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Understanding the Drought Phenomenon: The Role of Definitions

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Introduction

The occurrence of widespread, severe drought in Africa, India, North America, China, the USSR, Australia, and western Europe has once again underscored the vulnerability of developed and developing societies to drought. The occurrence of severe drought during 1982–83 is shown in figure 1. These recent droughts have emphasized the need for more research on the causes as well as the impacts of drought and the need for additional planning to help mitigate the possible worst effects of future droughts. Drought has been the subject of a great deal of systematic study, particularly reconstructions of drought history, computations of drought frequency, and to a lesser extent, investigations of first-, second-, and even third-order impacts of drought on society.

Considerable disagreement exists about the concept of drought. During a recent drought in the Brazilian northeast, for example, some Brazilian scientists and policy makers suggested that the region had been affected by a five-year drought. However, Brazilian meteorologists noted that the rainfall record indicated that only two of the last five years could have been classified as experiencing drought. Similar conflicts occurred in Australia as recently as 1984 between the Bureau of Meteorology and state Department of Agriculture officials. Rainfall statistics are summarized by the Bureau on a calendar year rather

than growing season basis. Their rainfall statistics were misleading and did not detect emerging drought conditions.

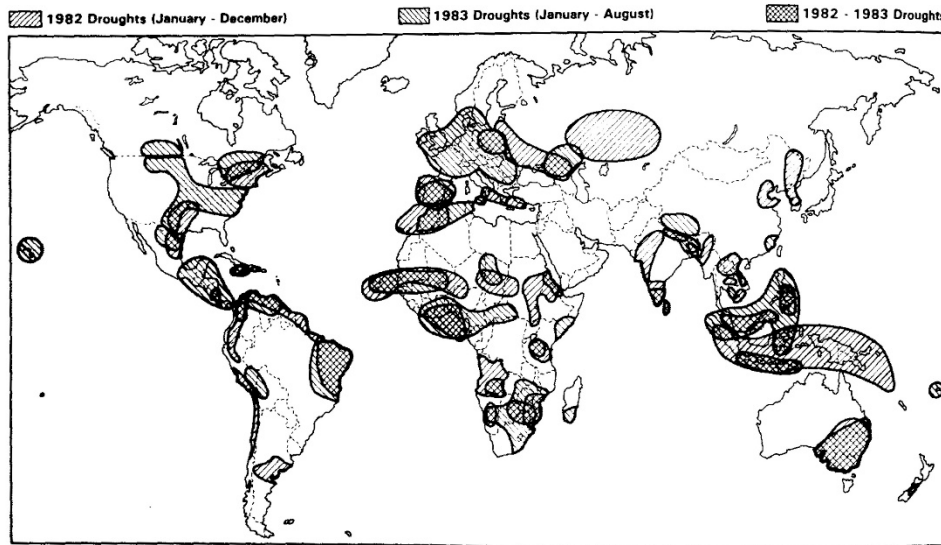


Figure 1. The occurrence of drought, January 1982 to August 1983.

In section 1 of the paper, numerous definitions of drought are reviewed to determine those characteristics scientists consider most essential for a description and an understanding of the phenomenon. Section 2 discusses the far-reaching impacts of drought on society. The final section suggests that definitions of drought are typically simplistic, and in that way often lead to a rather poor understanding of the dimensions of the concept. It is suggested that definitions of drought should not be formulated in a narrow sense but rather should incorporate both physical and social measures that have a local or regional significance.

Drought: An Overview

Drought occurs in high as well as in low rainfall areas. It is a condition relative to some long-term average condition of balance between rainfall and evapotranspiration in a particular area, a condition often perceived as “normal.” Yet average rainfall does not provide an adequate statistical measure of rainfall characteristics in a given region, especially in the drier areas.

