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and the National Drought Mitigation Center

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From the Director

The 1997–98 El Niño event has certainly raised the public's level of awareness of the impact of climate on society. Although the concern in the United States has focused more on mitigating the potential effects of floods, not all regions of the country are dealing with water surplus situations. An emerging drought in Montana and parts of some surrounding states has caught the attention of scientists and policy makers in recent months. Worldwide, droughts in Central America, Mexico, Brazil, Hawaii, some Pacific island nations, Indonesia, Australia, southern Africa, and elsewhere have attracted the attention of scientists, policy makers, and the media.

Now, as El Niño has lessened in intensity, the threat of La Niña is upon us. Concerns are increasing that the drought in Mexico and parts of the southern United States may intensify and spread into surrounding states in the Southwest. The National Drought Mitigation Center (NDMC) is currently working with the U.S./Mexico International Boundary Water Commission and the U.S. Bureau of Reclamation to organize an August training workshop on drought contingency planning to address short- and long-term issues of drought in the border states region. This workshop will be similar to regional workshops the NDMC organized in 1997–98. Since the last issue of *Drought Network News*, the NDMC has conducted workshops in South Carolina for the Southeast region and in Kentucky for the Midwest and Northeast regions. In additional to the usual mix of participants from local, state, and federal agencies attending these workshops, we have also had representatives from Taiwan, Mexico, Hungary, Korea, and Australia as participants.

The Western Drought Coordination Council (WDCC), formed by the Western Governors' Association in 1997 through a memorandum of understanding with key federal agencies, just completed its first year of activity. The list of accomplishments for the WDCC is quite impressive. The products developed by the WDCC working groups are available on the WDCC web site at http://enso.unl.edu/wdcc/. I encourage you to examine these products, described in somewhat greater detail on p. 18 of this newsletter. The NDMC will continue to serve as technical advisor to the WDCC in 1998–99. The annual

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work plan for the WDCC is also available on the web site.

The National Drought Policy Act of 1998 (HR 3035) is expected to pass the House of Representatives soon. It has been modified slightly from the version that passed the Senate (S 222) in November 1997. This bill would set up a federal drought commission to examine current laws and programs and make recommendations to the president and congress on the needs for a national drought policy. The U.S. Department of Agriculture will serve as chair for the commission, which will be composed of 16 members.

This issue of *Drought Network News* contains articles on drought monitoring in Africa, climate change and soil moisture relationships in Turkey, El Niño and drought linkages in India, Australian national drought policy, and the accomplishments of the WDCC. *Drought Network News* readers are encouraged to submit articles for the October issue to me no later than **September 1, 1998**, for inclusion in the October issue. Readers are also encouraged to submit announcements and other information of interest to our network members.

Donald A. Wilhite

Contents

Improving Drought Management and Planning through Better Monitoring in Africa

Introduction

Drought is part of the environment. It occurs in every part of the globe and adversely affects the lives of a large number of people, causing considerable damage to economies, the environment, and property. It also affects countries differently, having a greater impact on countries with poor economic conditions.

Recurrent drought in Africa in the last 30 years has had a disastrous effect on an economic and social situation that already had serious problems. Today, in the aftermath of these devastating droughts, planning and preparedness have become more important. Most disasters, including droughts, are no accident. They are made by misgovernment. However, competent governments, given foresight and funds, can build defenses against these natural disasters.

The enormous physical consequences of drought and the huge financial cost of relief efforts (compared to prevention) have led Africa to improve its drought management and preparedness scheme regularly.

Modern Techniques Used to Monitor Drought

In the current "information age," technological advances in communication, computers, and remote sensing have greatly improved our ability to measure the important characteristics and impacts of weather-related disasters. A well-integrated use of ground observations and earth-oriented satellite application improves drought monitoring.

Meteorological observations are the primary sources of information widely used for drought monitoring. Ground observations of rainfall so far have a tremendous potential to analyze past, present, and future weather conditions. One of the methods that is being developed involves numerical weather prediction models. These models strongly depend on meteorological elements observed from ground and space.

Meteorological observation of ocean surfaces is of tremendous importance in understanding and predicting ocean–atmosphere relations. Such observations are taken routinely in many parts of the world. This provides a good opportunity for drought prediction as well as ground verification of satellite measurements of the vast ocean surface.

The other method of accurate and timely weather data observation and collection from the ground is the Automated Weather Data Network (AWDN). The accuracy of measurements at ground level, especially in remote areas, is far from sufficient. For example, in Ethiopia, the National Meteorological Services Agency (NMSA) uses about 80 stations for the 10-day weather analysis and less than 50 stations for daily weather assessment and forecast. For real-time weather monitoring, NMSA uses less than 16 synoptic stations. Each station characterizes the weather for an area of more than 14,000 km^2, which is far from sufficient to monitor drought. This makes the integration of space-based meteorological observation essential.

Observations from meteorological satellites routinely provide more complete, more timely, and finer spatial coverage of terrestrial information. This information is normally produced by transformation of the observed radiance into environmental variables such as clouds, radiation, snow cover, sea ice, temperature, vegetation, and other meteorological and geophysical components. Recently developed techniques transform the satellite-observed radiance into more complex environmental phenomenon such as drought (Kogan, 1991).

Interest in satellite observation and subsequent evaluation of drought may be attributed to several characteristics of remote sensing. These include the fact that remote sensing provides a unique vantage point, a synoptic view, a permanent record or data archive, extra visual information, and cost effectiveness in many cases (Johnson et al., 1993).

Assessment of Drought Using Ground and Space Techniques

Drought indices

Various drought indices have been developed and used in many parts of the world (including Africa) to monitor the spatial extent and severity of drought conditions. Generally, drought indices are developed based on cumulative precipitation deficit. These provide guidance for the use of mitigation measures during a drought.

Some of the better-known drought indices are Percent of Normal, Deciles, Palmer Drought Severity Index (PDSI), Surface Water Supply Index (SWSI), Standardized Precipitation Index (SPI), Crop Moisture Index (CMI), National Rainfall Index (RI), and Dependable Rains (DR).

