecasts are effectively reaching potential users' (World Bank, 1996, p.14).

This review resulted in the inclusion of a pilot component on 'long-lead climatic forecasting' in the World Bank Environment Management Project (Box 5). This was apparently the first such an initiative using IDA credits in Sub-Saharan Africa. The investment of soft loan funds in strengthening scientific information implies that there are tangible net social benefits.

Meteorological services in Malawi, and in other Southern African countries are only just beginning to respond to new demands for climatic information, which implies broadening their activities. Traditional activities included satisfying the forecasting and real time information requirements for supporting aviation services, the collection of meteorological data that feeds into the WMO, as well as general weather forecasts. New and expanded activities include providing additional products, such as hydrological assessments, and making more locally specific the climatic forecasts coming from global and regional sources.

The preparation of the World Bank project and the subsequent review of climatic services which might be provided by the DMS also uncovered more general institutional weaknesses that would have to be addressed before it could play an enhanced role in climatic investigation and dissemination of information (Ward, 1999). The DMS had suffered the effects of inadequate and unpredictable funding, including virtual absence of investment since the early 1990s, so improving the range and quality of climatic products

required general strengthening of the department. This included the replacing and upgrading of IT equipment. For example, in 1991 access had been lost to historical meteorological data, the primary climatological resource of the DMS, due to a computer equipment breakdown. The continued lack of access to these data in 2002 was a constraint on the investigations in this study and climatic research more generally. Both climatological investigations and dissemination activities were narrowly constrained by lack of adequately trained middle level staff, as well as recurrent funds for travel. Remedying these weaknesses has taken four years, 1998-2001. In the meantime there have been severe practical limitations on new product development and dissemination.

Box 5: Institutional Strengthening - the Department of Meteorological Services (DMS) in Malawi

The Staff Appraisal Report for the Environment Management Project recognizes the Malawi agricultural economy's vulnerability to variations in rainfall and temperature. Furthermore, the IPCC anticipated increased climatic variability so that Malawi would then suffer increased incidence of drought and changing weather patterns. It was anticipated that 'meteorological monitoring and drought proofing would become essential tools in helping Malawi to adapt to longer term trends, and would also have short term benefits in helping to smooth out fluctuations in agricultural output and GDP.' (World Bank, 1997, para. 1.14).

'Long lead forecasting', that is seasonal and within season forecasts from one to several months ahead, are already in use in many agricultural economies around the world, and it was anticipated that the component would enable the DMS to develop such forecasts, tailored to the needs of key users, some of whom could be expected to pay for such information.

The project component envisaged modest total expenditure of US\$518,000 (3.8%) within a US\$13.7 million project over a five year period, including equipment, technical assistance, training, studies (70%) and recurrent expenditure (30%).

The project has successfully supported training outside Malawi to enhance professional capacity and technical upgrading. But severe budgetary pressures meant that the project has effectively cross-subsidised recurrent expenditure on existing activities including O & M.

The project was completed in mid 2002. There is a continuing lack of public funds to effectively utilize the DMC's enhanced capacity, and so there is a typical issue of post-project institutional sustainability.

Sources: World Bank 1997, Ward 1999

The World Bank project funded a first systematic survey of potential users and their requirements (Mkandawire and others, 1999). A follow-up review of potential fee paying customers indicated that these would require additional client dedicated services (Ward, 1999). But before DMS capacity had been strengthened, little could be done. This review also led to the establishment in 2001 of a National Meteorological Users' Council with a private sector chairperson, with the intention of strengthening links with users. Like other such *ad hoc* national councils, it has apparently not met with any regularity.

6.2 Potential applications of climatic forecasting

The discussion of the usefulness of climatic forecasting in Malawi continues to involve both those still limited things that are actually being done and then the potential applications. Experience in the five years since 1997 also provides more realistic indications of what is practicable now and in the near future. The range of potential applications that could contribute to improved management of climatic variability and extreme disastrous events is set out in Table 3. This table identifies the main type of user, the potential applications, the nature of the benefits, preconditions for achieving these benefits and risks of unsuccessful outcomes. Potential applications have been systematically reviewed in the surveys undertaken as part of the DMS project supported by the World Bank. The focus of that review has been on how enhanced capacity could provide services to user groups with a potential to pay (Ward, 1999), reflecting the concerns about financial sustainability. Most of the potential applications identified in Table 3 would be classified as a public good.

The largest and potentially most complex group of users is agricultural. Commercial farmers are as a group perhaps the most aware of agro-meteorological issues and many enterprises have a long history of collecting their own weather data. The highly specific needs of different groups and enterprises also makes it possible that some products tailored to their requirements could become fee based services (Ward, 1999). Meanwhile, as the account of the current state of services in section 6.3 indicates, they are regular, not uncritical users of existing, more generalized products.

Small farmers including those only involved in subsistence food production are the largest, but also the most difficult group to provide useful information for. Traditionally the task of relating to this group has been the responsibility of the Ministry of Agriculture and its extension staff. Indirectly, support services, marketing services as well as livelihood protection is directed to assisting this large and vulnerable group. However, with the spread of media and growing literacy, direct communication becomes a reality. This also raises the problem of preventing misinformation leading to inappropriate responses because of the vulnerability of most small farmers. Also there may be few practical ways in which forecasting applications can directly assist smallholders to respond to potentially unfavorable weather conditions (See below).

Within agriculture only crop production is considered in Table 3. This simplification can be justified because livestock systems are less important in Malawi. Livestock including nomadic pastoralism would require another parallel set of applications.

Water systems, as Box 2 suggests, include important uses including flood warning, hydroelectric system management and public water supply and disposal. The commercialization of utilities opens up the possibility of user funded, more specific applications. Hydrological conditions, such lake levels and ground water, are sensitive to cumulative precipitation over several years, multi-year forecasts would be of considerable value to both system management and investment decisions. If the apparent decadal quasi-cycles in rainfall were better understood, this would be of considerable value. However, information on flood and drought risk is again a public good.

The potential role of forecasting in national food security and wider macro-economic policy has been highlighted again by the 2002 food crisis, and this is discussed in Section 6.4. Before that, there is a formal summary of applications and related issues in Table 3, and this is complemented in Section 6.3 by a selection of views of potential users, obtained by the team during field studies in February, 2002.

Table 3: Potential Applications and Benefits of Seasonal and Intra-seasonal Climatic Forecasting in Malawi

Category of User	Potential Application	Nature of benefits	Preconditions	Risks
Part 1 Agricultural Production				
1. <u>Commercial Farmers</u>	<u>Seasonal:</u> Planning operations (area; crop/variety; water management Budgetary requirements and marketing output. <u>Intra-seasonal:</u> Input applications and timing Water management Harvesting dates	Increased certainty and reduced risk; Improved financial performance from optimizing operations to suit expected conditions.	Information available at time required and on correct scale. Marketing environment Supportive financial services	<i>Undue confidence in forecasts of normal conditions</i> - potentially more costly than warning of extreme conditions
2. <u>Small-scale/subsistence</u> a) Direct information via radio, TV, newspapers and market place	<u>Seasonal:</u> Choice of crop/ variety to suit rainfall. <u>Intra-seasonal:</u> Limited, ensuring correct application of fertilizer.	Increased certainty and reduced risk; -Improved food security in poor years -Improved marketable surplus in good years	Farmer resource base Effective extension advice (b) Effective support services (c) Predictable market environment (2.1;2.2)	<i>High cost decisions</i> - Limited resources - one planting a year. <i>Forecasts misinterpreted by media or farmers</i>
b) Agricultural. Extension Services	<u>Seasonal:</u> Dissemination of information to farmers and options available. <u>intra-seasonal:</u> Adjustment to earlier advice	Increase farmers knowledge of possible conditions and advice on varieties/types. Advise on response to changing conditions	Agr. Ext. Officers trained to interpret forecasts and implications and present advice in understandable way	Inaccurate advice given, Poorest extremely vulnerable
c) Agricultural Support Services (inputs, credit)	<u>Seasonal:</u> Condition specific selection of types, amounts, timing of seeds and inputs to supply <u>Intra-seasonal</u> Limited	Advance planning of supply and distribution Credit provision linked to purchase appropriate seed and inputs	Facilities available to provide credit and support in timely and adequate manner	
Part 2 Markets and System Management				
1 <u>Livelihood protection</u>	<u>Seasonal:</u> More specific planning on timing, scale and location and budgetary implications intra-seasonal: adapting plans	Improved livelihood security - reduced malnutrition, - morbidity - asset protection	Flexible programming - adjustable activities - resource availability including SGR, Budgetary reserve etc	Undue-confidence in forecasts High cost over-preparation c under-prepared

Category of User	Potential Application	Nature of benefits	Preconditions	Risks
2. <u>Agricultural marketing</u> (output)	<i>Seasonal and intra seasonal:</i> Forward and futures trading	Market efficiency increases: reduced price volatility and private sector strengthened	Market environment	Over-reaction to forecast of increasing probability of extreme event
3. <u>Strategic grain reserve</u>	<i>Seasonal and intra seasonal:</i> Build up and draw down decisions	Reduced likelihood of food crisis Counter-cyclical impacts on markets Efficiency savings	Financial Resource base Timely and accurate crop assessment Marketing institutions	Undue confidence in forecast of good harvest
4. <u>Water systems</u> a. Hydrology	<i>Seasonal and intra seasonal:</i> Flood warning to areas at risk.	Reduce dam age through preparedness and production decisions (see 1.).		
b. Hydro-electricity	<i>Seasonal and intra seasonal:</i> Dynamic water management and planning of balance of hydro and thermal supply	Minimize supply instability Minimize revenue volatility Efficiency savings	Options in systems management	Externalities for lower riperian countries
c. Water and sewage	<i>Seasonal</i> Drought mitigation measures - O & M on wells; - Introduce rationing	Reduced health risks Minimize household water supply and disposal costs	Fiscal environment	Limited
5. <u>Macro-economic policy</u>	Anticipate abnormal expenditure and revenue impacts in annual budget and in reviewing structural adjustment plans	Reduced fiscal volatility - improved budgeting - improved aid planning	Fiscal environment Understanding of macro- level effects of climatic variability	Pretext for fiscal indiscipline
6. Private sector investment	<i>Seasonal:</i> Dynamic decisions on equipment and O & M	Better private financial planning Strengthening investor confidence	Market environment Private sector resource base	
7. <u>Donors and IFIs</u>	Budgetary Planning Policy Advice	Earlier and more adequate responses to volatility; Improved advice on fiscal management	Government donor relationships; Budgetary sensitivity in programming	