Drought is a “creeping phenomenon” [1], making an accurate prediction of either its onset or end a difficult task. To most observers, it seems to start with the delay in the timing (or failure) of the rains. Others suggest it can be identified only in retrospect. Tannehill [2], for example, noted:

We have no good definition of drought. We may say truthfully that we scarcely know a drought when we see one. We welcome the first clear day after a rainy spell. Rainless days continue for a time and we are pleased to have a long spell of such fine weather. It keeps on and we are a little worried. A few days more and we are really in trouble. The first rainless day in a spell of fine weather contributes as much to the drought as the last, but no one knows how serious it will be until the last dry day is gone and the rains have come again . . . we are not sure about it until the crops have withered and died.

Drought severity, too, is difficult to determine. It is dependent not only on the duration, intensity, and geographical extent of a specific drought episode but also on the demands made by human activities and by the vegetation on a region's water supplies. Drought's characteristics along with its far-reaching impacts make its effects on society, economy, and environment difficult, though not impossible, to identify and quantify. The significance of drought should not be divorced from its societal context. While a drought may take place in a season or in a run of years, its impacts on society may linger for many years. Also, the impact of a drought depends largely on society's vulnerability to drought at that particular moment. Subsequent droughts in the same region will probably have different effects, even if identical in intensity, duration, and spatial characteristics.

Common to all types of drought is the fact that they originate from a deficiency of precipitation that results in water shortage for some activity (e.g., plant growth) or for some group (e.g., farmer). Clearly there are many natural and human factors that ultimately affect the availability of water to society. Sometimes this shortage coincides with periods of high temperature, low humidity, and/or high wind speed. Water shortages related to drought, however, must be considered a relative rather than absolute condition.

The lack of general acceptance of a precise and objective definition of drought, according to Yevjevich [3], has been one of the principal obstacles to the investigation of drought. Indeed, Yevjevich's view may represent the dominant view about drought definitions. Many contend that conflicting drought definitions often lead to confusion among decision makers about what constitutes a drought [4]. Confusion can lead to inaction, indecision, and, in many cases, ad hoc responses with little understanding of the societal and environmental implications of those responses [5]. Some observers suggest that a precise and objective drought definition could, at least in theory, form the basis for the development of more appropriate drought management strategies by individual citizens and government.

Because drought affects so many economic and social sectors, scores of definitions have been developed by a variety of disciplines. In addition, because drought occurs with varying frequency in all regions of the globe; in all types of economic systems, socialist and capitalist; and in developed and less developed countries alike, the approaches taken to define drought also reflect regional differences as well as differences in ideological perspectives. Impacts also differ from one location to the next depending on the societal context in which drought is occurring. Therefore, the search for a universally acceptable definition of drought appears to be a fruitless endeavor.

The Definition of Drought

Drought definitions might be categorized as either conceptual or operational, with conceptual referring to those definitions formulated in general terms to identify the boundaries of the concept of drought. For example, the *American Heritage Dictionary* [6] defines drought as "a long period with no rain, especially during a planting season." As another example, *Random House Dictionary* [7] defines it as "an extended period of dry weather, especially one injurious to crops." Conceptual definitions provide little guidance to those who wish to apply them to current (i.e., real-time) drought assessments.

Operational definitions attempt to identify the onset, severity, and termination of drought episodes. Estimations of potential impacts are included in some operational definitions. An operational definition, for example, would be one that compares daily precipitation values to evapotranspiration (ET) rates to determine the rate of soil moisture depletion, and expresses these relationships in terms of drought effects on plant behavior at various stages of crop development. The effects of these meteorological conditions on plant growth would be reevaluated continuously by agricultural specialists as the growing season progresses.

Operational definitions can also be used to analyze drought frequency, severity, and duration for a given historical period. Such definitions, however, require data on hourly, daily, monthly, or seasonal moisture deficiency or yield departures from "normal" (i.e., expected) in order to identify when drought occurred. These definitions can be used to calculate the probabilities of droughts of varying intensity, duration, and spatial characteristics.

Disciplinary Views of Drought

Drought is frequently defined according to disciplinary perspective. Subrahmanyam [8] has identified six types of drought: meteorological, climatological, atmospheric, agricultural, hydrologic, and water-management. Many others have also included economic or socio-economic factors as an essential factor in the determination of drought occurrence [9–11]. Although it is useful to compartmentalize the various views of drought, the boundary separating these views is often vague.