Among these, the SPI is a relatively new index. It is used to quantify the precipitation deficit for multiple time scales (averaging periods). These time scales reflect the impact of drought on the availability of different water resources. Soil moisture conditions respond to precipitation anomalies on a relatively short scale, while ground water, streamflow, and reservoir storage reflect longer-term precipitation anomalies (NDMC, 1998a). The SPI is being monitored at the climate division level for the contiguous United States by the National Drought Mitigation Center and the Western Regional Climate Center (WRCC).

Preliminary results of a case study of Ethiopian rainfall stations show that the potential exists for the SPI to provide near-real time drought monitoring in Africa based on quantifying the precipitation deficit for multiple time scales for a specific station or climatic divisions.

Satellite techniques

The effects of drought are evident on vegetation. Reduced biomass production, increased fire danger, and other long-term changes can often be linked to drought events (Peters et al., 1993). Satellite observations of vegetation can thus be used to monitor drought. One of the most popular methods is the Normalized Difference Vegetation Index (NDVI). This is an index derived from measurements of spectral reflectance acquired by the Advanced Very High Resolution Radiometer (AVHRR) on board NOAA's series of polar orbiting satellites. The NDVI was designed to measure density and vigor of green vegetation and to discriminate vegetated from nonvegetated surfaces (Kogan 1991). These data are being used in environmental monitoring and global climate change studies. This AVHRR-based monitoring tool for global drought watch is being used in many parts of the world, including North and South America, Europe, Africa, Australia, and Asia.

Despite the potential application of the NDVI, numerous shortcomings have also been revealed. For heterogeneous land cover, the NDVI is normally higher in areas with more favorable climate and soil and more productive ecosystems (forest) than in areas with less favorable environmental conditions (dry steppe). To reflect the ecosystem's features and to separate the weather signal from the ecological signal, the NDVI was modified into the Vegetation Condition Index (VCI) (Unganai, 1998). First, the maximum and minimum NDVI values, which correspond to favorable and unfavorable weather impacts on vegetation, are identified for each week of the growing season by calculating multiyear maximum and minimum composites. Then the amplitude for the identified extremes is calculated. The amplitude is also determined for each week of the growing season by calculating multiyear maximum and minimum composites. NDVI values are then normalized relative to this amplitude.

In cases of extended periods of cloud coverage, the NDVI values tend to be depressed, giving a false impression of water stress or drought conditions. To remove the effects of such cloud contamination in the satellite assessment of vegetation condition, the Temperature Condition Index (TCI) is used. The TCI is derived from Brightness Temperature (BT), and its algorithm is similar to the NDVI vegetation's response to temperature (high temperature is less favorable for vegetation). The combination of VCI/TCI is also used to estimate vegetation stress (Kogan, 1995).

Drought Prediction

Unlike most other natural disasters, droughts develop slowly and their existence is often unrecognized until human activity begins to be affected. It is not easy to forecast when a dry spell becomes a drought. In most cases, no single model or technique will serve in predicting drought. Therefore, several courses of action and integration of different techniques are usually required.

There are a number of concepts and techniques to predict drought. The following are some of the most important current concepts and technologies used in many parts of the world, including Africa.

Ocean–atmosphere interaction

The change in weather patterns during an El Niño/Southern Oscillation (ENSO) event alters regions of high and low pressures around the globe. Descending air of atmospheric circulation cells creates high pressure centers at the surface. The high surface pressures prevent areas of precipitation from moving into a region where these pressures exist. When these abnormal high pressure patterns persist, they lead to drought conditions, depriving the area and its ecosystem of rainfall. Droughts generally occur in the western Pacific, an area normally rich in rainfall, during ENSO events. Studies have indicated that there is a high correlation between ENSO and drought or rainfall deficiency in Africa. Thus, measurements and predictions of the sea surface temperature of the Pacific Ocean using improved numeric computer models can lead to better monitoring of drought.

The identification of ENSO as a drought precursor has raised the possibility of drought predictability. Teleconnections between North American precipitation patterns and ENSO events, and North Pacific sea-surface temperature anomalies, have been used as a precursor in many parts of the world. For example, in east Africa, studies have indicated that the correlation of ENSO with seasonal rainfall deficiency leading to drought is strong (Ogallo, 1994).

The ability that does exist is primarily the result of empirical and statistical relationships. In the tropics, empirical relationships have been demonstrated to exist between precipitation and ENSO events, but few such relationships have been confirmed above 30°N (NDMC, 1998b).

Therefore, the forecasting of seasonal precipitation anomalies, based on these precursors and models, appears to be an important step toward better drought monitoring in Africa. However, a considerable amount of research is still being conducted to develop models of the identified precursors and to find other precursors.

Synoptic weather systems

The immediate cause of drought is the predominant sinking motion of air (subsidence) over land surfaces that results in compressional warming or high pressure, which inhibits cloud formation and results in lower relative humidity and less precipitation. Prolonged droughts occur when large-scale anomalies in atmospheric circulation patterns persist for months or seasons (or longer). On the other hand, the semipermanent high pressure cells over the oceans supply moisture. For example, the weakening of the Atlantic and South Indian ocean semipermanent highs in the monsoon seasons results in a reduction of moisture to the equatorial regions of Africa. This has been observed during drought years. The complex nature of atmospheric phenomenon from the ground to the upper atmosphere must be better understood. However, the prediction models are becoming more sophisticated and more effective in many respects.

Drought Impacts and Human Suffering in Africa

The overall impact of a drought on a given country, and its ability to recover from the resulting human and material damage, depends on several factors. For one set of people it will mean disaster and famine; for another it will only be a matter of inconvenience. One of the most widely accepted reasons for the aggravation of drought impacts in Africa is the continuous increase in its population growth rate. The demands of a rapidly expanding population are placing increasing burdens on the continent and its resources. This means that the potential for adverse effects of disasters on human life is also growing, since population pressures will lead more people to live and work where risks are highest. This implies that population growth is a serious intensifier and multiplier of other social and economic problems, especially as it retards the prospects for developing a better life in the poorer countries. This makes drought impacts more severe in developing countries.

