DROUGHT MONITORING ACTIVITIES: CASE STUDIES

Considerable progress is being made in drought monitoring and early warning systems in many countries. The increased emphasis on improving these systems is largely the result of the mounting impacts of drought, reflecting greater societal vulnerability. Heightened monitoring capability, including the expansion of automated weather station networks and satellites and the Internet are contributing to such improvements. The Internet allows for improved access to critical data and information to assist in climate and drought assessments and the delivery of this information through a wide range of tools or decision-support products to users in many sectors. A few examples from various countries are included to illustrate some of the approaches being taken in drought-prone regions.

CHINA

The authority that monitors drought development in China is the Beijing Climate Center (BCC) of the China Meteorological Administration (CMA). BCC has used the Standardized Precipitation Index since 1995 to monitor drought occurrence and development in China on a 10-day basis. The monitoring results are published in the China Drought Monitoring Bulletin issued by BCC. Between 1995 and 1999, a Chinese

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drought monitoring and early warning system was developed and put into operation on a daily basis in 1999. This system provides accurate information on drought to various related governmental agencies and to the general public, which helps in the development of measures to mitigate the impacts of drought. The core of the system is a Comprehensive Index (CI) for drought monitoring developed by BCC as a result of its long experience in drought monitoring and impact assessment.

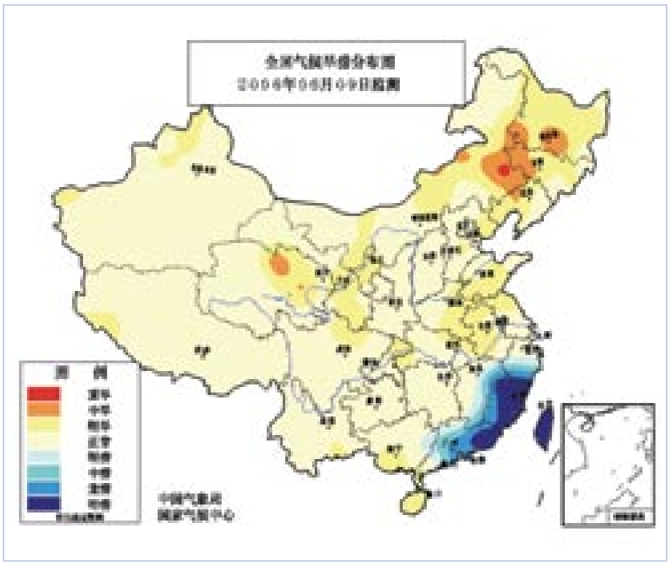

Figure 9. Drought monitoring for China, 9 June 2006; the colour scale from eggshell (in the middle) to red indicates increasing drought severity. (Source: China Meteorological Administration)

CI is a function of the last 30-day and 90-day SPI and the corresponding potential evapotranspiration. Based on CI and soil moisture monitoring from an agricultural meteorological station network and remote-sensing-based monitoring from CMA's National Satellite Meteorological Center, a number of drought monitoring products have being produced:

- Bulletin of China Drought Monitoring, which targets governmental agencies and is published at varying intervals;
- A drought monitoring and impact assessment briefing, broadcast on CCTV every Wednesday since 2004;
- Daily drought monitoring maps, which have been available on the BCC homepage since February 2003 (http://www.bcc.cma.gov.cn/en).

Figures 9 to 11 provide examples of drought monitoring products such as drought monitoring maps, soil moisture assessment and remote-sensing-based products. Spring drought in Ningxia province in 2006 had a significant impact on the winter wheat crop.

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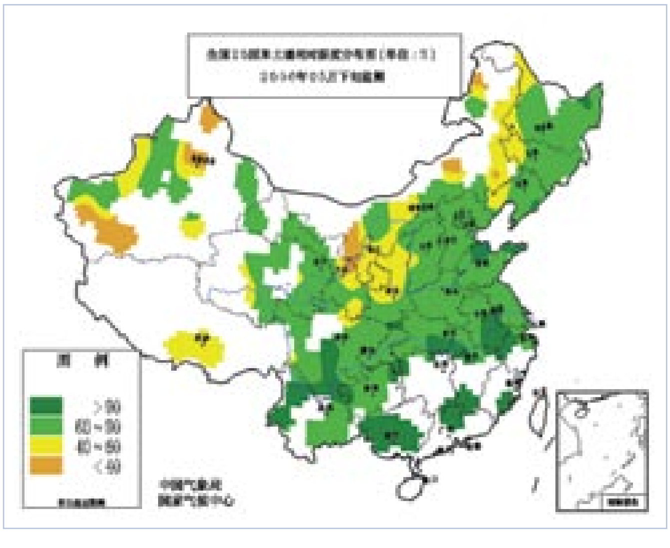