Category of User	Potential Application	Nature of benefits	Preconditions	Risks
8. <u>External trade (agricultural)</u>	Government parastatal import planning Private sector trading	Improved management of supply of inputs Efficiency savings Improved regional market integration	Trade policy environment	

6.3 The current state of forecast applications: user perspectives

The ultimate test of the usefulness of information is whether and how it is used and with what results. A formal and comprehensive survey of potential users of climatic information had suggested a substantial and broad demand for forecast applications (Mkandawire and others, 1999). There was then a follow-up consultancy about possible applications with one selected organization in the following sectors, an NGO in smallholder agriculture, commercial farming, tourism, insurance and public water supply (Ward, 1999). These were considered to be sectors in which potential clients might be willing to pay for more specific applications. However, it appeared in the course of this investigation (December 2001 – February 2002) that little progress had been made, with only one potential application, public water supply. This was partly because of limited interest on the part of some potential users. There was also lack of capacity in the DMS to pursue this initiative before the current program of staff training outside Malawi was completed (Box 5). In-post professional staff were all stretched in maintaining existing services.

In these circumstances, it seemed worthwhile to undertake a small, selective survey of potential and actual users of forecasts. This survey employed an in-depth interview technique previously tested in a study on the uses of climatic information in commercial agriculture in Swaziland (Bohn, forthcoming). Because of time constraints, only a few interviews could be completed, and so the survey is not representative of the full range of user groups. An illustrative selection of these user views on possibilities and problems associated with climatic information is presented here as a 'thumbnail sketch from the grassroots'⁵¹

Potential applications

Most agricultural operations are weather dependent to some degree. Commercial agriculture in Malawi, which includes tea, coffee, tobacco and maize production, is no exception. Many producers noted that seasonal forecasts could be useful but at present their application is limited. Some operations are influenced more by the weather than others and it is these that may benefit from forecasts. For example, weather is especially important for fertilizer and chemical applications. For tea production, for example, these applications can account for 38-40% of the cost. They are often the most expensive and vital part of the operation (Tea Estate Manager). For many agricultural operations such as this, however, it is the short term weather forecasts that actions will be based on. Users are less likely to act on seasonal forecasts. "There is nothing we can do really, we probably wouldn't change fertilizer application – if we knew there was going to be a wet February, but if we knew a day in advance of application that there was going to be heavy rainfall, this might change" (Tobacco Farmer).

At present users are aware of ENSO and its generalized impacts on the southern African region. There is quite a lot of information on ENSO in the newspapers, on the Internet and on the radio (Tobacco Farmer). Where the forecast information is received it is unlikely that direct action will be taken. However, there is the potential for the information to be incorporated into planning decisions. One farmer suggested that farming is 70% management and 30% the weather. Forecasts are in the position to help with this management.

Hydrologists are able to apply the forecasts, as they have to make long term decisions related to water resource use. The Department of Hydrology uses a combination of climate information, weather forecasts which they receive every day, 3 days and 10 days as well as seasonal forecasts. "Seasonal forecasts are very useful, although the distribution of rainfall is important as well" (Hydrologist).

Forecasts of the impact of ENSO can be useful for food security planning. It is a question of logistics, with a greater lead-time resulting in it being cheaper to source the maize and having more time to transport it (Aid Official). An ENSO analysis of rainfall would enable more involved judgment to govern the placement of food reserves, if the problem is known in advance it may be possible to balance prices. "Market prices are very sensitive to real and perceived food availability –if there is plenty to sell then this depresses food

⁵¹ The quotations in this section are taken from interviews during February 2002. There is a list with names of people contacted in Annex C.

prices" (Aid official). Hypothetically, subsidies could be targeted, for example, if the season was not going to be good, then support would not be given for long season maize, the short maturation varieties can be favored. Also with a poor season the culling rate of livestock can be increased. "There are very clear links to policy and planning decisions" (Official).

The general advice given to small scale and subsistence farmers is to plant with the rains. Those that take the risk and plant with the first rains can do well. However, if the rains start erratically then the early plantings may be lost. Usually smallholder farmers will not be in a position to purchase more seed. First, there is in practice little alternative short maturation seed available by planting time (November).⁵² Second, farmers could not afford to buy. Most farmers cannot take risks because they are so short of seeds. The dilemma is that farmers currently have no way of knowing if the good rains in October will continue or if they are just a storm and will be followed by a dry spell. They therefore have to take the opportunity to plant when it arises. Although this is a relatively benign climate compared to the rest of Africa, the problem is the poor mono-modal distribution, if farmers lose a crop such as maize there is nothing they can do for 12 months (Agriculturist). Seasonal forecasts do not appear to be incorporated much at this level. Agricultural extension advisers do not incorporate forecasts into their advice. However on the larger scale NGOs such as Care International do take account of the information and could provide warnings based on the forecasts to the poorer farmers (NGO Administrator).

There may be scope for linking fertilizer application more closely to rainfall. If there were a high probability of dry conditions, then the application may be discouraged. Alternatively, heavy rainfall leaches out nitrogen and may justify additional application (Agriculturist).⁵³

Problems

"All other things being equal it would be nice to have a good forecast. The danger of information is that it is nice to have but not useful." (Aid Official)

Despite the potential applications of the forecasts, users often stated that even if they had the information they wouldn't necessarily act on it. The reasons for this include issues relating to the forecasts themselves, the availability of the forecast information and users ability to respond.

Problems with the forecast application often relate to the forecast itself and the information it provides. There are many common issues across Southern Africa relating to forecast application. The constraints highlighted for example in Swaziland by Bohn (forthcoming) were again identified in this study. In particular the following problems which relate to forecast production were highlighted:

- The spatial scale of the forecast is not detailed enough. In Malawi, where the rainfall varies greatly within the country, the spatial scale of the forecast is not sufficient.
- The level of detail about the distribution of rainfall within the wet season needs to improve. Most seasonal forecasts produce information about the distribution of the rainfall over a period of 3 months. Users felt that more importantly they need to know about any likely wet or dry spells within this period.
- Information about the start and end of the rains is needed. For farmers relying on the start of the rains to plant their crops or the end of the rains to start harvesting, the onset and cessation of the rains are

⁵² The approximate national demand for maize seed in Malawi is around 40,000 tonnes. However, the amount of short maturation seed that could be acquired and distributed without considerable advance planning (1 –2 years) is probably around 1,000 tonnes (Personal communication, Stephen Carr).

⁵³ At least in Malawi there do not seem to have been experiments to test for the effects of wetter conditions on maize performance.

important periods. In addition to the start of the rains users need to know whether the rains have begun properly or whether they are likely to experience a dry spell.

- The timing of the forecast is important in determining responses. Where users are interested in taking action based on the forecasts they need time to respond.
- The reliability of the forecasts needs to improve. Many users felt that the current reliability was not sufficient for them to make significant changes to their behavior.
- Lack of forecast verification is an issue. Users would like to have more information about how accurate past forecasts have been. Verification by the forecast producers is not always seen as reliable.
- Other variables apart from rainfall and temperature are required. Solar radiation for example has a big impact on yield levels - thus an indication of cloudiness as well as rainfall would be advantageous.

There is also the problem of forecast dissemination. Some users do not have access to forecast information, as in the case of small scale farmers. Others could access the information but are often not aware of how to do so. "Radio is increasingly available, 50% of the population have access to it on at least a weekly basis, and if one person in a village hears the news they all know" (Aid Official). Agricultural extension officers do not disseminate forecast information.

There are other factors determining whether a forecast can be used effectively. It was often said by informants that an accurate seasonal forecast would not have made a significant difference to the ongoing food crisis.

The response options available to small scale and subsistence farmers are extremely limited. Observers noted that even if the forecasts were more accurate there is little farmers could do (Agriculturist). The majority of southern Malawi for example is planted with maize. There is little flexibility of what crop to plant, the seed choice or inputs. ⁵⁴ "This is a rural population who cannot make choices, farmers have no choice but to wait for the rains to begin - if there is going to be a short rainy season they still have to plant" (Agriculturist).

All small-scale farmers cultivate by hand. They cannot start cultivating until the rains come – the question is – what is a planting rain? This varies due to the state of the soil and the crop grown. There is often local knowledge involved – where species have rainfall triggers. Local knowledge is very important (Aid Official).

Commercial farmers may have more access to resources to respond to forecasts. They take an interest in forecasts, but are not necessarily going to change their behavior immediately. They are likely to adopt a wait and see approach, even if the forecast includes useful information. "Even if we knew about it I am not sure we would change anything, we wait until it happens and then react, we would wait until we are there" (Tobacco Farmer).

Possibilities

The problems highlighted may paint a negative picture of the potential for seasonal forecast applications in the near future. However there are measures that can be taken to make it more likely that forecasts are used more effectively.

Dissemination of the forecasts is an important factor in ensuring that forecast application is optimized. Some of the problems raised by users about the forecasts could be alleviated with better information

⁵⁴ There is the possibility of crop replacement, cassava for maize. However, this option would require mobilization of considerable planting material. Furthermore, the critical point of food security is before the traditional maize harvest in April. Cassava would only be ready to harvest in October.

channels. Reports produced by the Malawi DMS for example often contain detailed information missing from the regional seasonal forecasts. Users need to be aware of all the sources of information and where it is available.