In many African countries that have a subsistence lifestyle, the impact of drought usually extends to famine. Once a famine has reached the proportions of a major disaster, it is too late to mount a fast and efficient relief operation. Supplies rushed to a country are often held up at the country's ports, unable to be distributed by the existing infrastructure. Moreover, in a number of countries, governmental organizations that issue relief aid are not set up to respond quickly or effectively, and volunteer agencies are neither designed nor equipped to cope with starving masses. The drought in the 1980s and even in recent years caused millions of people to starve to death. The African continent in the mid-1980s suffered from famines on a scale never before experienced. As of April 1985, some 10 million people had abandoned their homes in search of food and water, 20 countries had been critically affected by drought, and 35 million lives were in danger (UIA, 1998). In east Africa and the Sahel, widespread starvation resulted from long-term drought in 1984.

Therefore, drought represents one of the most important natural triggers for malnutrition and famine, a significant and widespread problem in many parts of Africa and in other developing countries as well. However, deaths resulting from famine are sometimes mistakenly attributed to drought rather than to underlying causes of misgovernment. The occurrence of famine as a result of drought is believed to happen mostly because of inadequate planning, inadequate notification, slow response, government pride, misdirected aid, uncoordinated relief agency field work, politics, sluggish bureaucracy, ignorance, and incompetence. It is a grave problem that shakes the entire political, economic, and social foundations on which the stable and prosperous future for developing countries was to have been built (UIA, 1998). This shows that there should be appropriate planning and preparedness for drought, which can be a natural trigger for famine in Africa if the right circumstances exist.

Drought Management

Drought management is too often restricted to treating the symptoms, often when it is too late and only a relief function can be performed. A critical factor in the effectiveness of disaster management is the preparation of policy, management strategies, intervention criteria, and emergency action plans. A great deal of valuable time can be lost and confusion caused if planning for intervention only happens after the disaster has struck.

Major steps that should be taken include developing a national policy for drought preparedness, response, and mitigation measures; developing a drought contingency plan that includes early detection, monitoring, decision-making criteria, short- and long-range planning, and mitigation; and including programs that address public awareness of and education on drought and water conservation (Wilhite 1993).

Moving to a deliberate and purposeful policy of drought management and planning is urgently required of all African countries and other governments in the world. Although this may not be politically and economically palatable in the short term, efforts should be made to do so.

The Need for Data and Information Exchange and Coordination in Africa

In many African countries, data collection and analyses are carried out by a number of government departments and agencies, with little or no coordination. This strongly suggests the need for a suitable mechanism or independent agency that coordinates and facilitates the provision of information to all kinds of users. This can be done within the country and at the regional level. Subregional organizations such as the Arab Magreb Union (AMU), Permanent Inter-State Committee for Drought Control (CILSS), Economic Community of Central African States (ECCAS), Economic Community of West African States (ECOWAS), Inter-governmental Authority on Development (IGAD), and Southern African Development Community (SADC) could play an important role. Contributions of other international and governmental organizations like the UN Food and Agricultural Organization (FAO) and the U.S. Famine Early Warning System (FEWS) would also be improved by a smooth and well-coordinated information exchange.

The efforts that are being made to ensure timely warnings and provide guidance to decision makers and farmers through the Drought Monitoring Centres (DMC) in Nairobi (Kenya) and Harare (Zimbabwe) and the African Centre of Meteorological Applications for Development (ACMAD) in Niamey (Niger), which monitor the drought situation in Africa, would be much improved by a well-coordinated information and data exchange. It might also reduce the redundancy of work being done by different agencies for a specific area or country.

Conclusions

Technological advances in space studies allow improved drought monitoring using satellites with high resolution in a cost-effective manner. Ground techniques that are being developed to monitor drought should be integrated with space technology for better results. This technical know-how and its implementation should also consider the people and culture of the various countries.

Although African governments have taken some steps toward drought management and planning, the shift from relief to preparedness and mitigation will require an ongoing effort. Developing scientific understanding and techniques in each country and planning to shift from crisis management to risk management is a necessary condition for sustainable development. Hence, if better monitoring must be undertaken, the development of a management plan is essential. This will require considerable political courage and foresight.

The international community provided and still provides assistance in mitigating drought. The African people themselves should do the maximum possible to combat drought and become, at the least, self-sufficient. The coordination of drought monitoring data and information among government and international organizations is essential for better drought management in Africa. This strongly suggests the need for a suitable mechanism or independent agency that coordinates and facilitates the availability of information to all kinds of users. It may also help reduce duplication of efforts among the various groups involved in drought management.

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Editor’s Note: *Tsegaye Tadesse was a visiting research scientist at the National Drought Mitigation Center from February 1998 to May 1998.*

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Implications of Climate Change for Soil Moisture Availability in Turkey's Southeastern Anatolia Project Region

Introduction

The Southeast Anatolia Development Project (known as GAP) is a multifaceted development project for agriculture and water resources within the Turkish portions of the Euphrates and Tigris river basins. Through this project, the vulnerability of the region to drought has been investigated in both temporal and spatial terms. On completion of the project, 28% of the total water potential of Turkey will be brought under control through facilities on the Euphrates and Tigris rivers, which have a joint flow of more than 50 billion m^3 (GAP Regional Development Administration, 1997). The GAP project aims to irrigate 8.5 million hectares of land in Southeast Anatolia, which is 19% of the total economically irrigable lands in Turkey. A project of such magnitude inevitably is of major importance to the region's water resources and agricultural potential. It is therefore important to establish reasonable expectations of water use in the GAP region, since agriculture is going to be a critical component of the region's economy in coming decades. The GAP area is located in the continental Mediterranean rainfall region, and its annual precipitation varies between 400 and 800 mm. Annual precipitation decreases from north to south in the region, and the greatest portion of the annual precipitation falls in winter, December and January being the wettest months. Summers in the region are very dry, with high temperatures.