Figure 10. Soil moisture monitoring of the top 20 cm of soil from 21 to 31 May 2006. The higher the values, the wetter the soil. (Source: China Meteorological Administration)

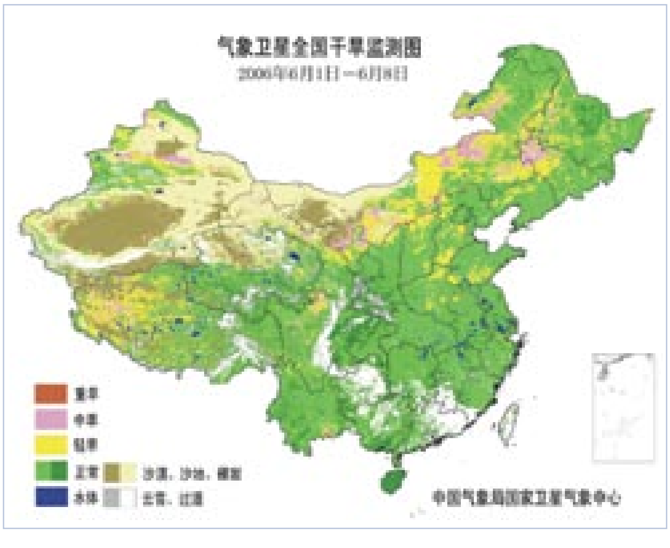

Figure 11. Remote-sensing-based drought monitoring for 1 to 8 June 2006. The colour scale on the left from blue to brown indicates the degree of drought severity. (Source: China Meteorological Administration)

IGAD CLIMATE PREDICTION AND APPLICATIONS CENTRE (ICPAC)

The Greater Horn of Africa, like many parts of the tropics, is prone to extreme climate events such as droughts and floods. In an effort to minimize the negative impacts of extreme climate events, WMO and the United Nations Development Programme established the regional Drought Monitoring Centre (DMC) in Nairobi and a sub-centre in Harare in 1989 covering 24 countries in the eastern and southern African subregion. In 2003, DMC Nairobi became a specialized institution of the Intergovernmental Authority on Development (IGAD) and was renamed the IGAD Climate Prediction and Applications Centre (ICPAC). The participating countries of ICPAC are Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Uganda and United Republic of Tanzania. The Centre is responsible for climate monitoring, prediction, early warning and applications for the reduction of climate-related risks in the Greater Horn of Africa.

ICPAC's main objective is to contribute to climate monitoring and prediction services for early warning and mitigation of the adverse impacts of extreme climate events on various socio-economic sectors in the region, such as agricultural production and food security, water resources, energy and health. The early warning products enable users to put mechanisms in place for coping with extreme climate- and weather-related risks in the Greater Horn of Africa. The Centre also promotes capacity-building for both climate scientists and users.

ICPAC provides regular regional climate advisories, including 10-day, monthly and seasonal climate bulletins as well as timely early warning information on evolving climate extremes and associated impacts. Regional Climate Outlook Forums are also being held before the onset of the major rainfall seasons to provide consensus climate outlooks and to develop mitigation strategies. Below are some of the activities undertaken by ICPAC:

- Development and archiving of regional and national quality-controlled climate databanks;
- Data processing, including development of basic climatological statistics;
- Timely acquisition of near real-time climate and remotely sensed data;
- Monitoring space-time evolutions of weather and climate extremes over the region;
- Generation of climate prediction and early warning products;
- Delineation of risk zones of extreme climate-related events;
- Timely dissemination of early warning products;
- Conducting capacity-building activities in the generation and application of climate products;
- Organization of climate outlook forums for the countries in the Greater Horn of Africa;
- Enhancement of interactions with users through user workshops and pilot application projects;
- Climate change monitoring, detection and attribution.

Figures 12 to 14 illustrate a range of climate- and drought-related products produced by ICPAC (http://www.icpac.net). The products depict cumulative rainfall deviations from the mean for Marsabit, Kenya; a regional climate outlook map; and a map illustrating the food security outlook for the countries in the Greater Horn of Africa, respectively.