The discussion of the disciplinary perspectives of drought which follows is the result of a review of more than 150 published definitions. For purposes of discussion these definitions of drought are clustered into four types: meteorological, agricultural, hydrologic, and socio-economic.

Meteorological Drought

Meteorological definitions of drought are the most prevalent. They often define drought solely on the basis of the degree of dryness and the duration of the dry period. For example, meteorological drought has been defined as a "period of more than some particular number of days with precipitation less than some specified small amount" [12]. Linsley et al. [13] referred to it as a "sustained period of time without significant rainfall." Downer et al. [14] considered it to be a "deficit of water below a given reference value, with both deficit

duration and deficit magnitude taken into account." Each of these definitions is vague. What is meant, for example, by "sustained" and "significant"?

Meteorological drought definitions are also often site specific, and the thresholds used to distinguish drought from nondrought periods are seldom spelled out. Some meteorological drought definitions developed for application in various countries of the world include:

- 1) less than 2.5 mm of rainfall in forty-eight hours (United States) [15];
- 2) fifteen days, none of which received as much as 0.25 mm (Britain) [16];
- 3) when annual rainfall is less than 180 mm (Libya) [17];
- 4) actual seasonal rainfall is deficient by more than twice the mean deviation (India) [18]; and
- 5) a period of six days without rain (Bali) [17].

Definitions constructed for application to one region but applied to another often create problems since the meteorological conditions that result in drought are highly variable around the world. Perceptions of these conditions are equally variable. Both of these points must be taken into account in order to identify the characteristics of drought and make comparisons between regions.

To answer the question "What is a viable meteorological definition of drought?" we must know the reason behind the choice for each of the delimiting criteria used in each definition. What, for example, is the significance of forty-eight hours with less than 2.5 mm of rainfall? Were these values arbitrarily selected, or were they chosen to coincide with a critical threshold in plant behavior or streamflow reduction? Answers to these questions are important because they allow us to test a definition's reliability and applicability.

Other drought definitions compare the degree of dryness to a long-term average, often referred to as "normal." McGuire and Palmer [19], for example, have referred to drought as a "period of monthly or annual precipitation less than some particular percentage of normal." To some (e.g., Palmer [20]), drought is a temporary departure from the average climate toward drier conditions.

The Palmer Drought Severity Index (PDSI), developed in 1965 by W. C. Palmer [21], is probably the best-known meteorologic drought definition in the United States and is well known internationally. For example, its applicability in assessments of moisture conditions has recently been tested in South Africa, China, and Australia. The index is based on the concept of a hydrologic accounting system.

The PDSI relates drought severity to the accumulated weighted differences between actual precipitation and the precipitation requirement of evapotranspiration (ET). Although commonly referred to as a drought index, the PDSI is actually used to evaluate prolonged periods of abnormally wet or abnormally dry weather. It is widely used in the United States to evaluate long-term moisture conditions. A national map of index values is published monthly in the US Department of Agriculture's *Weekly Weather and Crop Bulletin*.

Gibbs and Maher [22] have applied the concept of deciles of precipitation to the study and classification of droughts in Australia. Monthly and annual precipitation totals are ranked, highest to lowest, and decile ranges determined from the cumulative frequency of the distribution. The first decile represents the precipitation values in the lowest 10 percent

of the distribution. The second decile represents the precipitation values falling between 10 and 20 percent of the distribution, and so on. The tenth decile range would represent the highest 10 percent of the precipitation values in the distribution.

This system has formed the basis of the Australian Drought Watch System [23]. Severe drought is equated with a dry period not exceeding the fifth decile range over a period of three or more months. Extreme drought occurs when precipitation values do not exceed the first decile range over a period of three or more months. Severe and extreme drought occurred over all of eastern Australia during the peak of the 1982–83 drought episode [24]. Meteorological droughts do not necessarily coincide with periods of agricultural drought. At times inconsistencies of this kind result in conflicts between the agriculturist and meteorologist, as noted above.