Climatic Impact Assessment

The implications of climatic change for selected soil-water parameters are evaluated in 13 major agricultural and water resources project regions (Figures 1 and 2). The scenarios include 10 hypothetical cases involving combinations of +2 and +4 degrees Celsius and -20%, -10%, 0%, +10%, and +20% precipitation changes. The precipitation scenarios compare well with precipitation changes generated from GCM data and are similar to assumptions made by previous

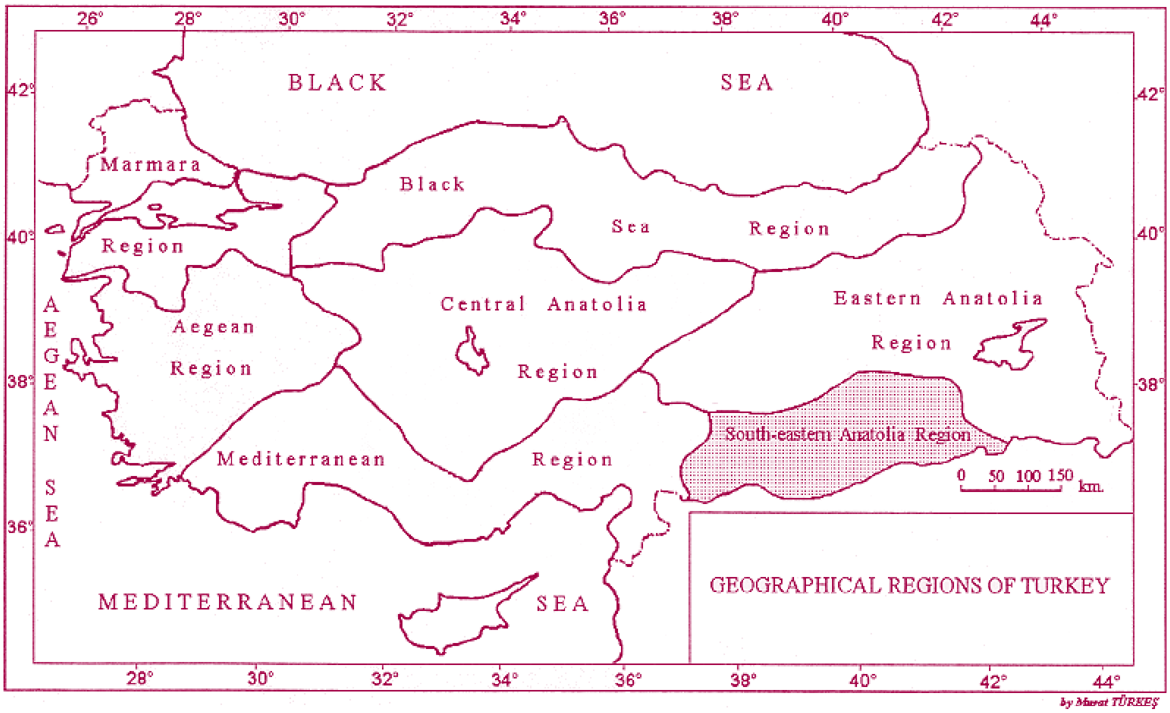


Figure 1. Location of the study area.