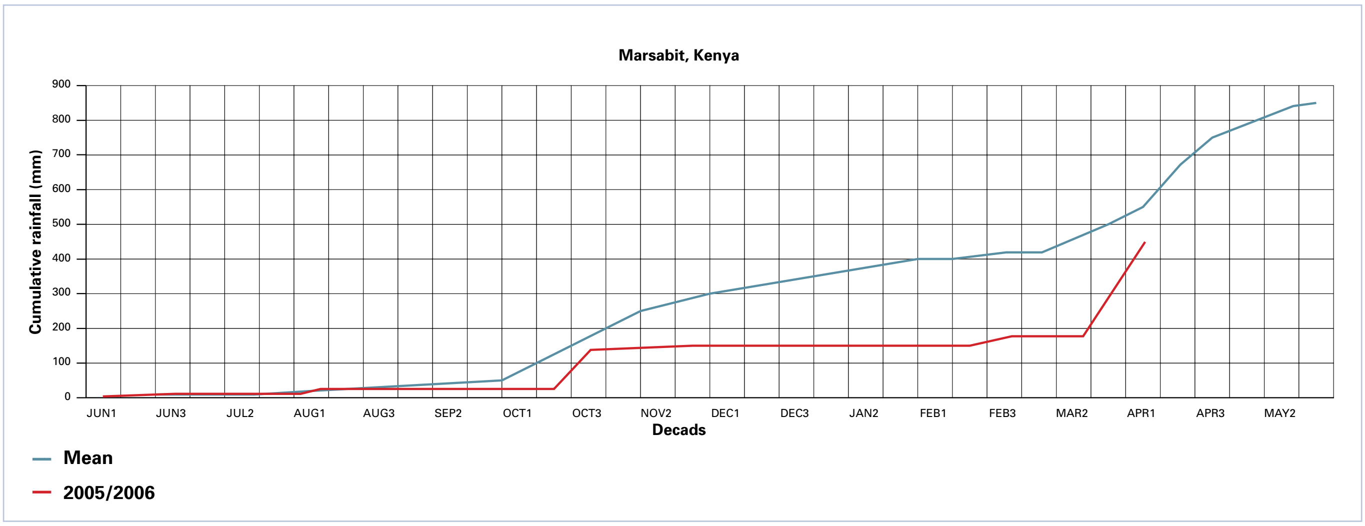

Figure 12. Examples of cumulative decadal rainfall over parts of Kenya from June 2005 to early April 2006. (Source: ICPAC)

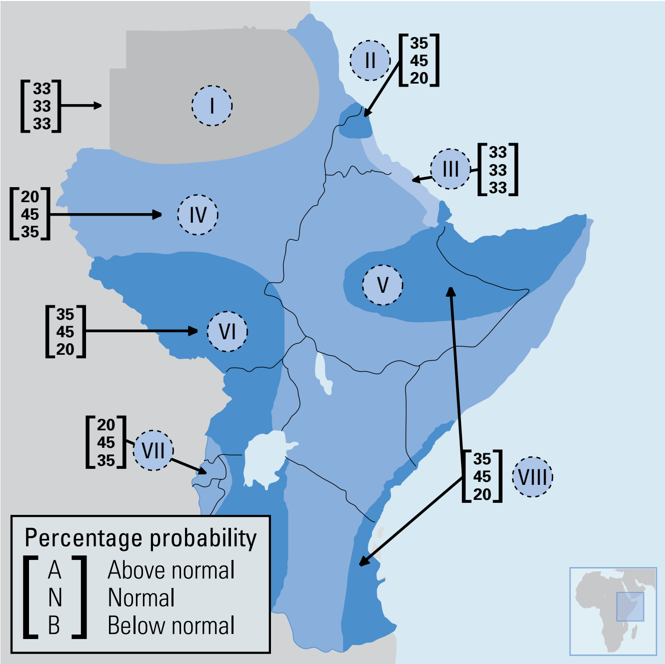

Figure 13. Climate outlook for the Greater Horn of Africa, March to May 2006. (Source: ICPAC)