In the United States, Changnon [25] has attempted to link drought thresholds and impacts in Illinois. Using departure of precipitation from normal over a twelve-month period as the basis for his study, Changnon found that 75 percent of normal precipitation over a twelve-month period resulted in only selected economic sectors being affected, such as some agricultural activities and the water supply of a few small towns. All agricultural activities and production were affected when precipitation was 60 percent of normal; 50 percent of normal precipitation produced an impact on all agricultural activities and most urban and industrial users.

Some scientists are critical of climatically defined drought because it is expressed in terms of a thirty-year precipitation period, which has been agreed to (by international convention) as the basis for the calculation of "normal." Thirty years, however, represents only a small part of the historical record for most locations and would not be representative of the long-term climatic record. Moreover, for climatic regimes characterized by a large interannual variation of precipitation, the "normal" is less meaningful than other statistical measures such as the range, median, or mode of the precipitation distribution [4].

Some meteorological definitions of drought also encompass atmospheric parameters other than precipitation, but these definitions are less common. Popov [26] used wet-bulb depression and Ivanov [27] incorporated humidity and temperature as an indicator of the drying power of the atmosphere. Levitt [28] expressed atmospheric drought as proportional to the vapor pressure deficit of the air. Condra [29] referred to drought as a "period of strong wind, low precipitation, high temperature and, usually, low relative humidity," a definition formulated for the US Great Plains and reflecting drought characteristics specific to this region. These definitions, however, may not be transferable to other regions of the world.

Agricultural Drought

Agricultural drought definitions link various characteristics of meteorological drought to agricultural impacts, focusing, for example, on precipitation shortages [30, 31]; departures from normal [32]; or numerous meteorological factors such as evapotranspiration [33].

A plant's demand for water is dependent on prevailing meteorological conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil. An operational definition of agricultural drought should account for the variable susceptibility of crops at different stages of crop development. For

example, deficient subsoil moisture in an early growth stage will have little impact on final crop yield if topsoil moisture is sufficient to meet early growth requirements. However, if the deficiency of subsoil moisture continues, a substantial yield loss would result. Barger and Thom [34] have tried to link drought to its impact on a specific crop—corn.

Kulik [35] represented drought intensity as the difference between plant water demand and available soil water. Kulik concluded that the upper 0.2 m of soil was critical to plant growth because of nutrient supplies, and the root activity and activities of microorganisms that take place in that layer. Therefore, drying of this soil layer was an early indicator of yield loss; i.e., a measure of drought intensity. Kulik defined a dry period as one during which only 19 mm of available water remained in the upper 0.2 m of soil; when only 9 mm of available water remains, very dry conditions prevail.

In 1968 Palmer [36] modified the PDSI to better reflect agricultural drought conditions. The Crop Moisture Index (CMI) defined drought in terms of the magnitude of computed abnormal ET deficit. This deficit is the difference between actual and expected weekly ET. The expected weekly ET is the normal value, adjusted up or down according to the departure of the week's temperature from normal. The CMI has been adopted by the US Department of Agriculture and is published weekly in its *Weekly Weather and Crop Bulletin* as an indicator of the availability of moisture to meet short-term crop needs.

Hydrologic Drought

Definitions of hydrologic drought are concerned with the effects of dry spells on surface or subsurface hydrology, rather than with the meteorological explanation of the event. For example, Linsley et al. [37] considered hydrologic drought a "period during which streamflows are inadequate to supply established uses under a given water management system" (see also Dracup [38]). The frequency and severity of hydrologic drought is often defined on the basis of its influence on river basins. Hydrologic droughts are often out of phase with both meteorological and agricultural drought.

Whipple [39] defined a drought year as one in which the aggregate runoff is less than the longterm average runoff. Since low-flow frequencies have been determined for most streams, hydrologic drought periods can be of any specified length. If the actual flow for a selected period of time falls below a certain threshold, then hydrologic drought is considered to be in progress. However, the number of days and the level of probability that must be exceeded to define a hydrologic drought period is arbitrary [40]. These criteria are specific to individual streams or river basins.