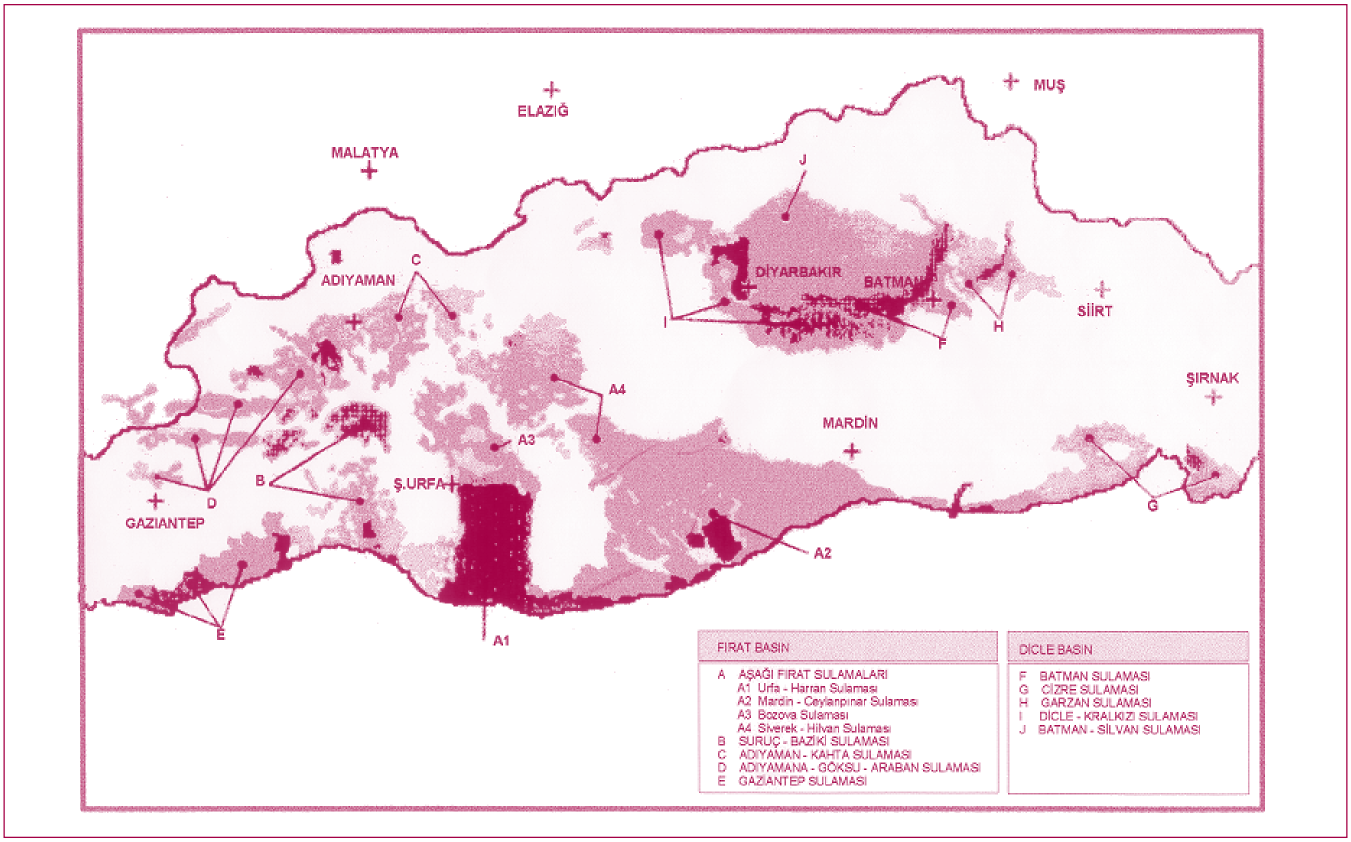


Figure 2. Major agricultural and water resources project regions of GAP.

hydrologic studies for climatic impact assessment (Gleick, 1987).

The study uses a computerized version of the original Thornthwaite water balance model, which was developed by Willmot (1997). The model requires data on precipitation, temperature, soil-water holding capacity, heat index, and latitude of a given station. It computes potential and actual evapotranspiration, soil moisture deficits, and soil moisture surplus for a predetermined time period. There are 28 climate stations within and nearby the study area. A grouping of the stations was made within each individual project area. Using the Thiessen method, representative values of precipitation, temperature, and moisture field capacity were constructed for each project area. Each project area thus was treated as a single unit of a study site.

Climate Impact Assessment Results

The results of the model runs for the hypothetical scenarios were plotted as differences from the soil moisture deficit. In Figure 3, changes in the soil moisture deficit (D) from the present are shown for a 2°C warming and prescribed precipitation changes. Groups of subregions that portray similar trends and changes are identified. A general behavior observed in all groups is that during part of spring and all of summer, the region will be affected by severe water shortages. Enhancement of the soil moisture deficit even extends to early autumn in most cases. The severity of the dryness increases during this period because the moisture demand is not satisfied by precipitation. Even with an increase in precipitation, a 2°C warming will be sufficient to cause an extended period of drought throughout the year in the region. In all the subregions, a 2°C warming coupled with a 20% decrease in precipitation will cause a major soil moisture deficit in the region. The extent of the drought also varies geographically. The effect of warming on summer deficits is most pronounced in the Cizre subregion. The timing of the deficit period shifts one month ahead in the southeastern parts of the region, starting in April. The demand for moisture peaks in all subregions in June.

Figure 4 shows the monthly changes in soil moisture deficit under a scenario of a +4°C increase in temperature. The severity of the water shortage in

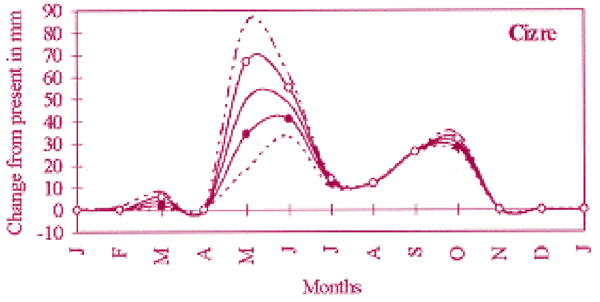
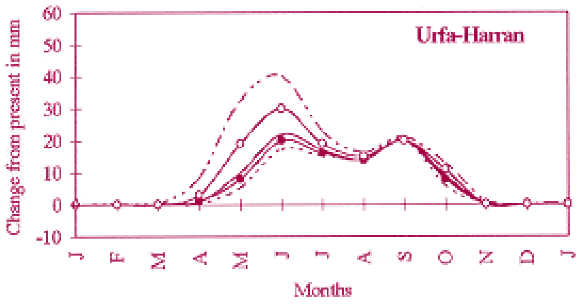
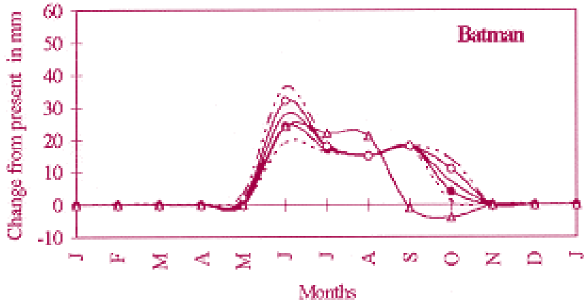
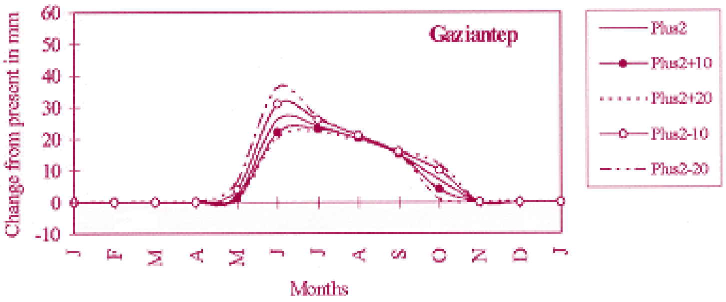
	None
	Adıyaman-Kahta
	Batman-Silvan Bozova-Urfa Dicle-Kralkızı Garzan Mardin-Ceylanpınar Siverek-Hilvan
	Adıyaman-Göksun-Araban Suruç-Baziki

Figure 3. Changes in soil moisture deficit from the present under a +2°C warming and prescribed precipitation changes.