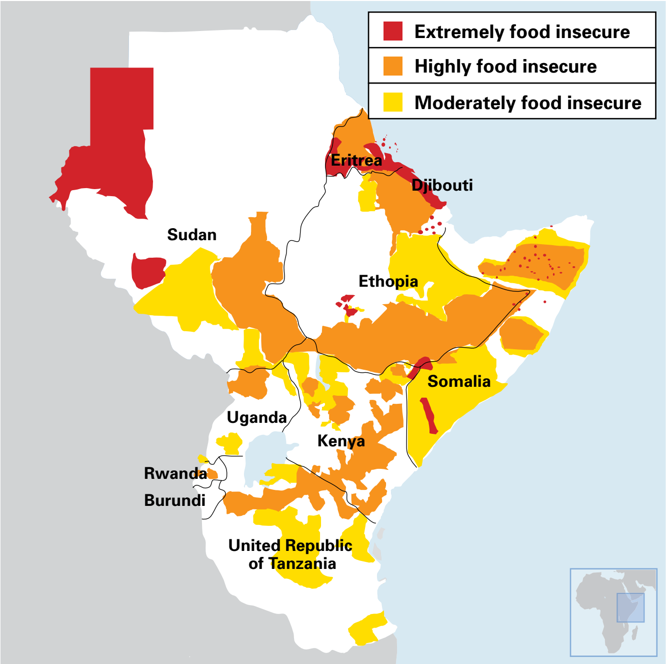

Figure 14. Food security outlook for the Greater Horn of Africa, September to December 2005. (ICPAC)

SOUTH AFRICA

Drought is a normal, recurrent feature of the South African climate. Droughts have in the past resulted in significant economic, environmental and social impacts and highlight the country's continuing vulnerability with regard to this natural phenomenon. During low rainfall periods, policymakers, agriculturalists, businesses and the general public often require additional rainfall data for decision-making and planning.

In response to recurring drought in South Africa, the South African Weather Service (SAWS) established a drought monitoring desk where information regarding observed rainfall and long-range forecasts could be presented in one place for easy access. It also provides an opportunity for people to compare the current year's rainfall with amounts from previous dry periods to assist them in their decision and planning practices.

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Neither the percentage of normal nor the decile-based drought indices can assist decision makers with the assessment of the cumulative effect of reduced rainfall over various time periods. Neither of these indices can describe the magnitude of the drought compared with other drought events. SPI can alleviate both of these principal shortcomings while at the same time being less complex to calculate than some of the other drought indices now in use at the South African Weather Service. SPI is an index based on the probability of rainfall for any timescale; it can be useful in assessing the severity of drought and can be calculated at various timescales that reflect the impact of the drought on the availability of water resources. The SPI calculation is based on the distribution of rainfall over long time periods, preferably more than 50 years. The long-term rainfall record is fit to a probability distribution, which is then normalized so that the mean SPI for any place and time period is zero. SPI values above zero indicate wetter periods and values less than zero indicate drier periods.

On 23 November 2005, the Department of Agriculture issued a report indicating that eight of South Africa's nine provinces were being severely affected by drought, the exception being the densely populated Gauteng province, a minor player in agriculture. At that time, the northernmost province, Limpopo, had had districts flagged as disaster areas since 2003 and 2004, with 27 of its 37 municipalities affected. The dams of the province were at their lowest levels, an average of 36 per cent of capacity, compared with 64 per cent the previous year.

The severity of the situation was clearly reflected in the different timescales of the SPI maps on the SAWS Drought Monitoring Page (http://www.weathersa.co.za/DroughtMonitor/DMDesk.jsp), updated at the beginning of December 2005. A very dry winter and the lack of good spring rains exacerbated the dry conditions in some areas.

The main rainfall features in November 2005 were near normal rainfall over most of South Africa, but wet conditions over parts of the Western Cape, the Eastern Cape,