Although the PDSI is sometimes used as an indicator of hydrologic drought, other definitions have been formulated which better serve the needs of hydrologists. For example, a definition of hydrologic drought was developed in Colorado during 1981 to provide information about drought conditions and water supply in high-elevation river basins that are dependent on snow melt as their main source of water supply [41]. The Surface Water Supply Index (SWSI) was intended to be complementary to the PDSI, with the latter applying mainly to nonirrigated areas independent of mountain water supplies.

The SWSI integrates historical data with current figures of reservoir storage, streamflow, and precipitation at high elevation into a single index number. The SWSI scale is synonymous with the scale used for PDSI values. Colorado's Drought Assessment and

Response Plan [42] is implemented when SWSI and PDSI values exceed specified thresholds. For example, a SWSI of -1.0 activates Colorado's Water Availability Task Force which makes assessments and projections on snowpack, soil moisture, reservoir and ground water levels, precipitation, temperature, and streamflow.

Socio-economic Drought

Definitions which express features of the socioeconomic effects of drought can also incorporate features of meteorological, agricultural, and hydrological drought [43]. They are usually associated with the supply and demand of some economic good. Yevjevich [3] has suggested that the time and space processes of supply and demand are the two basic processes that should be considered for an objective definition of drought. Heathcote [44], for example, defined agricultural drought as a "shortage of water harmful to man's agricultural activities. It occurs as an interaction between agricultural activity (i.e., demand) and natural events (i.e., supply), which results in a water volume or quality inadequate for plant and/or animal needs." Gibbs [45] expanded this definition, noting that demand was "dependent upon the distribution of plant, animal and human populations, their lifestyle and their use of the land."

In some instances, land use practices can either create a drought situation (e.g., agricultural or hydrologic drought) or make an existing one worse. The dust bowl years in the US Great Plains in the 1930s, the Sahelian drought in West Africa in the early 1970s, and the recent Ethiopian drought are often cited as examples of the symbiosis between drought and human activities.

In 1936, J. C. Hoyt [46] referred to drought as occurring "when precipitation is not sufficient to meet the needs of established human activities." He proposed this definition in the midst of the 1930s US Great Plains drought. W. G. Hoyt [9] later expanded this concept, stating that droughts may result if "in the economic development of a region man creates a demand for more water than is normally available."

Sanford [47] argued that drought should not only be linked to precipitation (supply) but also to trends or fluctuations in demand as well as to factors other than weather which influence supply. Sanford presents two scenarios that represent time (x axis) and supply of some economic good (y axis). In the first scenario, demand by society for an economic good is assumed to be static throughout the time period. The level of supply (livestock feed in Sanford's example) varies considerably from one year to the next as a result of shortages of rainfall and other factors influencing supply. Therefore, drought occurs when supply falls below the level of requirement. In the second scenario, the demand trend is more realistically represented as increasing with time. The trend of supply, however, is decreasing as a result of ecological changes, such as declining soil fertility. Thus the frequency with which supply falls below demand increases. We feel that the interrelationship between man and drought requires more scientific attention.

The preceding discussion illustrates several significant features of drought. First, the various approaches taken by scientists and nonscientists to define drought demonstrate its complex and interdisciplinary nature. Second, although most definitions emphasize the

physical aspects of drought, the social aspects are closely related. Third, few (if any) definitions adequately address the impacts of drought. As a result, the primary, secondary, and tertiary impacts of drought are poorly understood.

The Impact of Drought

Yevjevich et al. [48] suggested that the study of drought problems would be facilitated if drought was considered in a systems context. Figure 2 describes succinctly the interrelationships between the physical and social factors. As Yevjevich et al. noted, the physical aspects of drought are derived from the atmosphere-ocean-continent system. Each drought is unique in its set of physical characteristics as well as in its geographic scope and location. It is interesting to note that Yevjevich considers the physical characteristics of drought to be dictated by the physical environment. Drought events are shown as inputs to a physical-environment system and a social system. The characteristics of drought events, physical-environment systems, and social systems combine and interact to produce impacts on the physical-environment and social system. The social system responds to mitigate or alleviate drought-related impacts. This view of drought reflects the focus of previous studies of drought on the physical aspects of the phenomenon. Yet the ultimate significance to society of drought lies in its impacts.