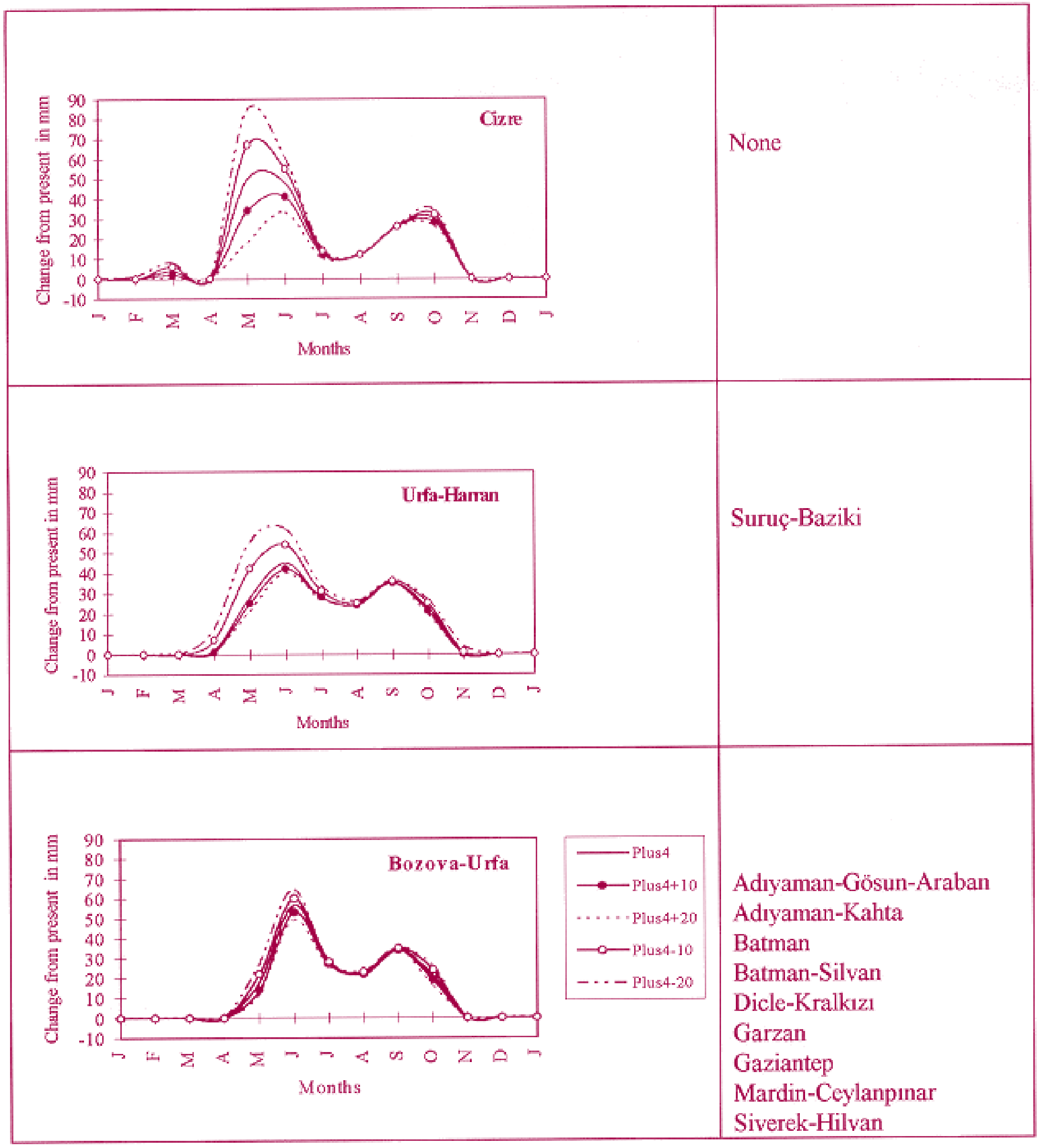


Figure 4. Changes in soil moisture deficit from the present under a +4°C warming and prescribed precipitation changes.

the GAP region is even more pronounced in this figure. Cizre is still the most sensitive to climate changes. In general, an extended period of water deficit, lasting almost 7 months, dominates throughout the region. Western and southeastern parts of the region are most affected by the water shortage. Because winter precipitation in the region is insufficient, a +4°C warming will not cause a major soil moisture deficit during the November–March period. On the other hand, because climatic demand for water increases more than does precipitation during spring and summer, a +4°C warming decreases water availability in all subregions, causing a dry period lasting 6–7 months. This extended period of soil moisture deficit is attributed to the increased spring and summer evapotranspiration and lack of precipitation. An increase in precipitation of at least 20–30% would be necessary to maintain the summer soil moisture content at its present level under a warming of +4°C. As expected, the largest changes in D occur with a +4°C warming combined with a 20% decrease in precipitation. In the Cizre subregion, the change from the present D nearly reached 90 mm in May. The beginning of the water shortage period in the region varies too. In most parts of the region, the soil moisture deficit begins in May and peaks in June. In the southeasternmost parts of the region, where the annual precipitation can be as low as 300 mm a year, the soil moisture deficit begins in April, and the change in D from the present is marked by larger differences. In other words, the timing of D shifts one month ahead in the southeastern portion of the GAP region. Another interesting conclusion is that with a warming of 4°C, the effect of increasing precipitation on reducing the soil moisture deficit is insignificant. In most subregions, increasing precipitation even 20% had little impact on reducing the summer soil moisture deficit. It is possible to conclude that in areas where summers are very dry, additional precipitation increases would not eliminate the adverse impact of warming on soil moisture content.