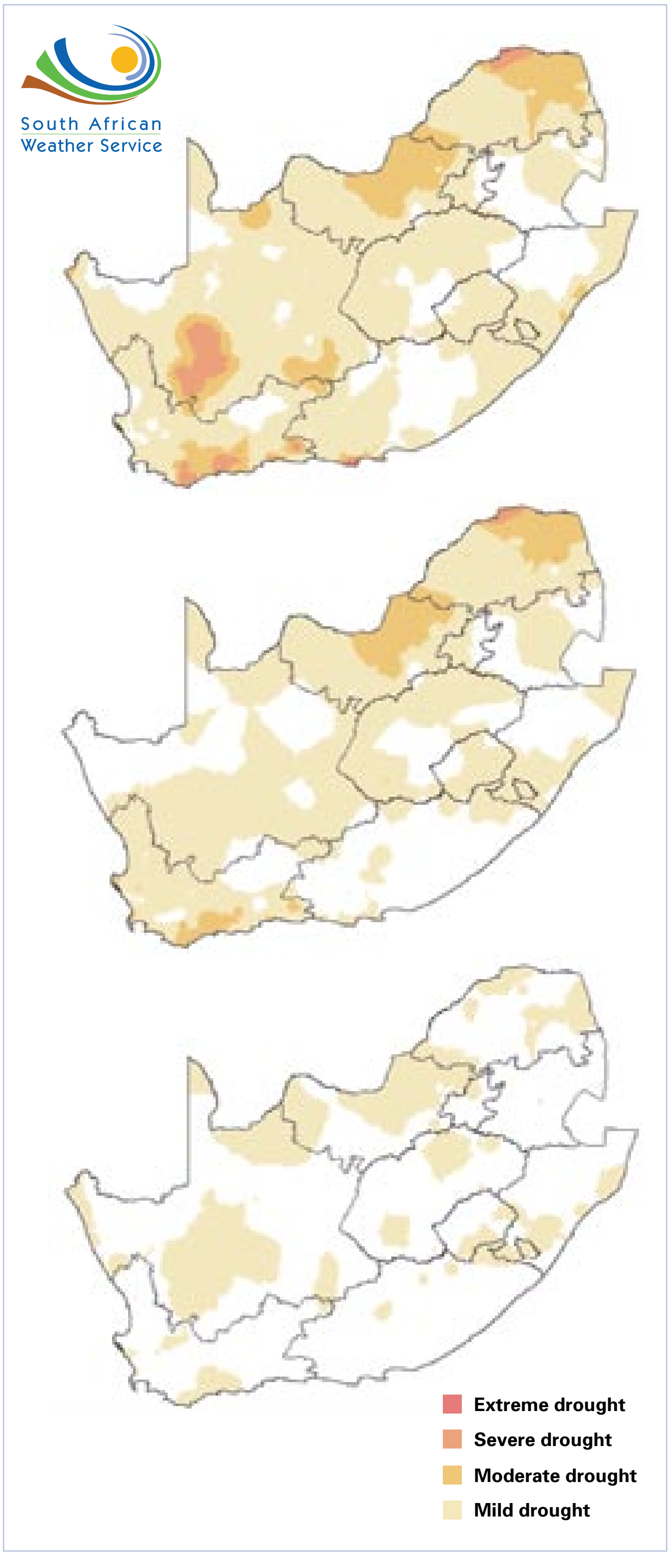

Figure 15. Standardized Precipitation Index (SPI) for South Africa, November 2005 (top); September to November 2005 (middle); June to November 2005 (bottom). (Source: South African Weather Service)

KwaZulu-Natal and Mpumalanga (Figure 15, top). According to available data, no part of the country received rainfall much below the normal value for the month.

From September to November 2005, there was some alleviation of the dry conditions in the northern provinces as well as the far south (Figure 15, middle). However, some dryness remained in the northernmost province, Limpopo.

The rainfall for the six-month period, as shown by the SPI map for June to November 2005, shows near normal conditions over the largest part of South Africa, but moderate to very dry conditions in several areas, most notably in the Southern Cape, southern parts of the Northern Cape and the far north (Figure 15, bottom). Even though some parts of Limpopo received good rains during November 2005, there was still a strain on water resources.

PORTUGAL

The Palmer Drought Severity Index is used to characterize drought in Portugal. This index has been adapted and calibrated to the specific climatic conditions of mainland Portugal. The PDSI performs a parameterized computation of the soil water balance and compares the estimated soil moisture content with its climatological mean.

Evolving drought patterns are presented in monthly PDSI maps that show the spatial distribution of drought in Portugal. These maps are used to monitor spatial and temporal variations in drought across mainland Portugal, which is helpful in delineating potential disaster areas for agriculture and other sectors, allowing for improved on-farm decisions to reduce impacts.

The 2004–2005 hydrological year began with favourable amounts of precipitation in October, except in the southern region, where it was dry to normal. The months that followed were dry to extremely dry, resulting in the development of a very intense drought. Figure 16 and Table 1 show the monthly PDSI variations expressed as percentages of area affected in mainland Portugal. In addition, they reveal a deterioration of drought conditions during the winter months, with some attenuation in March because of the occurrence of precipitation in the country's northern and inner regions. During June, July and August, the drought situation worsened. These months normally contribute, on average, only 6 per cent of the annual precipitation. Precipitation received during the first 15 days of September lessened the severity of drought in the northern and central regions.