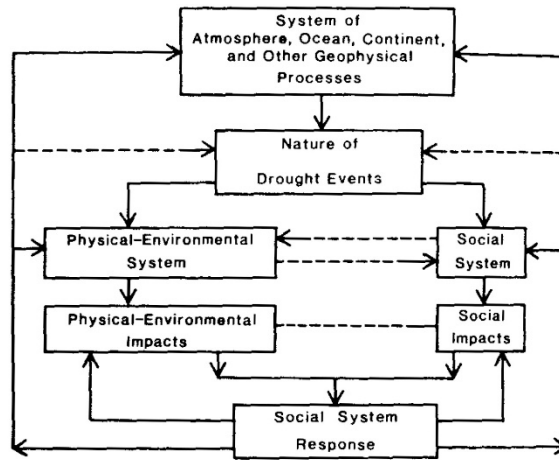


Figure 2. Drought viewed in a systems context [48].

Figure 3, from a US Department of Agriculture report on food problems and prospects in Sub-Saharan Africa [49], presents a similar picture about weather (or climate), and drought as a part of it. Weather is viewed strictly as a physical phenomenon, whose origins and impacts are independent from social factors. After examining figure 3 it is evident that weather, or drought, affects far more than just crop yields and that social factors can be equally significant in determining society's vulnerability to drought and, thus, the type and magnitude of drought impacts. Thus, how drought is perceived, and defined, determines the likely response of societies to drought events.

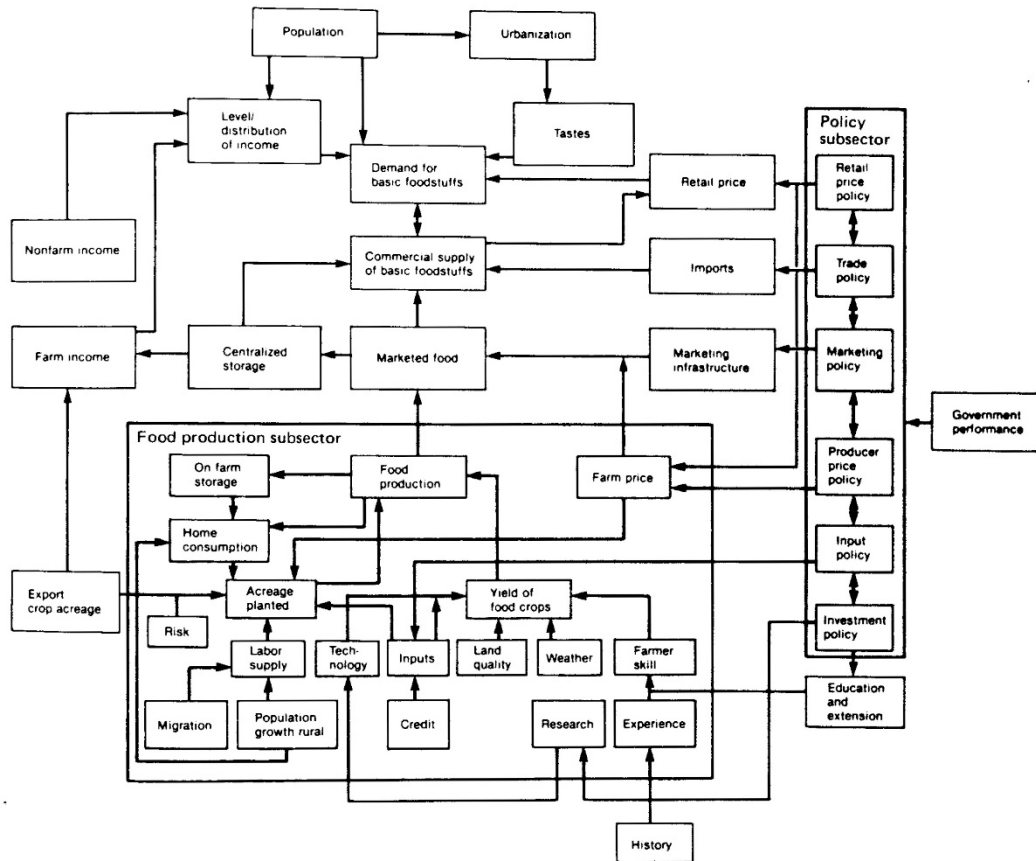


Figure 3. Interaction among food balance factors, Sub-Saharan Africa [49].