The detail of the information available is at present insufficient for many users to exploit. The current scientific capacity of forecasters does mean that this situation is not going to change quickly. However, as Bohn (forthcoming) argues, background climatological information for a region or a specific site can add value to the information provided by climatic forecasts. Simple statistical analyses of climate data can produce information valuable to users.⁵⁵

The appropriate use of probability forecasts and the issue of whether users can interpret them correctly are topics regularly raised by forecasters and users alike. The best way to present the information is regularly under discussion at SARCOF meetings.

6.4 Climatic forecasting and the 2002 food crisis⁵⁶

To provide a more immediately relevant and specific example of the issues to be addressed in realizing the possibilities of climatic forecasting, we pose the question whether forecasting could have contributed to reducing the effects of the 2002 food crisis? Could climatic forecasting, or more broadly, meteorological monitoring and forecasting have made a greater contribution to reducing the social damage and economic costs of the 2002 food crisis? Investigations into the causes of the crisis typically highlight the following weather related issues:

- Farmers were unable to take advantage of the early onset of the main rains in 2000 because of disruptions to, or late distribution of seed and fertilizers under the TIP;
- The more severe and extensive floods caused substantial crop losses, but these were only slowly appreciated in the final crop assessment in May 2001;
- The relatively 'normal' rains in 2001/02 were locally erratic, especially in the critical month of February, with consequent reductions in maize yield;
- There was generalized concern that the El Niño event, developing in 2002 would increase the risk of drought in 2002/03.

Turning to the actual role of climatic forecasting over the two seasons 2000/01 and 2001/02, a review of global and regional (SARCOF) forecasts, as interpreted and disseminated in Malawi, indicates that the central forecasts for 2000/01 were broadly correct (Box 1). Internationally climatologists were in agreement that a La Niña event would continue in the Pacific (See Figure 5.3). SARCOF in its September 2000 forecast, reconfirmed in December 2000, indicated that there was likely to be above average rainfall across the region, including the whole of Malawi. However, there was little appreciation in the Early Warning System (FEWS NET), in the Ministry of Agriculture or in the Department of Disaster Management of the possible negative implications of these generalized forecasts. The Ministry of Agriculture was reducing the scale of the TIP from all to half of smallholders, predicated on a normal or favorable climatic outlook. Seeds and inputs were distributed slowly and there was the new problem of targeting. So farmers were hampered by lack of available inputs in responding to the early onset of the main rains. This was a factor that

⁵⁵ For example, measures of whether rainfall is proving exceptionally erratic as the season progresses are useful to food security planners and those involved in markets, including farmers.

⁵⁶ This section draws on Devereux (2002) and interviews done during the course of this study that provided a broadly consistent picture of what had happened and the causes of the food crisis.

contributed to reduced production. The Department for Disaster Management did not take any additional preparedness measures, despite the increased risk of abnormally severe and widespread flooding.

During the rainy season the DMS provides a bulletins for 10 day periods on rainfall, temperature and sunshine for the met stations under its responsibility. However, these are virtually raw data without agro-meteorological interpretation, or even a simple statistical analysis to facilitate understanding. As the season progressed crop monitoring provided limited indications of actual problems experienced by farmers, or of the negative impact of unfavorable weather and high rainfall, apart from flood damage reports. It was not recognized that high rainfall and exceptionally extensive cloud cover reduced photosynthesis and evaporation, which contributed to waterlogging. There is apparently no body that is analyzing and reporting on agro-meteorological information in any detail. Initial crop assessments after the planting rains were therefore over optimistic and had to be progressively reduced in each round. Only after harvest was the extremely poor crop revealed. Apparently many farmers did not themselves realize that they were going to get a poor crop until cutting began.

In July 2000 Malawi's Strategic Grain Reserve began the year with near to capacity stocks of 175,000 tonnes and the recently established National Food Reserve Authority (NFRA) had associated accumulated debts of MK 1 billion (US\$ 16 million). Some of the stocks acquired in 1999-2000 were already close to two years old and needed to be replenished. The advice from the IMF, with World Bank agreement, was to reduce stocks by two thirds to reduce NFRA debt. This advice was made during the growing season of 2000/01 when the actual maize crop was still uncertain, but there had been an earlier over-optimistic assessment. Furthermore there were unrealistic estimates of root crop production that would apparently buffer food consumption against a poor maize crop. Some 35,000 tonnes were exported to Mozambique and Kenya. ADMARC and NFRA ran down stocks, deciding not to procure domestically from the 2001 harvest. By July- August 2001 stocks were almost exhausted, as remaining stocks had been sold off at below prevailing market prices. Government decided to make what were, in effect, replacement purchases by importing 150,000 tonnes of maize. With logistical costs alone of US\$50 – 80 per tonne the *additional* costs of replacement were close to US\$ 15 million wiping out the savings from disposal. The controversial decision by government to reduce the level of the Strategic Grain Reserves was, with hindsight, premature, as was the advice to do this. Both advice and decision were based on poor and inadequate information about the agricultural situation. There is also an uncomfortable parallel between this episode and the bad decisions on grain stock management made in Zimbabwe a decade earlier in the lead into the 1991/92 drought (Glantz, 1998 and SADC 1993 and above Footnote 42).

There was apparently little understanding of how fragile the society and economy had become. The sensitivity of maize and also the tobacco crop (in which smallholders are now more involved as producers) to the weather through the season was not fully appreciated. National economic and food security decisions appear not to have been sufficiently well-informed by an understanding of agro-meteorological relationships. If there had been a better understanding of this uncertainty and fragility, then it would have been recognized that it is unwise to advise or take critically important decisions on food security until the size of the maize and tobacco crops, critical to smallholder incomes and employment, are reasonably well established, perhaps in April or May.

For 2001/2 SARCOF correctly forecast broadly average total rainfall (DMS, 2002). However, rainfall had been locally erratic, especially in the critical month of February as reflected in the ten-daily bulletins and informal reports from some places of 'drought'. But there was no widespread drought (Box). Meanwhile the DMC in Harare since February 2002 had also been confirming global indications of an El Niño event possibly developing during the year. It also cautioned against premature concerns about a resultant drought in 2002/3.

Overall, therefore the meteorological input into anticipating and assessing the scale of the emerging crisis seems to have been quite limited. The seasonal forecasts are highly generalized, and unless there is a major drought risk, they have been interpreted as implying a normal or good year. There is a problem of

users placing 'undue confidence' in forecasts when these seem to have convenient implications (Table 3). Another serious issue is the apparent inability to make use of meteorological information for assessing the state of smallholder agriculture. The potential agricultural applications are not attempted and followed up by closer monitoring of the weather on a local basis through the growing season.

Chapter 7.

Conclusions and Recommendations

7.1 Climatic variability, agriculture and economic performance

Agriculture and the economies of Southern Africa are highly sensitive to climatic variability

The 2002 food crisis became apparent only after this study had begun, and so this report is not about that crisis. Nevertheless, the crisis has underscored the vulnerability of the region, and especially the rural poor, to food insecurity. The rural poor in countries such as Malawi, Zambia and Zimbabwe depend heavily on cereals, and especially maize cultivation, for their own consumption as well as market purchases.

Maize (and cereals), being largely rainfed, are extremely sensitive to rainfall variability, which alone explains about 60% of fluctuations in production since 1972 (28 years). The cost to the region of each of the droughts of 1982, 1992 and 1994/95, in terms of reduction in maize production alone, has been around US\$1 billion, whilst even the less severe 1997/98 drought involved around US\$300 million in reduced maize output.

The 1991/2 drought reduced agricultural GDP of the region by some US\$ 3 billion. The wider impact on GDP was at least as severe, involving a year on year reduction in economic growth of 2.2% and, excluding the broader based economy of South Africa, over 6% in the rest of the region. The impact also extends beyond the year in which this climatic shock occurred, due to the lagged effect on other sectors.

Climatic shocks are also likely to be regional because of the high level of covariance in cereal production, as well as interactions between economies that are part of a regional market.

The Southern African region's agricultural economy is more sensitive to climatic variability than previously appreciated

The severe droughts of 1992 and 1994/95 occurred within a relatively extended drier period that lasted from approximately 1981/2 until the mid-1990s, which probably intensified the effects of each drought. The combined effect was a too narrow preoccupation with drought rather than the broader problem of climatic variability.

Extremely high rainfall anomalies of about 25% or more above average are unfavorable for cereal and maize production. They also pose increased risks of flood-related fatalities, damage to physical capital and disruption to economic activities. Agricultural performance is also sensitive to erratic rainfall - less well understood intra-seasonal variations in the distribution of rainfall.

So the region is not just at risk to drought shocks, but is likely to perform most well only within a favorable run of conditions that is associated with annual rainfall falling within a 90 – 120% band of long term mean total rainfall. Both climatic forecasts that anticipate and actual meteorological reports that confirm extremely high rainfall should therefore also signal the need for increased concern about regional food security.

El Niño and La Niña are both important

Fluctuations in maize and cereals output are also associated with global climatic phenomena – as reflected in the El Niño Southern Oscillation (ENSO). Extreme El Niño events (1972, 1982, 1992/94 and to a lesser extent 1997/98) have been associated with regional droughts that affected in particular South Africa and Zimbabwe. So the increased risk of an extreme El Niño event should put the region on the alert against a possible drought and a related food crisis. However, El Niño events alone are not a good predictor of

agricultural performance. The floods and poorer agricultural year 2000/1 was associated with a La Niña event.

South Africa and Zimbabwe are at the core of a south east African climatic region, characterized by a unimodal austral (southern) summer rainfall pattern that is sensitive to extreme El Niño events (Figure 2.3). Towards the north of the region in Malawi, Zambia, and probably in much of Mozambique (if reliable data were available), there are somewhat distinct rainfall-crop production patterns, historically more often sensitive to erratic intra-seasonal distribution than to the relatively rare low rainfall or drought year. These distinct patterns suggest the need for greater attention to climatic variability at a country and sub-regional level.