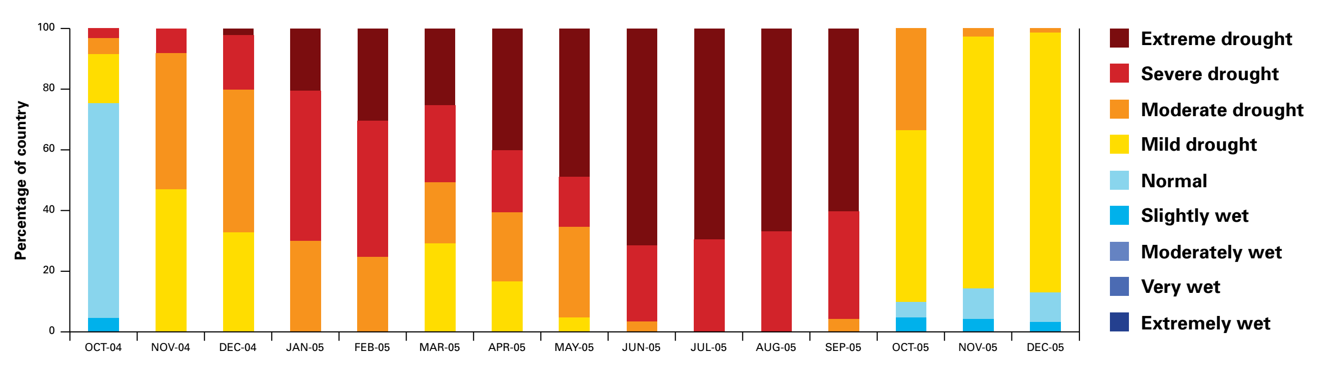

Figure 16. Percentage of Portugal affected by drought, October 2004 to December 2005. (Source: Instituto de Meteorologia, I.P., Portugal)

Palmer Drought Severity Index (PDSI)	**Area affected by drought in 2004–2005 (per cent)**														
	2004			**2005**											
	31 Oct	30 Nov	31 Dec	31 Jan	28 Feb	31 March	30 April	31 May	30 June	31 July	31 Aug	30 Sept	31 Oct	30 Nov	31 Dec
Moderately wet	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slightly wet	47	0	0	0	0	0	0	0	0	0	0	0	6	5	5
Normal	22	1	0	0	0	0	0	0	0	0	0	0	6	12	11
Mild drought	20	47	30	0	0	26	15	4	0	0	0	0	52	81	83
Moderate drought	5	47	48	25	23	22	22	28	3	0	0	3	36	2	1
Severe drought	1	5	20	53	44	28	20	20	33	27	29	36	0	0	0
Extreme drought	0	0	2	22	33	24	43	48	64	73	71	61	0	0	0

Table 1. Percentage of mainland Portugal affected by drought in 2004 and 2005. (Source: Instituto de Meteorologia, I.P., Portugal)

Figure 17 shows the number of consecutive months in severe and extreme drought through the end of September 2005.

The impacts of the drought on agriculture, energy and urban water supply were significant. Figure 18 illustrates these impacts on the urban water supply. The number of people affected by drought from April to December 2005, as shown in Table 2, is also a good indicator of the widespread impacts associated with this drought event.

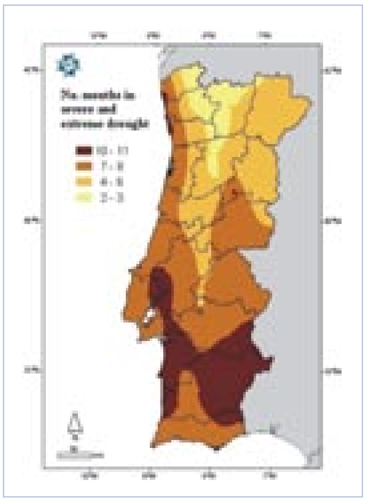

Figure 17. Spatial representation of consecutive months in severe and extreme drought situations in Portugal, October 2004 to September 2005. (Source: Instituto de Meteorologia, I.P., Portugal)

Period	Affected population	
	With supplemented water	With cuts/reduction in supply
1st half April	14 175	213
1st half May	8 395	2635
1st half June	26 500	26 781
2nd half June	23 440	25 217
1st half July	26 004	26 350
2nd half July	54 831	53 312
1st half August	48 500	60 061
2nd half August	94 372	100 500
1st half September	73 097	66 127
2nd half September	69 588	39 429
2nd half October	48 883	30 083
2nd half November	11 921	13 354
2nd half December	10 238	13 445
Maximum	**94 372**	**100 500**

