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END InSight

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The Many Dimensions of Drought

Although the first question on most people's minds is, "When is this drought going to be over?," answering this question depends on how one defines drought. Drought has a range of definitions, but a basic one is that, "Drought…originates from a deficiency of precipitation over an extended period of time, usually a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector" (1).

This definition illustrates that drought impacts are a complex function of water sources and water use (2). It also forms the basis of important policy decisions, such as changes in water management, increased implementation of conservation measures, or the release of government assistance to farmers and others whose livelihoods are directly affected.

However, within this basic definition lie gray areas regarding the dimensions of particular droughts and which economic sectors and natural resources are most affected. To deal with this ambiguity, researchers and forecasters have defined several different types of drought: 1) *meteorological,* defined by the degree of dryness compared to average and the duration of the dry period; 2) *agricultural,* wherein meteorological and hydrological drought are linked to agricultural impacts; and 3) *hydrological,* when precipitation shortfalls affect surface or subsurface water supplies (1). These categories are used by the U.S. Drought Monitor to illustrate drought impacts on their weekly maps.

All three drought types can occur simultaneously. For example, within the context of a meteorological drought, agricultural drought is normally the first type to become apparent, particularly in areas that rely heavily on stored soil moisture rather than irrigation. If below-average precipitation continues, hydrological drought and consequent water shortages may become apparent.

Within each of these categories, there are several other key aspects of drought that must also be considered. Five of the most important are: 1) time scale, 2) probability, 3) precipitation deficit, 4) application of the definition to precipitation to different water sources, and 5) the relationship of the definition to the impacts of drought (2).

Drought impacts are a complex combination of water resources and water use. The form of precipitation has important influences for defining drought. Usable water sources include soil moisture, groundwater, snowpack, streamflow and reservoir storage (2). For drought to truly end, each of these water sources must be replenished. Heavy winter rainfall over short periods of time may increase streamflow and reservoir levels to normal levels temporarily, but may do little to replenish soil moisture, and may not entirely compensate for the longer-lasting water supplies that snowpack provides.

Drought Indices

To more effectively understand drought and its impacts (including its beginning and end), researchers have created a variety of indices to measure the depth and type of water deficits. As Michael Hayes of the National Drought Mitigation Center notes, "Drought indices assimilate thousands of bits of data on rainfall, snowpack, streamflow, and other water supply indicators into a comprehensible big picture" (3). Specific indices may be best suited to particular purposes, as the next sections will describe.

Percent of Normal (average): A simple calculation effective for comparing between single regions or seasons. However, since "normal" is a mathematical construct based on a limited number of years, it may not always reflect emerging climatic trends or patterns dominant in the longer climate record. Because precipitation data are frequently characterized by a skewed (non-normal) distribution, average is not always the most accurate measure to describe precipitation characteristics. Important information about the variability of precipitation cannot be discerned by using the percent of normal.

Standardized Precipitation Index (SPI): SPI is an index based on the probability distribution of the long-term precipitation record for a desired period of time. It can be computed for different time scales, allowing for assessment of drought severity in both the short- and long-term and providing early warning of drought. One of the great virtues of SPI is that rigorously tested criteria for drought initiation and termination are an implicit part of the index. Thus it is a favorite among many drought planners. Wet periods can also be monitored using SPI.

Palmer Drought Severity Index (PDSI): The PDSI uses an algorithm to calculate water balance and soil moisture, based on temperature and precipitation inputs; thus it is particularly useful for agricultural applications. It is used by many U.S. government agencies and

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states to trigger drought relief programs. However, PDSI may fail to show emerging droughts for several months and is best suited for areas of the Midwest for which it was developed. Snowfall, snow cover, and frozen ground are not included in the index, so it may be less useful during the winter and spring months.

Crop Moisture Index (CMI): Derived from the PDSI, CMI shows short-term moisture supply across major cropping regions; however, it is not intended for monitoring long-term drought.

Surface Water Supply Index (SWSI): SWSI supplies hydrological elements missing from PDSI, such as mountain snowpack, streamflow, precipitation and reservoir storage on a basin-by-basin basis. SWSI is best suited for "mountain water dependent" areas such Colorado, where it was developed and where it is used in triggering Colorado Drought Plan actions. However, making comparisons between basins is difficult, and water management changes within a basin require that SWSI be redeveloped for that basin.

Reclamation Drought Index (RDI): Similar to SWSI, the RDI incorporates temperature as well as precipitation, snowpack, streamflow, and reservoir levels in order to define drought on a river basin level. The Bureau of Reclamation uses RDI to trigger the release of emergency drought funds, and it is included in the drought plan of the state of Oklahoma.

Deciles: This measure groups the occurrences of precipitation into deciles (tenths of the data distribution), rather than averages. Deciles are subjectively classified into two-decile groupings, such that "much below normal" precipitation is defined as precipitation in the lowest 20 percent of the historical record, and "much above normal" precipitation is in the highest 20 percent of the record. Deciles are easy to calculate, and they provide a statistically accurate measure of precipitation; however, they require a long-term climatic record. Australia uses deciles to determine drought relief for farmers and ranchers, who can only request assistance for droughts of an intensity that occurs only once every 20-25 years and have lasted longer than 12 months.

Drought Monitor: The U.S. Drought Monitor (DM) is a regular feature of the END InSight monthly packets, and it provides a new "index" of drought activity. The DM is a multi-agency collaboration of drought experts that provides a subjective assessment of a wide variety of objective drought indices and drought impact indicators, including many of those mentioned above. One of the great virtues of the weekly DM map is that it is coordinated by national drought experts from several federal agencies and it is informed by input from regional federal, state, and local experts across the country. However, because input is voluntary, there can be occasional under-reporting of sub-regional drought variations.

A New Definition of Drought?
Beyond the various definitions of drought and various ways of measuring it, Kelly Redmond of the Western Regional Climate Center offers a provocative alternative definition of drought: drought occurs when there is insufficient water to meet needs. This definition takes both supply and demand factors into account, making drought more than merely a meteorological deviation from average precipitation. Thus, using this definition, drought frequency and severity will probably increase in the West regardless of climatic patterns as long as rapid population growth and increased demands on water supplies continue. Indeed, under this definition many rural communities and increasing numbers of urban ones may find themselves in perpetual drought (4).

–Rebecca Carter, CLIMAS

References

(1) National Drought Mitigation Center. What is drought? Accessed at http://www.drought.unl.edu/whatis/concept.htm on May 27, 2003.

(2) McKee, T., N. Doesken, and J. Kleist. 1993. The relationship of drought frequency and duration to time scales. 8th Conference on Applied Climatology, January 17–22, 1993, Anaheim, California.

(3) Hayes, M. Drought indices. National Drought Mitigation Center. Accessed at http://www.drought.unl.edu/whatis/indices.htm on May 27, 2003.

(4) Redmond, K. 2002. The depiction of drought: a commentary. *Bulletin of the American Meteorological Society,* 83(8):1143-1147.

About END InSight

END InSight is a year-long project to provide stakeholders in the Southwest with information about current drought and El Niño conditions. As part of the Climate Assessment for the Southwest (CLIMAS) project at the University of Arizona, END InSight is gathering feedback from stakeholders to improve the creation and use of climate information.

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