Southern African agriculture is becoming more sensitive to climatic shocks

There is evidence of increasing volatility in agricultural indicators, such as maize yields and macro economic performance. Malawi and Zambia have experienced significantly increased climate-related fluctuations in agricultural performance since about 1988-1990, affecting the performance of the wider economy. In Malawi the 2002 crisis followed a year of abnormally high rainfall and has emerged in a year of erratic and unfavorable rainfall - but not drought. The evidence of increasing volatility is inconclusive for other economies up to the late 1990s. The 2002 food crisis suggests that increased volatility may be becoming more widespread.

Sources of increasing sensitivity to climatic shocks

At least six factors appear to be contributing to this increasing economic fragility:

- ***Non-sustainable agricultural practice:*** stagnation in cereal production due to failure to follow cropping patterns that sustain soil nutrient levels and increased fertilizer applications to compensate for the effects of intensified land use and environmental degradation.
- ***Structural change in agriculture:*** this has resulted from deliberate land redistribution and also economic processes, both influenced by policy. In Zimbabwe increasing volatility in maize yields was associated with the shift in production to smallholders and a decline in large scale commercial output *before* the political crisis over land ownership (Benson & Clay, 1998; Benson, 1998). In Malawi decades of marginalizing the small farmer, and then switching in the 1990s to encouraging the small farmer in tobacco has increased volatility. Such developments may involve a relative shift in production from more favorable land types, sometimes with at least partial supplementary irrigation on commercial farms, to more marginal, at risk physical environments. Structural change, which is potentially positive in equity terms, has not been accompanied by sufficiently successful attempts to establish a viable credit system, input supply and a supportive marketing structure for smaller producers.
- ***Institutional weaknesses*** in agriculture reflect lack of success in many sectoral and structural adjustment programs. Sahn and Arulpragasam (1991) concluded about structural adjustment in Malawi, "Policies must also concentrate on structural weaknesses that constrain smallholder agriculture and contribute to widespread food insecurity and malnutrition." Harrigan (2001) reiterates this conclusion a decade later. The 2002 regional crisis confirms that too little has been achieved.
- ***Political instability*** and problems of governance have affected Malawi, Zambia, Zimbabwe and Lesotho. Meanwhile, Mozambique, Namibia and South Africa made progress towards political stability in the 1990s.
- ***The short-term behavior of external aid,*** which has been influenced by political, governance issues as well as directly economic and humanitarian considerations, has also been an important factor in the volatile public finances of Malawi.

- **The effects of HIV/AIDS on human resources** are insidious, much discussed, but so far largely unquantified.

Climatic change is frequently mentioned in the context of an extreme event, such as the 1991/92 drought or the 2000/1 floods in Mozambique. There is as yet no conclusive evidence that the region is experiencing extreme events more frequently or experiencing longer-term aridification (Hulme and others, 2001). However, both occurrences are anticipated as the consequences of climatic change (IPCC, 2001). This review of climatic variability and economic performance highlights the need for closer examination of the precise nature of extreme events or climatic anomalies. For example, extreme events might take the form of increasingly erratic rainfall patterns, causing failure of the rains at critical moments in the crop growth cycle. There might also be more frequent, intense storms, with more damaging impacts in countries more vulnerable to floods like Malawi and Mozambique. A fuller understanding of the environmental and the socio-economic consequences of variability is necessary for isolating the forms of climatic change and their implications.

7.2 Climatic forecasting

There is an urgent need to find ways to reduce vulnerability to climatic variability and the threat posed by climatic change. One of the ways to do this is to improve the informational basis of decisions at all levels, from smallholder to national and international agencies. That is the rationale for seeking to exploit the many potential applications of climatic forecasts (Table 3). What has been achieved? What is still to be done? How worthwhile are such efforts? Should climatic forecasting be a priority for international aid and the use of scarce human resources within Southern Africa?

Regional forecasting

Through the 1990s efforts continued to improve climatic forecasting and provide better frameworks within which this information is effectively disseminated – through regional Early Warning Systems, climatic forums and national level activities.

Cost benefit comparisons

A formal cost benefit calculation would be misleading because of the difficulties in quantifying costs and benefits. Nevertheless, when even qualitative values and the modest costs are compared, the not unreasonable conclusion is that supporting and strengthening climatic forecasting is worthwhile. The economic losses caused by climatic variability are very large, and the costs of forecasting are modest. So even a small reduction in losses through improvements in public decisions and private risk management justifies investment in strengthening forecasting and its continued support.

Forecasting costs

The present annual cost of long term climatic forecasting for Southern Africa is around US\$ 5 million. Precise costing is difficult because many agencies are involved, and in many cases only a part of their forecasting and information dissemination costs can be attributed to the regional effort.

The value of forecasting

A precise and robust valuation of the forecasting process at a regional level is impossible, but there is no doubting its usefulness as expressed qualitatively:

- The existence of a scientific consensus process for risk assessment is necessary, because of the rapid diffusion of often incomplete, misleading accounts of global developments through the media, including satellite and global television;
- The SARCOF process has provided a vehicle for the reintegration and strengthening of meteorological expertise within the region;

- There is now an established annual cycle for focusing on climatic variability and assessing drought risk which feeds into wider decision-making processes in public and private sectors;
- The evolving weather situation during the annual agricultural cycle is now monitored more closely and reported in a more comprehensive way within the region;
- Regional climatic forecasting has so far been a learning process: each year juxtaposing formal risk assessment and actual outcomes draws attention to further complexities in the climatic system and has suggested ways to refine the assessment.

At the same time there is some sense of disappointment. First, the discovery of El Niño teleconnections with weather and agricultural performance in Southern Africa created unrealistic expectations in the mid-1990s about the power and precision of climatic forecasting. Secondly, the full extent of increasing sensitivity of the region's agricultural economy and the vulnerability of the population and infrastructure to flood, not just drought, to climatic variability more generally had not been appreciated. Thirdly, there is a problem that whilst forecasts have considerable potential value, users often note that their application is limited by features of the forecasts and also users ability to respond.

The 2002 food crisis

Some of the important issues about the usefulness of forecasts have been highlighted by the 2002 food crisis.

The meteorological input into anticipating and assessing the scale of the emerging crisis in 2002 has been quite limited. Seasonal forecasts are highly generalized (Figure 5.1). Unless there is a major drought risk then the forecasts are interpreted by public decision-makers and the private sector in their risk assessments, as implying a normal or good year. This happened in 2000 and again in 2001.

In Malawi the unfavorable effects of high rainfall in 2001 were recognized only retrospectively at harvest time. By then many costly decisions, notably in grain reserve management, had been made on the basis of poor advice. When the crisis came, it was widely assumed to be either caused or exacerbated by a drought in 2002, and this is still being regularly stated in the western media. However, the supposed drought was not reflected in regular and frequent meteorological reports.

Increasing the usefulness of climatic forecasting information

Much has still to be done in make forecasting products more useful and to ensure that they are then effectively used. Forecasting should explore ways of refocusing on climatic variability more broadly, rather than narrowly on drought risk. This will require more research and closer monitoring on variability, downscaled to zonal levels and intra-seasonal timescales. There would be benefits from more precise forecasts on:

- Risk of extremely high or low rainfall (say a 1 in 10 year event);
- Timing of the rains;
- Risk of erratic rainfall.

The fragility of agriculture and the rural economy and society in Malawi, and perhaps elsewhere, are now more fully accepted. So there should be a greater interest in potentially useful information on the evolving weather situation. More specific information would be of use to more specific user groups, such as water system managers, commercial farmers and the public institutions and NGOs working with small farmers.

There is an apparent inability in national and international institutions to make effective use of meteorological information. The potential agricultural applications are not attempted and followed up by closer monitoring of the weather on a local basis through the season. These things will require more extensive agronomic – meteorological collaboration.

Further benefits could come from better anticipation and more rapid reporting of variability. That implies giving greater importance to meteorological input into early warning and to building better more rapid responses to an evolving situation. More systematic agro-meteorological research is needed to clarify the relationships between erratic rainfall, and also extremely high rainfall, and crop performance. The effect of abnormally wet conditions on performance appears not to have been subject to experimentation in Malawi or elsewhere in Southern Africa.

For the foreseeable future most of the agricultural benefits appear likely to be realized by commercial farmers operating on a large scale with a wide range of options. The restricted options for smallholders imply that the main use of information is to improve food security actions, to prepare for a poor season. These should be directed to minimizing the effects of climatic variability on household food security. These actions need to be accompanied by measures to buffer the wider economy and employment against the fluctuations likely to result from a climatic shock. The need for better understanding of climatic information implies a strengthening of management and planning capacity, so that forecasting is used to inform strategies for preparedness and the actual organization of public action. Those responsible for agricultural and food security decisions need to become better informed too on agro-climatic relationships and their implications, and to take them in to account. The potential users of information need to have a fuller understanding of what 'normal' may mean for them – that it might mean erratic rainfall - or what an El Niño event, such as that which was developing in 2002, is likely to imply.

7.3 Information and public action

This study has focused on meteorological and climatic forecasts, one of many forms of information that are usually provided as a public good. These investigations, which also covered agricultural and economic issues, were hampered by the weaknesses in statistical data. These deficiencies have become more serious during an extended period of near budgetary chaos in Malawi and under-funding of statistical and scientific information systems from recurrent expenditure. The HIV/AIDS epidemic may now be another factor eroding the human resources needed to sustain these systems. It was possible to fill some of the gaps in meteorological data needed for this study, because coincidentally one of the contributing parties, the Climatic Research Unit at the University of East Anglia, held complementary historical rainfall data for Malawi. Attempts were also underway under the World Bank project for strengthening the Department of Meteorological Services (Box 5) to recover inaccessible historical data vital to climatology.

A controversial issue, beyond the scope of this investigation, is the reliability of recent agricultural production statistics that appear to have prejudiced important decisions about food security and economic management in Malawi, thus contributing to the 2002 crisis. There were uncertainties too about biases in time series for the national accounts and public finances. These were considerations that have restricted the scope of this study and are reflected in the use throughout of relatively simple forms of analysis. Such an approach may have wider applicability, since there are many other low-income countries with weak information systems.