Table 2. Number of people affected directly or indirectly by drought in Portugal, 2005. (Source: Instituto de Meteorologia, I.P., Portugal)

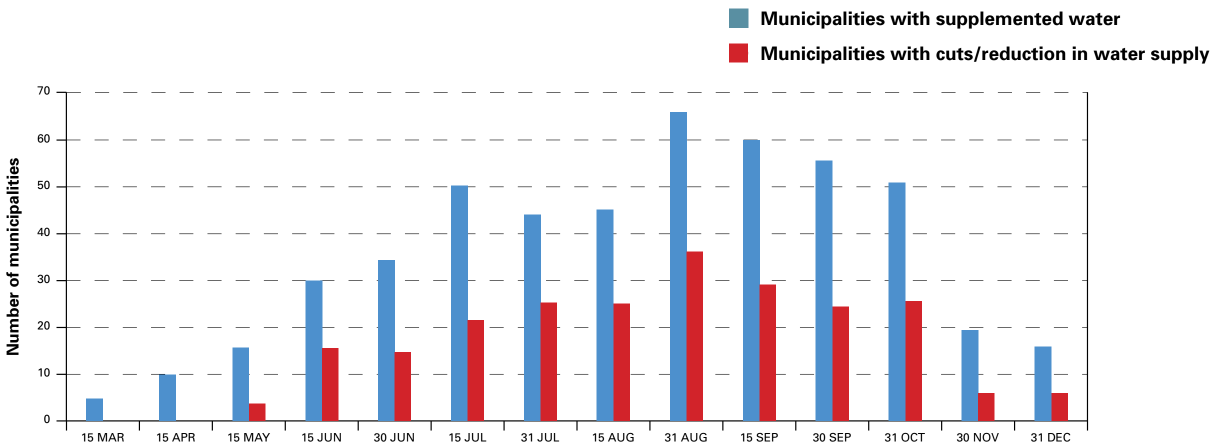

Figure 18. Number of municipalities with supplemented water (blue) or cuts/reduction in household supply (red). (Source: Instituto de Meteorologia, I.P., Portugal)

AUSTRALIA

The island continent of Australia straddles the southern subtropical zone, with its mainland extending from around 11°S across the “Top End” to 39°S in the south-east. The northern regions are seasonally tropical while the eastern, south-eastern and south-western coasts and near inland regions are generally well watered but prone to high interannual and seasonal variability in their rainfall. The more inland regions range from arid to semi-arid. Droughts, sometimes covering vast tracts of the continent, are a recurring feature of Australia’s climate. Many of the more severe and widespread droughts are associated with El Niño events.

Given that rainfall is by far the dominant factor determining the success or failure of the growing season across Australia, drought monitoring has for many years been synonymous with the monitoring of rainfall deficiencies. The Australian Bureau of Meteorology’s Drought Watch Service, in operation since 1965, has used accumulated rainfall percentiles over successive months to identify regions of rainfall deficit and excess. Areas with rainfall accumulations below the 10th or 5th percentile for periods of three months or more are referred to as being seriously or severely in deficit, respectively. Figure 19 shows the extent of serious or worse rainfall deficiencies at the peak of the last El Niño-related drought during 2002–2003.

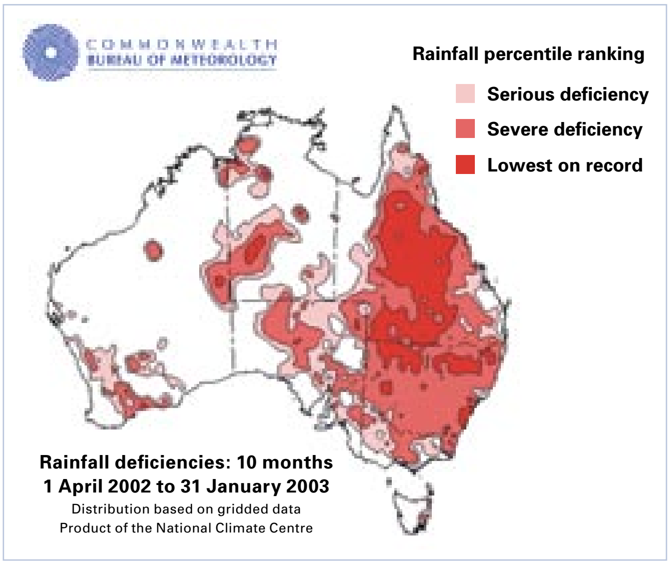

Figure 19. The extent of serious or worst rainfall deficiencies at the peak of the last El Niño-related drought in 2002 and 2003. (Source: Australian Bureau of Meteorology)