Results of this study suggest that the projected climate change could have major impacts on the timing and magnitude of soil moisture availability in agricultural areas of the GAP region (Komuscu et al., 1998). Among the most significant results of this study are decreases in soil moisture during the growing season across the region. The severity of the soil moisture deficit increases in the south central and southeastern parts of the region, which already suffer from low precipitation. Because the region receives most of its precipitation during the winter, an increase in precipitation in other months will not eliminate the adverse impact of warming on soil moisture. Summer soil moisture deficits increased substantially under all scenarios. Even a 20% increase in precipitation had very little effect on preventing rapid depletion of soil moisture under the warming scenarios. In other words, the projected temperature changes would be responsible for most of the increase in summer deficits in the GAP region as a result of increased evapotranspiration rates. Intensification of the dryness during the growing season in the region means higher demand for water by crops. A prolonged deficiency of soil moisture may retard plant growth and lead to agricultural drought. This in turn means enhancing the water supplies in the region and preventing crops from being subjected to extended periods of drought and subsequent crop failure. Various adaptation strategies are needed to combat agricultural drought in the region. Adaptation to climate change through new crops and crop varieties, more advanced dry farming methods, improved water management, more efficient irrigation systems, and changes in planting will be important in limiting negative effects of warming and taking advantage of beneficial changes in climate. Continued and substantial improvements in crop yields would be needed to offset the adverse effects of warming and decreased summer soil moisture in the region. Of course, irrigation practices are greatly needed in drought-prone areas for higher crop yields. Higher temperatures and increasing summer soil moisture deficit certainly will boost the demand for irrigation. In addition, if large areas will be irrigated in the region, then the problem of optimum water use will arise as the demand for water by other sectors increases.

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No Droughts over India Following Very Strong El Niño Episodes

One of the external factors responsible for the interannual variability of Indian summer monsoon rainfall (ISMR—June through September) is the El Niño phenomenon. About half of the droughts over India have been related to this phenomenon. Other external factors, such as the Eurasian snow, also affect the year-to-year variability of the ISMR. It is believed that in such cases, the ISMR becomes locked into its own internal dynamics.

An examination of very strong El Niño cases after 1870 reveals that most of these cases have resulted in severe droughts over India. However, it is interesting to note that following a strong El Niño, India has never experienced a drought. Table 1 clarifies this point. The strong El Niño cases have been determined using Quinn et al. (1987), updated from *Climate Diagnostic Bulletins* published by NOAA/NWS/NCEP. The ISMR is taken from Parthasarathy et al. (1994). The long-term mean ISMR is 852 mm, with a standard deviation of 84 mm. Normally, the ISMR is considered deficient (drought) when it is at least one standard deviation below the long-term mean.

Serial No.	***Strong El Niño:***		***Following Year:***	
	Year	**ISMR**	**Year**	**ISMR**
1	1877	604	1878	976
2	1884	933	1885	847
3	1891	793	1892	992
4	1899	629	1900	890
5	1911	737	1912	806
6	1918	651	1919	885
7	1925	804	1926	903
8	1941	728	1942	958
9	1957	789	1958	889
10	1972	653	1973	913
11	1982	735	1983	956
12	1987	697	1988	961
13	1997	~870	1998	**?**

Table 1. Years of very strong El Niño cases and ISMR (in mm).

The mean ISMR for the strong El Niño cases is 740 mm, while the mean ISMR following the strong El Niño cases is 915 mm. The t-statistic for testing the difference between these two means is 5.47. This is highly significant. Thus there seem to be no droughts over India following very strong El Niño episodes. Whether the serial number 13 (Table 1) proves to be lucky or unlucky for India will be determined by the 1998 monsoon.

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Australia's National Drought Policy Continues to Evolve

Australia is an arid continent with a high variability in its annual rainfall. Given the frequency and severity of droughts and the consequent high financial and social costs to the nation and to individuals, and the associated potential for further degradation of the land, a national policy on drought was clearly needed.

Australia's National Drought Policy (NDP) was ratified by the state and Commonwealth (federal) governments in 1992 (White, 1993; White et al., 1993; White and O'Meagher, 1995). Its aims are to:

- encourage primary producers and other sections of rural Australia to adopt self-reliant approaches to managing for climatic variability;
- maintain and protect Australia's agricultural and environmental resource base during periods of extreme climate stress; and
- ensure early recovery of agricultural and rural industries, consistent with long-term sustainable levels.

Further detail on policy evolution in both Australia and South Africa is described by O'Meagher, et al. (1998b).

Constraints to Policy Implementation

A number of factors have impeded full implementation. The first has been the frequency and severity of El Niño events affecting large areas of the Australian continent since 1991. The extent and intensity of these droughts reached a climax in 1994, when little rain fell across the continent from March to September. The second factor was that many farmers were already experiencing high debt at the commencement of these droughts. This was in part due to the banks aggressively offering loan finances in the mid-1980s, high interest rates in the late 1980s, and commodity price failure, particularly wool, as in 1989. Many farmers were therefore poorly equipped financially to cope with a major drought.

It also needs to be appreciated that Australia's agriculture is largely unsubsidized, although there is provision for financial support from government during periods of exceptional drought, or for reducing land degradation through catchment revegetation and other community schemes associated with the National Landcare Program. For this reason, there can be considerable community and political pressure in below-average seasons for areas to be declared as warranting financial support for drought relief.

Drought Exceptional Circumstances

The Australian Labour Party (ALP), which has modest rural support at best, was in power at the national level from 1982 to 1996. It was during this period that "rorting" (fraudulent manipulation and abuse of the system for financial gain) of drought funds by some states was identified, and the National Drought Policy drafted and ratified. Given the intensity of drought during the 1990s, the provisions in the NDP for providing financial support to farmers during exceptional droughts was invoked in 1994.

Declaration of areas as experiencing Drought Exceptional Circumstances (DEC) was based on objective assessment of rainfall, agronomic and environmental factors, water supply, net farm income, and scale of the event (White and O'Meagher, 1995). However, there was a sense of disbelief among many farming communities when applications by state government for DEC on their behalf failed (White and Karssies, 1997). The failure of these applications was usually because the rainfall deficit in these areas was not considered severe enough to warrant DEC declaration. It had to be established that a drought was a greater than 1 in 20 year event (i.e., within the worst 60 months in 100 years) and of more than 12 months duration. Confounding factors included mean annual rainfall having been way above average over much of eastern Australia during the 1970s; poorly prepared submissions by some of the states for DEC; and arguments between the states and the Commonwealth over the effectiveness of what rainfall was received and over "lines on maps," attributable in part to administrative boundaries not coinciding with those associated with rainfall deficit.