Good quality, trustworthy data is a necessary condition for effective natural disaster risk management and all areas of public action. Strengthening and sustaining information systems in Malawi and other low-income countries as a public good has to be an international priority.

As soon as there is evidence of enhanced risk of an extreme event, the international community, as well as SADC countries, need to take into account the consequences of a major shock in preparing for country level economic strategy and aid policy discussions. In an attempt to learn from the 1991/92 drought, in 1994/95 and again 1997/98 greater efforts were made to ensure food security, assess the need for humanitarian aid and prepare for the wider economic and financial consequences of a climatic shock. As the 2002 crisis has again demonstrated, there is much to be done to make better use of information on climatic variability in public policy at country, regional and international levels.

Annex A

Statistical Tables and Additional Graphs

Table 3.1: Growth Rates of Key Economic Aggregates During 1990 - 1998

		1990	1991	1992	1993	1994	1995	1996	1997	1998
ANG	GDP	2.5%	-1.1%	-4.9%	-26.0%	13.6%	2.5%	5.9%	12.9%	8.8%
	AGRI	-0.3%	-1.3%	-27.3%	-46.7%	9.9%	26.5%	15.3%	9.7%	5.0%
	IMP	-1.7%	-13.0%	19.5%	-40.6%	-0.2%	15.7%	9.8%	-15.8%	-7.7%
	Y	15.6%	30.2%	-4.9%	-32.5%	11.3%	33.1%	63.3%	-12.8%	23.6%
BOT	GDP	4.9%	4.2%	2.7%	2.4%	4.2%		-	-	
	AGRI	3.2%	2.3%	0.5%	-1.0%	-2.8%	-2.6%	-0.3%	4.0%	3.5%
	IMP	38.5%	11.1%	26.5%	-10.4%	-10.4%	34.6%	-7.5%	-2.0%	-9.9%
	Y	-9.0%	44.2%	-29.0%	-1.2%	-18.1%	-6.3%	30.9%	0.3%	-31.0%
LES	GDP	5.0%	-0.6%	4.4%	5.1%	14.9%	9.3%	13.3%	3.4%	-2.6%
	AGRI	-7.0%	-31.2%	-7.3%	27.4%	15.1%	-20.1%	54.7%	1.1%	4.6%
	IMP	-0.1%	-0.6%	-1.5%	-3.6%	-7.2%	22.5%	-5.6%	-2.2%	-1.5%
	Y	12.7%	-55.5%	33.0%	59.7%	-16.3%	-5.4%	51.8%	-16.9%	-3.5%
MAL	GDP	4.8%	7.8%	-7.9%	10.8%	-11.6%	13.9%	11.7%	5.2%	4.0%
	AGRI	-0.2%	12.8%	-25.1%	53.0%	-29.3%	38.2%	35.0%	3.9%	2.7%
	IMP	-11.3%	9.2%	100.0%	-11.5%	2.5%	-41.9%	-21.6%	-24.6%	-1.4%
	Y	-15.9%	15.1%	-57.8%	207.5%	-39.4%	44.1%	7.6%	-30.6%	28.3%
MOZ	GDP	0.6%	5.3%	-9.5%	7.4%	10.2%	4.2%	7.6%	10.7%	11.7%
	AGRI	1.1%	-4.0%	-18.2%	21.3%	-6.6%	17.4%	10.8%	7.6%	7.0%
	IMP	0.1%	11.4%	17.3%	-27.9%	8.1%	-7.9%	-24.7%	-15.9%	19.0%
	Y	19.8%	-27.9%	-48.5%	221.3%	-7.8%	25.4%	26.0%	0.0%	2.1%
NAM	GDP	-2.2%	11.1%	5.8%	-3.6%	7.1%	3.5%	3.7%	1.6%	1.6%
	AGRI	11.3%	9.5%	-6.1%	5.0%	15.5%	2.5%	4.9%	-7.6%	-5.0%
	IMP	18.1%	-5.0%	3.5%	-13.3%	4.2%	-6.3%	-5.6%	-15.9%	-2.5%
	Y	3.6%	19.6%	-74.4%	104.9%	16.6%	-41.8%	40.0%	78.9%	-59.1%
SAF	GDP	-0.5%	-0.9%	-2.3%	1.4%	3.0%	3.0%	4.1%	2.4%	1.6%
	AGRI	-7.1%	4.5%	-27.3%	24.0%	7.9%	-19.9%	24.0%	2.7%	-5.0%
	IMP	-3.5%	-2.1%	66.2%	-23.8%	10.8%	27.9%	-5.9%	-5.7%	-2.5%
	Y	-17.9%	5.9%	-52.6%	129.2%	19.9%	-45.5%	76.9%	-8.8%	-3.8%
SWA	GDP	9.5%	2.4%	1.1%	2.8%	3.5%	3.2%	3.7%	3.4%	0.6%
	AGRI	-3.5%	6.4%	-19.8%	-5.6%	3.9%	-4.7%	23.7%	-6.0%	-1.2%
	IMP	4.2%	-9.8%	7.3%	-11.2%	5.5%	-10.2%	-3.9%	112.0%	-14.3%
	Y	-23.4%	64.1%	-43.9%	24.3%	42.7%	-27.1%	90.1%	-27.0%	8.0%
TAN	GDP	4.4%	4.5%	-8.4%	12.9%	0.9%	2.5%	3.9%	3.7%	3.7%
	AGRI	4.7%	4.5%	-8.4%	14.2%	2.6%	4.0%	4.8%	3.1%	2.2%
	IMP	6.4%	28.4%	37.3%	6.8%	11.4%	7.2%	-10.8%	52.7%	-6.1%
	Y	-2.2%	-17.2%	-10.3%	12.9%	-4.2%	21.1%	2.1%	-23.6%	22.9%
ZAM	GDP	-3.0%	2.7%	-3.3%	6.9%	-5.9%	-1.2%	6.7%	3.4%	-0.4%
	AGRI	-8.9%	5.2%	-33.1%	68.1%	-51.6%	33.4%	-0.6%	-5.1%	-6.1%
	IMP	28.0%	-50.5%	343.0%	-49.4%	-44.9%	47.1%	6.2%	39.0%	57.1%
	Y	-21.3%	21.2%	-53.2%	198.9%	-39.0%	-3.9%	42.2%	-26.1%	1.0%
ZBW	GDP	7.2%	3.2%	-5.5%	2.0%	5.3%	-1.0%	8.5%	2.6%	1.5%
	AGRI	12.1%	1.0%	-23.2%	27.1%	7.3%	-7.6%	19.8%	2.6%	4.9%
	IMP	99.6%	-22.7%	526.3%	-44.9%	-55.7%	48.5%	71.3%	-25.7%	-5.0%
	Y	7.7%	-18.1%	-69.1%	260.0%	-2.4%	-62.9%	183.8%	-17.5%	-12.1%

* Shadowed columns are ENSO years

** GDP = Gross Domestic Product; AGRI = Agricultural GDP; IMP = Agricultural Imports; Y = Cereal Yields

Table 3.2: Relationship Between Total Cereal Production and Climatic Variables: Regression Results

a. Southern Africa: Cereal Production

Model	Dep.var.	Const	SEARI	SEARI ¹	SEARI ²	R ² adj	Tests
(1)	Y _t	17711.2 (1%)	11928.0 (1%)	-	-	0.45	Func.
(2)	Y _t	29976.0 (1%)	-	-11662.4 (1%)	-	0.57	OK
(3)	Y _t	19291.8 (1%)	11791.0 (1%)	-	-34293.0 (1%)	0.60	OK
			EN	SSTDJF (-1)			
(4)	Y _t	18994.5 (1%)	-5449.3 (1%)	-	-	0.37	OK
(5)	Y _t	19823.3 (1%)		-2328.4 (5%)	-	0.17	OK

b. Zimbabwe: Cereal Production

Model	Dep.var.	Const	SEARI	SEARI ¹	SEARI ²	R ² adj	Tests
(1)	Y _t	2213.1 (1%)	2291.1 (1%)	-	-	0.44	Func.
(2)	Y _t	4524.4 (1%)	-	-2198.0 (1%)	-	0.54	OK
(3)	Y _t	2491.7 (1%)	2266.9 (1%)	-	-6045.1 (1%)	0.57	OK
			EN	SSTDJF (-1)			
(4)	Y _t	2485.5 (1%)	-1150.5 (1%)	-	-	0.46	Func.
(5)	Y _t	2556.4 (1%)	-	-394.3 (5%)	-	0.13	OK

c. Malawi: Cereal Production

Model	Dep.var.	Const	SEARI	SEARI ¹	SEARI ²	R ² adj	Tests
(1)	Y _t	1502.0 (1%)	127.4 (NS)	-	-	-0.03	Func., Norm.
(2)	Y _t	1761.8 (1%)	-	-246.3 (NS)	-	-0.01	Func., Norm.
(3)	Y _t	1630.1 (1%)	116.3 (NS)	-	-2781.2 (10%)	0.06	Norm.
			EN	SSTDJF (-1)			
(4)	Y _t	1521.1 (1%)	-96.0 (NS)	-	-	-0.02	Func., Norm.
(5)	Y _t	1469.7 (1%)	-	34.7 (NS)	-	-0.03	Norm.

The models estimated are the following:

- (1) $Y_t = a + \beta \cdot SEARI_t + e$
(2) $Y_t = a + \beta \cdot SEARI_t^{-1} + e$
(3) $Y_t = a + \beta \cdot SEARI_t + \gamma \cdot SEARI_t^2 + e$
(4) $Y_t = a + \beta \cdot EN_t$
(5) $Y_t = a + \beta \cdot SSTDJF_{(t-1)}$

where

Y_t: Cereal Production (whether regional, in Malawi or Zimbabwe)
SEARI: South East Asia Rainfall Index
EN: Dummy for El Niño Events
SSTDJF: Index for Sea Surface Temperature (SST) in the Tropical Pacific in December/ January/ February (DJF). SST is an indicator used to identify the forming of El Niño Events.