Although an extended period of rainfall deficiency in any area is virtually a prerequisite for drought, there is widespread recognition in Australia that the formal declaration of a drought is a more complex issue. It involves consideration not only of the rainwater supply but also the subsequent uses for that rainfall once it has fallen onto farmlands, runs into streams and rivers, is stored in dams, is used to drive hydro-electric power stations and is supplied to cities and towns across the nation. Furthermore, given the size and geographical location of Australia, it is unusual for there not to be one or more areas of varying size at any given time experiencing serious or severe rainfall deficiencies. Whether or not such areas are declared drought stricken and then whether the drought is of sufficient intensity, duration and extent for those affected to be eligible for government relief involves a complex series of assessments by national and state authorities.

The recognition that drought is a “normal” feature of Australia’s natural, economic, and social environments has led the national and state governments to agree that climate-sensitive industries and enterprises must learn to manage drought risk, along with all the other attendant and ongoing risks that they face. Nonetheless, the governments do recognize that, from time to time, some droughts become so severe, chronic or widespread that there is a need to offer support to those worst affected. Such occurrences in Australia are called “exceptional circumstances”.

In 2002–2003 Australia experienced an especially severe and widespread drought, accompanied by record high temperatures in many regions. At the peak of the drought, 57 per cent of the Australian mainland had registered 10 months or more of serious to severe cumulative rainfall deficits, and 90 per cent, below the median (Figure 19). With the experience of the drought fresh in mind, and also recognizing the need for a more objective, fair and transparent process underpinning the declaration of exceptional circumstances, the Primary Industries Ministerial Council of Australia in 2005 commissioned the establishment of the National Agricultural Monitoring System (NAMS).

NAMS was developed over the next 12 months under the leadership of the Bureau of Rural Sciences in collaboration with the Bureau of Meteorology and the Commonwealth Scientific and Industrial Research Organization (CSIRO). The outcome is a freely accessible website containing current maps, graphs and reports on the state of the climate system across Australia, and information on production for major dryland broad-acre agricultural systems. As well as current data, NAMS also contains historical information on measured and modelled production, financial impacts, remote-sensing indices and climate.

The NAMS website presents information on screen and in the form of printable reports, providing general background, current climatic conditions and production and resource statistics for regions that can be specified by the user. Regions can range in size from the entire country to individual local government areas or the statistical local areas used for summarizing Australian census data.

Collectively, NAMS information shows the status of current conditions for the major agricultural production systems and production prospects for the upcoming growing season. NAMS is initially directed at monitoring and supplying data for dryland broad-acre industries, with plans to extend the system to cover the extensive irrigated regions of Australia and also for more intensive industries such as horticulture.

As NAMS draws on a common information database for the entire country, it will facilitate a more consistent approach to the drought declaration process through the use of the following:

- A common template and language for describing drought in terms of probabilities;
- A common set of declaration criteria;
- A common process for the subjective "on-ground" assessment of drought impacts.

The NAMS website is at http://www.nams.gov.au. Detailed information on Australia's national drought assistance measures, including the declaration of exceptional circumstances, can be found at http://www.daff.gov.au/droughtassist, while information on the rainfall deficiency monitoring system can be found at http://www.bom.gov.au/climate/drought/drought.shtml.

CONCLUSION

Drought affects more people than any other natural disaster and results in serious economic, social and environmental costs. The development of effective drought monitoring, early warning and delivery systems has been a significant challenge because of the unique characteristics of drought. Significant strides have been made in recent years to improve the effectiveness of these systems. With the increasing frequency and severity of drought in many regions of the world and increased societal vulnerability, more emphasis is now being placed on the development of drought preparedness plans that are proactive rather than reactive and emphasize risk-based management measures. Improved drought monitoring is a key component of a drought preparedness plan and a national drought policy. Early warning systems can provide decision makers with timely and reliable access to information on which mitigation measures can be based. There are many challenges to improving these systems, but a comprehensive, integrated approach to climate and water supply monitoring is proving to be successful in many countries.