The Bureau of Resource Sciences (BRS) had responsibility for coordinating the scientific advice to the Rural Adjustment Scheme Advisory Council on whether or not DEC should be invoked in different regions (White and O'Meagher, 1995). DEC declarations would enable financial support in terms of interest rate subsidies and farm household support (food on the table) to be provided to farmers deemed commercially viable in the long term. Considerable use was made of rainfall and temperature data from the Australian Bureau of Meteorology, rainfall maps and other geographic information system (GIS) products from the Queensland Departments of Primary Industries and Natural Resources (Brook and Carter, 1996), farm survey data, regional visits by the Rural Adjustment Scheme Advisory Council, remote sensing imagery (McVicar and Jupp, 1998), and the agronomic output from simulation models of agricultural systems. These models have proved invaluable for assessing the effectiveness of rainfall and placing the severity of current droughts in historical context. Final decisions on DEC declaration are made by the Commonwealth Government on advice from the Council.

A Change in Government

In 1996, the Coalition (Liberal Party and National Party, the latter having a large rural constituency) won office from the ALP and formed the new national government. Their agenda included a large downsizing of the Commonwealth Public Service, privatization of public assets, and reduction of foreign debt. It also implemented significant changes in the evolving NDP.

The objectives of the NDP remain, commitment to the policy having been reaffirmed by the Commonwealth and the states in 1997. The Minister for Primary Industries & Energy has recently announced a more generous Farm Management Deposit Scheme to replace existing tax-based risk management tools, more generous welfare arrangements for farmers, increased support for climate research, and the phasing down of interest rate subsidies for DEC. There has been some relaxation of the guidelines for DEC, including an extension from 6 to 12 months of the period post-revocation when financial support shall cease. However, the criteria for DEC declaration are still in place.

There has also been support for the concept of using net farm income as the major determinant of financial support. For example, Thompson and Powell (1998) argue that drought is but one of the risks that farmers face. Associated with this is greater emphasis on Exceptional Circumstances (EC), as distinct from DEC, where a number of factors can contribute to an exceptional event. The Minister has announced that drought relief payment equivalent support is to be extended to other exceptional circumstances (Anderson, 1997).

This author and others (e.g., O'Meagher et al., 1998a) are concerned that an incomes-based approach to declaring EC runs the risk of creating significant barriers to structural adjustment in the agricultural sector through the creation of a de facto minimum incomes scheme for farmers. There is therefore a need to continue to pursue the development of objective, science-based triggers for drought support.

Drought Assessment Research

Concurrent with the above has been the increasing use of agronomic models and other tools to identify when DEC events occur. Initiated in BRS (White et al., 1998), a national research program was undertaken to test cropping, grassland, and rangeland models in different environments. This program proved highly successful, it being clearly shown that objective assessment and ranking of agricultural droughts, although difficult, was certainly possible. The outcomes of these studies, and others in southern Africa, are being published in a special issue of the international journal *Agricultural Systems* (Elsevier Science) due out in mid-1998. Other research programs aimed at helping farmers become more self-reliant and able to cope with drought have been funded and coordinated by the Land and Water Resources Research & Development Corporation (LWRRDC) and other R&D Corporations as part of the National Climate Variability (R&D) Program.

In conclusion, despite minor setbacks, there is cause for optimism about the NDP. The policy is now firmly in place with both national and bipartisan support. Farmers are now much more aware of its existence, and of the need to be more self-reliant, rather than reliant on government, in managing financially viable farming operations. A range of objective tools, including improved seasonal forecasts, agronomic models, Decision Support Systems (agronomic and financial), remote sensing imagery, and GIS, have been developed to help farmers, agribusiness, and government anticipate, plan for, monitor, assess, and manage drought. Education and extension programs are also in place to ensure that the concepts are becoming better understood and the tools used efficiently.

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Western Drought Coordination Council Products Available

The products of the Western Drought Coordination Council's first year make significant contributions to the information available to assist planners in preparing for and recovering from drought. Among the products presented at the Council's annual meeting June 4, 1998, in Albuquerque, New Mexico, were:

- *Western Climate and Water Status*, a quarterly report that funnels information on water supply, snowfall, and other climate-related issues from scientists and technicians to policy makers.
  http://enso.unl.edu/wdcc/quarterly

- The Catalog of Federal Drought Assistance Programs, first compiled by the Federal Emergency Management Association (FEMA), now enhanced and republished on the World Wide Web.
  http://enso.unl.edu/wdcc/products/programs.pdf

- *How to Reduce Drought Risk*, a vulnerability assessment guide for state, regional, and community drought planners, was developed by the Council and the National Drought Mitigation Center.
  http://enso.unl.edu/wdcc/products/risk.pdf

The Council's finished drought mitigation products are available on its web site: http://enso.unl.edu/wdcc/products/infoproducts.html.

The National Drought Mitigation Center provides technical advice and staff support to the Western Drought Coordination Council and its working groups.

Other accomplishments of the Council include:

- helped the NDMC conduct U.S. Bureau of Reclamation-sponsored drought planning workshops.
- analyzed 17 state and 11 local drought plans to see what each contained.
- reviewed and analyzed reports on the 1996 drought by the Western Governors' Association and FEMA.
- initiated survey of states to learn about short-term drought impacts and response strategies.
- initiated development of a historical climate database inventory
- initiated transformation of data from single-purpose networks into a multipurpose management tool.
- initiated distribution of climate-related products via the Unified Climate Access Network.
- initiated assessment of daily, weekly, monthly, seasonal, yearly, and historical data anomalies based on evaluation of the mean, median, and variance.
- identified data availability and limitations regarding streamflow, reservoir, and divisional precipitation.
- assessed the usefulness of various precipitation indices to assess their potential for drought monitoring.
- identified parameters of drought assessment to include meteorological, agricultural, and hydrological descriptions, while giving consideration to appropriate indicators for assessing drought impacts.
- monitored various weather and climate prediction information relevant to forecasting drought for decision makers.
- examined the potential for the application of soil moisture, evaporation, atmospheric and global ocean circulation patterns to support improved forecasting.
- inventoried drought communication products and developed information about the Council.

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