Figures in parenthesis are the significance levels of the coefficients, NS stands for non significant. The tests undertaken are autocorrelation, heteroscedasticity, normality and functional form. We only report those tests that were not passed, OK for those models where all tests were passed.

Table 3.3 Southern Africa: Economic Impact of the 1992 Drought**a. GDP Growth Rates (% per annum)**

Country	10 Year Av.	Trend. Growth	Actual Growth		
	1980 – 1990	1980-1990	1991	1992	1993
Botswana	1.7	1.0	-4.1	-1.6	-10.8
Lesotho	4.6	4.7**	-0.6	4.4	5.1
Malawi	2.5	2.8**	7.8	-7.9	10.8
Mozambique	0.2	0.0	5.3	-9.5	7.4
Namibia	0.2	0.4**	11.1	5.8	-3.6
South Africa	1.8	1.7**	-0.9	-2.3	1.4
Swaziland	7.2	7.1**	2.4	1.1	2.8
Zambia	0.5	0.8	2.7	-3.3	6.9
Zimbabwe	3.6	3.1**	3.2	-5.5	2.0

b. Agricultural Sector Product or agricultural GDP Growth Rates (% per annum)

Country	10 Year Av.	Trend. Growth	Actual Growth		
	1980 – 1990	1980-1990	1991	1992	1993
Botswana	2.5	3.3**	2.3	0.5	-1.0
Lesotho	1.3	2.2**	-31.2	-7.3	27.4
Malawi	1.4	2.0**	12.8	-25.1	53.0
Mozambique *	5.0	6.4**	-4.0	-18.2	21.3
Namibia	2.2	1.8**	9.5	-6.1	5.0
South Africa	1.8	2.9**	4.5	-27.3	24.0
Swaziland	2.0	2.4**	6.4	-19.8	-5.6
Zambia	2.4	3.5**	5.2	-33.1	68.1
Zimbabwe	3.7	3.1**	1.0	-23.2	27.1

Notes: * Mozambique's growth rate only from 1984 to 1990

** denotes that the trend growth rate is significant (at the 1%, 5% or 10% sign. level)

- (1) Actual Growth 1991: $GDP_{1991}/GDP_{1990} - 1$
(2) Actual Growth 1992: $GDP_{1992}/GDP_{1991} - 1$
(3) Actual Growth 1993: $GDP_{1993}/GDP_{1992} - 1$
(4) 10 Year Average Growth: $(GDP_{1990}/GDP_{1980})^{1/10} - 1$
(5) Trend Growth: is β predicted by the following model:
 $\ln Y_t = a + \beta t$

where

 Y_t : is GDP or agricultural GDP in year t

t: is a time trend ranging from 0 for 1980 to 10 for 1990

Table 4.1: Finance Aggregates Malawi, 1980 – 2001*

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Total Revenue and Grants	1722.6	1704.9	1665.5	1650.9	1866.4	2049.7	1996.9	1841.4	2240.0	2441.8
Revenue	1415.0	1431.5	1422.7	1476.9	1674.4	1850.4	1797.5	1646.6	1752.9	2081.4
Grants	307.6	273.4	242.8	174.0	192.0	199.3	199.5	194.7	487.1	360.4
Total Expenditure	2547.3	2306.7	2331.2	2230.9	2385.5	2452.5	2736.1	2325.4	2494.9	2715.4
Recurrent Expenditure	1304.9	1502.1	1518.2	1492.9	1729.4	1781.8	2044.0	1740.0	1619.3	2022.1
Development Expenditure	1242.4	804.5	813.0	737.9	656.1	670.7	692.1	585.4	794.6	620.2
Extra Budgetary	0.0	237.7	0.0	0.0	0.0	108.8	170.3	0.0	81.0	73.1
Deficit exc. Grants	-1132.3	-1112.8	-908.5	-753.9	-710.6	-710.9	-1109.0	-678.8	-741.3	-634.1
Deficit inc. Grants	-824.7	-839.5	-665.6	-579.9	-518.6	-511.6	-920.4	-484.1	-254.2	-194.7
Financing	824.7	839.5	665.6	579.9	518.6	511.6	920.4	484.1	254.2	194.7
Foreign Loans (net)	284.1	202.7	437.9	490.6	251.3	307.7	362.8	225.8	379.5	400.3
Borrowing	442.5	408.7	509.0	578.9	486.9	599.5	801.5	559.4	601.4	597.7
Repayment	158.4	206.0	71.0	88.3	235.6	291.8	438.7	333.6	221.9	197.4
Domestic Borrowing (net)	540.6	636.7	227.7	89.3	267.4	203.9	557.6	258.3	-125.3	-205.6

* All figures are in million Kwacha (constant prices)

Table 4.1: Finance Aggregates Malawi – 1980 – 2001* (cont.)

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/2001
Total Revenue and Grants	2102.3	2231.6	2023.4	1853.3	2119.3	2249.7	2497.2	2715.1	2697.6	3158.6	3750.0
Revenue	1897.3	1897.7	1733.0	1569.3	1282.3	1554.0	1947.1	2176.9	1967.1	2142.1	2280.5
Grants	205.0	334.0	290.4	284.0	837.0	695.7	550.1	538.2	730.5	1016.5	1469.5
Total Expenditure	2495.3	2463.2	2634.6	3263.9	3219.9	2755.9	2812.9	3399.3	2965.2	3395.7	3996.2
Recurrent Expenditure	1928.5	1957.7	2048.7	2234.7	2630.9	2181.7	2253.4	2934.1	2003.1	2042.8	2748.4
Development Expenditure	566.8	505.5	585.9	1029.2	589.0	574.2	559.5	465.2	962.1	1352.9	1247.8
Extra Budgetary	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Deficit exc. Grants	-596.6	-565.5	-901.6	-1694.7	-1876.8	-1201.9	-865.8	-1222.4	-998.1	-1253.6	-1715.7
Deficit inc. Grants	-391.6	-231.5	-611.2	-1410.7	-1150.3	-506.2	-315.7	-684.1	-267.6	-237.0	-246.2
Financing	391.6	677.6	611.2	1410.7	1150.3	506.0	315.7	684.1	267.6	237.0	246.2
Foreign Loans (net)	482.7	702.3	499.1	595.9	577.3	178.4	573.6	287.2	961.4	440.8	404.5
Borrowing	733.3	513.6	650.3	791.1	774.6	475.2	762.1	520.3	1237.2	792.2	906.3
Repayment	250.6	188.7	-151.2	-195.2	-197.2	-296.8	-188.6	233.1	275.9	351.4	501.7
Domestic Borrowing (net)	-91.1	-24.7	112.1	-814.8	572.9	327.6	-257.8	396.9	-693.7	-932.0	-158.3

* All figures are in million Kwacha (constant prices)

Table 4.2.1: Composition of Recurrent Expenditure in Malawi, 1980 – 2001

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
<i>General Public Services</i>	29%	27%	30%	30%	24%	28%	24%	24%	28%	29%
<i>Social and Community Development</i>	21%	19%	19%	20%	18%	17%	19%	17%	16%	19%
<i>Economic Services</i>	16%	15%	18%	17%	15%	15%	14%	14%	15%	14%
<i>Unallocable Services</i>	34%	40%	33%	33%	43%	41%	43%	45%	41%	38%

Table 4.2.1: Composition of Recurrent Expenditure in Malawi, 1980 – 2001 (cont.)

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01
<i>General Public Services</i>	33%	31%	32%	31%	32%	21%	25%	27%	32%	27%	50%
<i>Social and Community Devel.</i>	20%	16%	19%	21%	31%	30%	34%	40%	30%	41%	28%
<i>Economic Services</i>	13%	23%	22%	20%	11%	12%	7%	8%	6%	8%	6%
<i>Unallocable Services</i>	33%	31%	27%	28%	26%	37%	34%	24%	31%	23%	17%

Table 4.2.2: Composition of Development Expenditure in Malawi, 1980 – 2001

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
<i>General Administration</i>	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
<i>Social and Community Services</i>	35%	31%	36%	32%	36%	29%	20%	26%	24%	29%
<i>Economic Services</i>	57%	66%	63%	66%	63%	69%	77%	70%	72%	68%
<i>Unallocable Services</i>	8%	3%	1%	2%	1%	2%	4%	4%	3%	3%

Table 4.2.2: Composition of Development Expenditure in Malawi, 1980 – 2001 (cont.)

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01
<i>General Administration</i>	0%	0%	0%	0%	28%	16%	40%	14%	10%	22%	20%
<i>Social and Community Services</i>	32%	49%	44%	20%	51%	54%	29%	44%	58%	37%	30%
<i>Economic Services</i>	64%	46%	17%	29%	15%	24%	16%	39%	27%	41%	49%
<i>Unallocable Services</i>	4%	6%	39%	51%	6%	6%	15%	3%	4%	0%	0%

Table 4.2.3: Composition of Total Expenditure in Malawi, 1980 – 2001

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
<i>General Administration</i>	16%	19%	20%	21%	18%	21%	19%	19%	20%	22%
<i>Social and Community Services</i>	28%	23%	25%	24%	22%	20%	19%	19%	18%	21%
<i>Economic Services</i>	35%	31%	33%	32%	27%	28%	28%	26%	31%	26%
<i>Unallocable Services</i>	22%	28%	22%	23%	33%	32%	34%	36%	30%	31%

Table 4.2.3: Composition of Total Expenditure in Malawi, 1980 – 2001 (cont.)