The far-reaching impacts of drought in the United States (table 1) were recently classified by the Institute for Policy Research of the Western Governors' Policy Office (WESTPO) [50]. WESTPO assembled this comprehensive listing of drought-related impacts in the economic, environmental, and social sectors in response to several consecutive years of drought. Many of these impacts are relevant to drought situations in other countries. In the United States' case each impact cited is linked to one or more of the following five groups: municipalities, state governments, businesses and industries, agricultural enterprises, and households and individual citizens. This list suggests that droughts often have complex and long-lasting impacts. Also listed in table 1 are constraints that inhibit responses to drought by each of these groups.

Although table 1 appears to be a complete summary of drought impacts, at least one important group, the federal government, has been omitted. Since the 1930s drought in the United States, the federal government has become the Primary, and usually only, source of assistance to the distressed area. During the mid-1970s drought, sixteen federal agencies administered forty separate assistance programs. During 1976-77, aid to water users alone, primarily in the form of loans and grants from four agencies, totaled \$5 billion [51]. The

total cost to the federal government of the 1974–77 drought program probably exceeded \$7 billion [5]. Other governments, such as Australia, South Africa, the United Kingdom, India, and Kenya, to name just a few, have responded in a similar fashion (but on a lesser scale) to recent episodes of severe drought.

Table 1. Identification and classification of drought-related problems [50]

Affected groups and sectors*	Problems and impacts
	<i>Lack of water</i>
	lack of precipitation
	lack of soil moisture
	lack of groundwater
	lack of surface water (in streams and storage)
	<i>Economic impacts</i>
A	economic loss from drought-impacted dairy and beef production
A	impaired productivity of rangeland
A	forced reduction of foundation stock
A	closure/limitation of public lands to grazing
A	high cost/unavailability of water for cattle
A	high cost/unavailability of feed for cattle
A	increased predation
AMS	range fires
A	economic loss from drought-impacted crop production
A	damage to perennial crops; crop loss
A	impaired productivity or cropland (wind erosion, etc.)
A	insect infestation
AS	plant disease
A	wildlife damage to crops
B	economic loss from drought-impacted timber production
B	forest fires
BS	tree disease
BS	insect infestation
BS	impaired productivity of forest land
AS	economic loss from drought-impacted fishery production
HS	damage to fish habitat
HS	insufficient flows for anadromous and catadromous fish
HS	loss of young fish due to decreased flows (e.g., loss in generating turbines, etc.)
BMS	economic loss from drought-impacted recreational businesses (decreased patronage, etc.)
BMS	economic loss to manufacturers and sellers of recreational equipment
BMS	economic loss to industries impacted by drought-related power curtailments
BMS	economic loss to industries directly dependent on agricultural production (e.g., fertilizer manufacturers, food processors, etc.)
HBS	unemployment from drought-related production declines
SA	strain on financial institutions (foreclosures, greater credit risks, capital shortfalls, etc.)