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/2001
<i>General Administration</i>	26%	25%	26%	21%	31%	20%	28%	25%	25%	25%	41%
<i>Social and Community Services</i>	22%	22%	24%	20%	34%	35%	33%	41%	40%	40%	28%
<i>Economic Services</i>	24%	27%	21%	23%	12%	14%	9%	13%	13%	21%	19%
<i>Unallocable Services</i>	27%	26%	29%	36%	23%	30%	30%	21%	22%	14%	11%

Table 4.3: RIM (Rainfall Index for Malawi)

<i>Year</i>	<i>RIMJFM</i>	<i>RIMF</i>
1970	99.9%	99.0%
1971	88.0%	92.7%
1972	73.9%	63.4%
1973	135.4%	121.1%
1974	83.5%	94.7%
1975	128.1%	139.4%
1976	98.6%	67.5%
1977	145.6%	107.9%
1978	90.4%	108.2%
1979	82.3%	81.3%
1980	82.5%	116.9%
1981	100.3%	127.1%
1982	76.5%	92.1%
1983	102.2%	135.9%
1984	102.8%	96.4%
1985	108.8%	91.0%
1986	83.3%	67.0%
1987	110.6%	125.7%
1988	152.1%	131.8%
1989	91.1%	77.0%
1990	109.0%	94.2%
1991	58.5%	27.2%
1992	113.1%	122.0%
1993	77.5%	56.1%
1994	77.4%	102.3%
1995	106.9%	123.8%
1996	112.1%	130.4%
1997	92.7%	77.6%
1998	116.6%	93.7%

RIM: Rainfall Index for Malawi as to reflect only rainfall in the most important months for rain-fed crops (RIMF for February or RIMJFM for an average of January/February/March) and weighting rainfall in each area by the hectareage under maize production*

**The weighting is for Agricultural Development Divisions (ADD) as follows :*

<i>Karonga</i>	<i>0.027</i>
<i>Mzuzu</i>	<i>0.095</i>
<i>Kasungu</i>	<i>0.176</i>
<i>Lilongwe</i>	<i>0.196</i>
<i>Machinga</i>	<i>0.203</i>
<i>Blantyre</i>	<i>0.162</i>
<i>Shire</i>	<i>0.068</i>
<i>Salima</i>	<i>0.074</i>
<i>Total</i>	<i>1.000</i>

Figure A1.1 Real GDP growth - Mozambique, 1981 - 1998

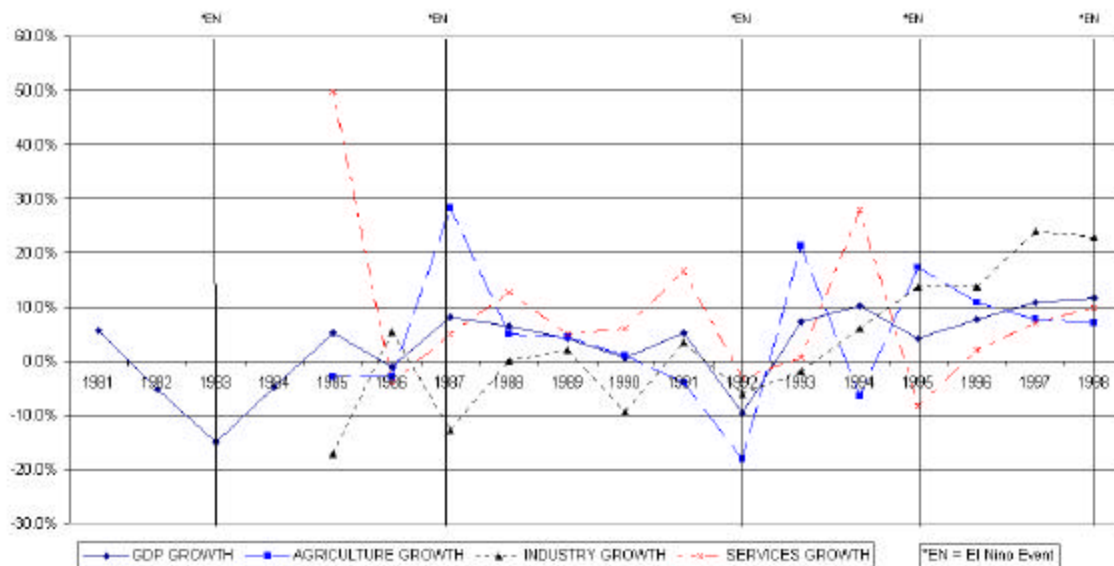


Figure A 1.2: Real GDP growth - South Africa, 1981 - 1998

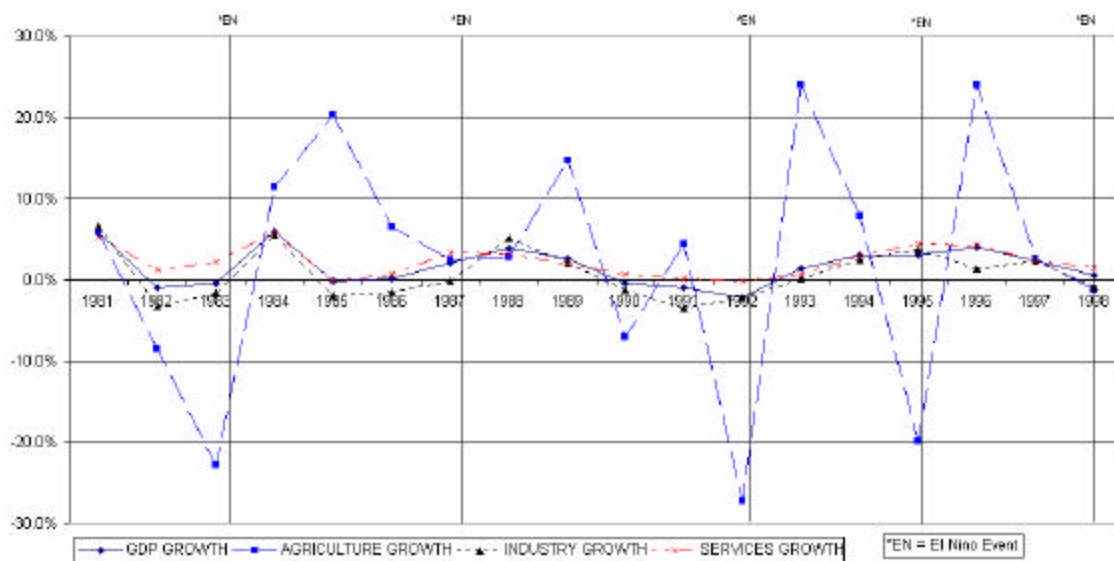


Figure A1.3: Real GDP growth - Zambia, 1981 - 1998

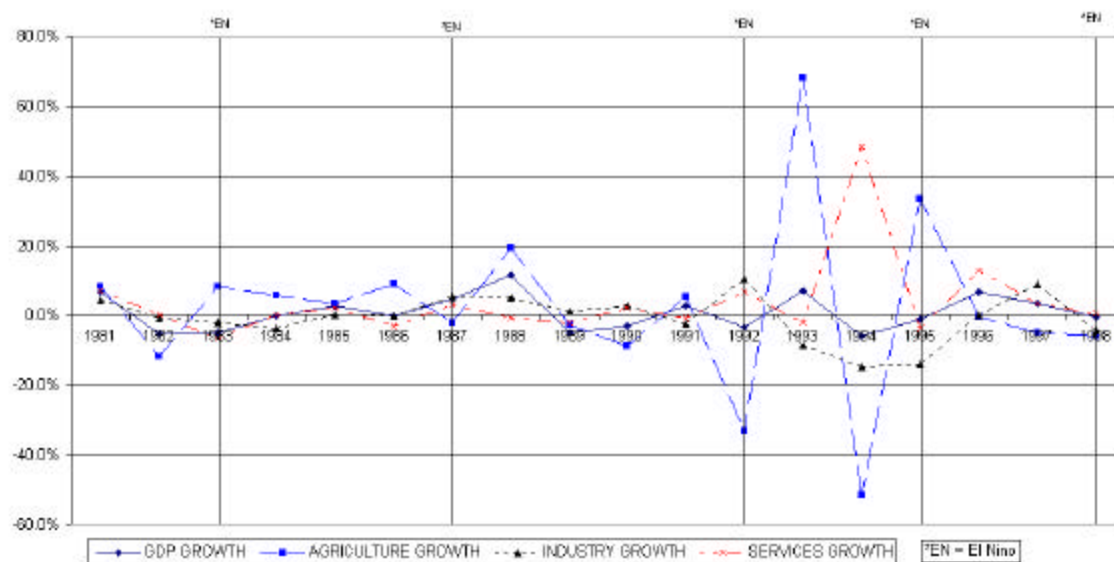
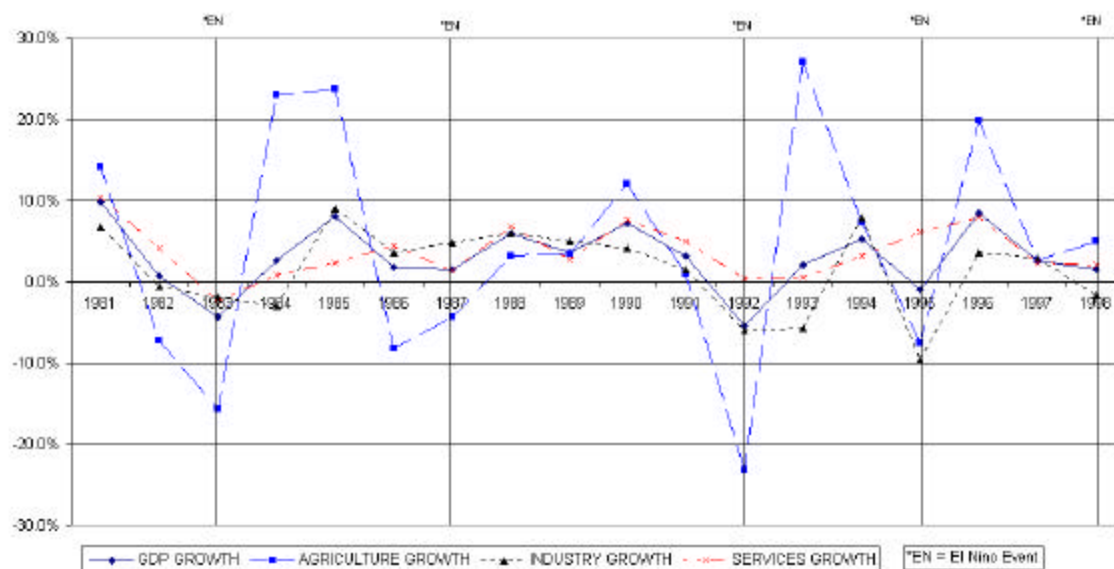


Figure A1.4: Real GDP growth - Zimbabwe, 1981 - 1998



Annex B

ENSO indices

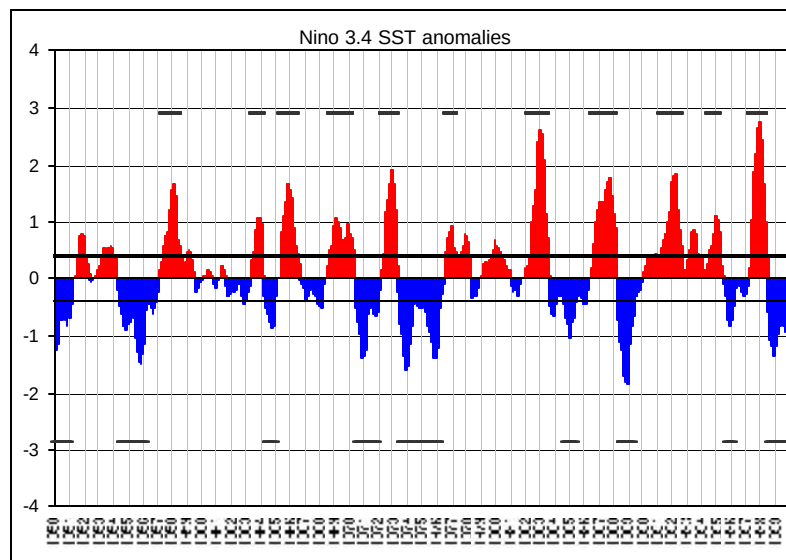
The two most common indicators of ENSO are changes in sea surface temperatures in the tropical Pacific and changes in atmospheric pressure.

When trying to relate ENSO indices to other variables it is necessary to consider that there may be a lag between the event starting and the resultant impacts.

Sea surface temperatures

SST anomalies were obtained from the Climate Prediction Center (NOAA, 2000) <http://www.cpc.ncep.noaa.gov/data/indices/index.html>. These data are representative of the Niño region 3.4 in the tropical Pacific commonly used as an ENSO indicator.

A plot of SST anomalies since 1950, relative to a base period climatology from 1950-79, can be seen below. ENSO events are marked as horizontal bars indicating the duration and sign of the event. El Niño is positive and La Niña negative.



Values above thresholds of $\pm 0.4^{\circ}\text{C}$ are indicative of an ENSO event..

Southern Oscillation Index (SOI)

The SOI is defined as the normalized pressure difference between Tahiti and Darwin. It is often used alone or in conjunction with sea surface temperature as a measure of ENSO events. El Niño events occur when the SOI is negative, La Niña events when the SOI is positive.

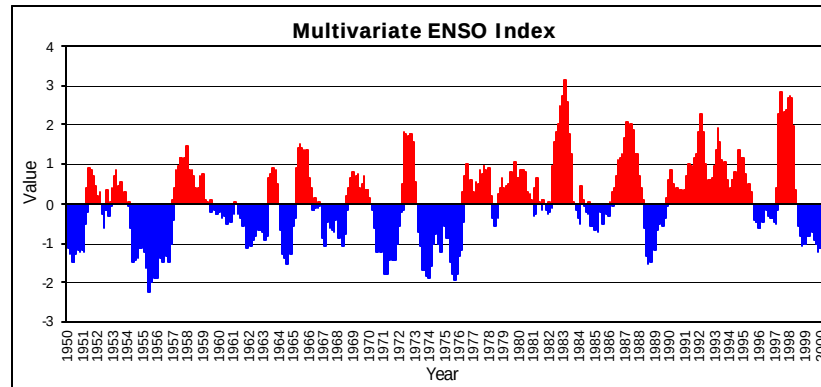
Multivariate ENSO Index (MEI)

The MEI is an alternative to the commonly used SST's and SOI. The MEI incorporates both these indicators and others and it has been suggested it reflects the nature of ENSO better. Negative MEI values are La Niña and positive values are El Niño. MEI is a bi monthly index. Thus it might be necessary to use the MEI value of month(i-1) and month(i) as if it were the value for month(i) only.

<http://www.cdc.noaa.gov/~kew/MEI/>

A plot of the MEI for DEC/JAN 1950 through FEB/MAR 2000 can be seen below.

ENSO years since 1950



El Niño Years	La Niña Years
1997 (4/97-4/98)	1998 (7/98-?/00)
1994 (6/94-3/95)	1995 (9/95-3/96)
1991 (3/91-7/92)	1988 (5/88-6/89)
1987 (7/86-2/88)	1984 (9/84-6/85)
1982 (4/82-7/83)	1975 (9/74-4/76)
1976 (8/76-3/77)	1973 (6/73-6/74)
1972 (4/72-3/73)	1970 (7/70-1/72)
1969 (9/68-3/70)	1964 (5/64-1/65)
1965 (5/65-6/66)	1954 (6/54-3/56)
1963 (6/63-2/64)	1950 (1/50-2/51)
1957 (5/57-6/58)	

Figures in brackets denote the precise months/years that are included. ENSO years are known as the year when the event starts. For Malawi an event that starts in 1997 for example is likely to impact the 1997/98 wet season. Often it is only the most extreme ENSO events with the strongest anomalies that result in impacts in Africa.

Annex C

List of organizations and persons interviewed during visits by Edward Clay and Louise Bohn to Malawi, November 26 to December 6, 2001 and from February 1-15, 2002, and also in Washington, D.C. October, 2001

a. Government of Malawi

Ministry of Finance: Mr. Patrick H. Kabambe, Deputy Budget Director; Mr. Ted Sitima-wina, Deputy Chief Economist, Economic Affairs Division

Department of Meteorological Services: Mr. D. R. Kamdonyo, Director, and Mr. J. L. Nkhowe, Deputy Director, Monitoring and Prediction; Mr. Adams Chavula, Meteorologist assigned to NEWS

Ministry of Agriculture: Mr. Ben Mkomba, Acting Controller, Planning Division; Mr. Rhino Mchenga, Senior Economist, Head of National Early Warning System; Mr. Bosco Noel Magombo, Statistician

Department of Disaster Preparedness, Relief and Rehabilitation: Mr. J.M.K. Chiusiwa, Chief Relief Officer.

Department of Water Resources, Division of Hydrology: Mr. P. Kaluwa, Chief Hydrologist

National Food Reserve Agency: Henry Gaga, General Manager; Charles Moses, Monitoring.

Electricity Supply Company of Malawi (ESCOM) Planning Department: Peterson E. Zunbuni, Senior Manager; Wetton D. Saiwa, Sr. Engineer; Joseph Sheva, Economist; Panda Kadaimanja, Statistician

b. International and bilateral agencies

World Bank: Ms. C. Kimes, Sr. Operations Officer; Mr. Stanley Hiwa, Senior Agricultural Adviser; Ms. Agi Kiss, Lead Ecologist and Task Manager for the Environmental Management Project

Also in Washington, D.C.: Malawi Country Team: Robert Liebenenthal, former Resident Representative, Malawi; Mr. Johannes Zutt, Operations Officer; Mr. Sudhir Chitale, Sr. Economist; Mr. Jorge Munoz, Sr. Agr. Economist; Environment Group, Africa Region; Mr. Arne Dalfelt, Sr. Environment Specialist; Robert Clement-Jones, Sr. Environment Specialist

FAO: Masuru Yamada, Program Officer; Mr. Mark Davies, Donor Committee on Agriculture and Food Security

WFP: Ms. Adama Diop-Faye, Representative; Ms. Moira Simpson, Disaster Mitigation and Response Project; Mr. Masozi Kachale, Information Officer

DFID: Mr. Harry Potter, Senior Agricultural Adviser; Mr. Karl Livingstone, Economist

EU Food Security Unit: Dr. Elizabeth M. Minofu Sibale, Program Officer

NOAA- Dr. Wassila Thiaw, Chief Africa Desk; Mr. Kabineh Konneh, Program Manager for Africa

USAID – Ms. S. Tokar, Bureau of Humanitarian Response, OFDA

c. NGOs, research organizations, commercial sector, technical cooperation personnel and other individuals

Bunda College of Agriculture, University of Malawi: Prof. G.Y. Kanyama-Phiri, Principal; Dr. Henry Banda, Dean, Faculty of Rural Development; Prof. James Banda, Livestock production specialist and Deputy Dean, Member of Presidential Committee on Agriculture; Dr. Charles Mataya, Director, APRU; Mr. Henry Kwavale, Program Manager, APATU; Mr. Killy Sichinga, Sr. Research Fellow APRU and Lecturer in Statistics

Commercial Farming: Mr. Simon Wallace, Tobacco Farmer; Mr. John Hull, Tobacco Farmer; Mr. Jim Melrose, Lujeri Tea; Mr. Bouke Bjil, Lujeri Tea; Mr. Chris Barrow, Namingomba Tea; Mr. Peter Stedman, Eastern Produce; Mr. Dennis Lewis, Managing Director Matambo Estate; Mr. Terry Pearse, Illovo Sugar; Mr. Chris Payne, Eastern Produce

CARE International: Mr. Nick Osborne, Country Representative

FEWS NET Project: Mr. Sam Chimwaza, Representative; Mr. Evance Chapasuka, Asst. Representative

Mr. Stephen Carr, formerly Sr. Agricultural Adviser, World Bank;

Dr. John G. M. Wilson, Fisheries Expert

Ms. Zabrae Valentine, National Democratic Institute;

Dr. Maxx Dilley, International Research Institute for Climatic Prediction

Annex D

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