SM	revenue losses to state and local governments (from reduced tax base, hunting and fishing license fees, etc.)
M	revenues to water supply firms
M	revenue shortfalls
M	windfall profits
B	economic loss from impaired navigability of streams, rivers, and canals
HABMS	cost of water transport or transfer
HABMS	cost of new or supplemental water source development
	<i>Environmental impacts</i>
AS	damage to animal species
SH	damage to wildlife habitat
AH	lack of feed and drinking water
AS	disease
A	vulnerability to predation (e.g., from species concentration near water)
S	damage to fish species
S	damage to plant species
AM	water quality effects (e.g., salt concentration)
HS	air quality effects (dust, pollutants)
HS	visual and landscape quality (dust, vegetative cover, etc.)
	<i>Social impacts</i>
MS	public safety from forest and range fires
MS	health-related low flow problems (e.g., diminished sewage flows, increased pollutant concentrations, etc.)
AHBMS	inequity in the distribution of drought impacts/relief
	lifestyle impacts
HAS	unemployment
HA	loss of savings
H	retirement
A	small family farming
HABMS	uncertainty
HBMS	recreation
H	personal hygiene
H	dirty cars and streets
H	water reuse in home
HB	entertaining
	<i>Constraints to implementation of drought mitigation measures</i>
MS	legal/institutional constraints
MSA	to water conservation/efficiency measures
MSA	to water supply augmentation measures
MSA	water supply facilities (exploration, distribution, storage)
A	weather modification
HABMS	financial constraints
ABMS	to water conservation/efficiency measures
ABM	to water supply augmentation measures
AM	water supply facilities (exploration, distribution, storage)
S	weather modification

	inadequate drought management capability/authority
M	local
S	state
S	federal
MS	inadequate understanding of drought problems and mitigation measures; public apathy
AM	shortages of needed parts, equipment, manpower (e.g., drilling rigs and operators, pumps, pipe, etc.)

*M, municipalities; S, state governments; B, business and industries; A, agricultural enterprises; H, households and individuals

Table I shows clearly that the potential impacts of drought in the United States, at least, are concentrated largely in the economic sector, with agriculture the most often affected of the five groups identified. Because of the diversity of these impacts and their ripple effect on the economy, they are difficult to quantify. More explicit and objective definitions, incorporating both physical and socio-economic aspects of drought, could assist in the quantification of impacts and allow for more precise comparisons of the effects of drought within and between geographical regions.

Conclusion

To summarize:

- 1) the lack of a precise (and objective) definition of drought in a specific situation has been an obstacle to understanding drought, which has led to indecision and/or inaction on the part of managers, policy makers, and others;
- 2) there cannot (and should not) be a universal definition of drought;
- 3) available definitions demonstrate a multidisciplinary interest in drought;
- 4) it is useful to subdivide definitions of drought into four types on the basis of disciplinary perspective (meteorologic, agricultural, hydrologic, and socio-economic);
- 5) drought is a complex phenomenon with pervasive societal ramifications;
- 6) most scientific research related to drought has emphasized the physical over the societal aspects of drought;
- 7) drought severity is sometimes expressed by its societal impacts, although the precise nature of those impacts is difficult to quantify;
- 8) secondary and tertiary effects often extend beyond the spatially defined borders of drought;
- 9) drought impacts are long lasting, at times lingering for many years; and
- 10) human or social factors often aggravate the effects of drought.

Each of these points highlights our need to develop a better understanding of the concept of drought. The criteria selected to define drought must be stated explicitly so that the definition can be evaluated and its applicability to other locations examined.

Drought's impacts must be seen as dynamic, resulting from interactions between supply and demand. Supply can be expressed in terms of the physical subsystem and linked to concomitant impacts in the social subsystem. Demand must be viewed as interacting with supply and as continually changing. The relationships of supply and demand for the principal economic goods are highly variable from one country to another, from one region to the next, and from one period to another.

Definitions of drought should reflect a regional bias since water supply is largely a function of climatic regime. Of course, the size of the region over which any definition is applicable may vary considerably. Primary impacts will likewise be regional in character, but secondary and tertiary effects of a drought can have national and, at times, global implications. For example, droughts in Zimbabwe can adversely affect regional food supplies in southern Africa.

The inadequate understanding of the concept of drought and the lack of appreciation of its physical and social impacts by the scientific community and governments has serious worldwide implications for the future as the difference between food production and consumption narrows. Governments should prepare for droughts by developing and implementing strategies and plans that reduce associated impacts. More precise and objective definitions of drought can greatly improve the understanding of the concept and its impacts and facilitate strategy development. Otherwise, the mistakes and failures of the past will no doubt be repeated, although with the likelihood of more severe consequences.

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