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Managing drought risk in a changing climate: The role of national drought policy

Donald A. Wilhite [a,*], Mannava V.K. Sivakumar [b], Roger Pulwarty [c]

[a] School of Natural Resources, University of Nebraska, Lincoln, NE 68583, USA
[b] 27 Chemin des Corbillettes, 1216 Cointrin, Geneva, Switzerland
[c] National Oceanic and Atmospheric Administration, Climate Program Office and Earth Systems Research Laboratory, 325 Broadway R/ESRL, Boulder, CO 80305, USA

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ABSTRACT

There is increasing concern worldwide about the ineffectiveness of current drought management practices that are largely based on crisis management. These practices are reactive and, therefore, only treat the symptoms (impacts) of drought rather than the underlying causes for the vulnerabilities associated with impacts. Through the adoption of national drought policies that are focused on risk reduction and complemented by drought mitigation or preparedness plans at various levels of government, the coping capacity of nations to manage droughts can be improved. The time for adopting an approach that emphasizes drought risk reduction is now, given the spiraling impacts of droughts in an ever-increasing number of sectors and the current and projected trends for the increased frequency, severity and duration of drought events in association with a changing climate. This paper discusses the underlying concepts of drought, the principles and objectives of national drought policies and a drought planning process that has been effective in the preparation of drought mitigation plans.

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1. Introduction

In recent years, concern has grown worldwide that droughts may be increasing in frequency, severity, and duration given changing climatic conditions and documented increases in extreme climate events (Sivakumar, 2012; Peterson et al., 2013). Responses to drought by governments throughout the world are generally reactive – poorly coordinated and untimely – and are typically characterized as "crisis management" (Wilhite and Pulwarty, 2005). In addition, the provision of drought relief or assistance to those most affected has been shown to increase vulnerability to future drought episodes by reducing self-reliance and increasing dependence on government and donor organizations. Thus, it is imperative that emergency relief be provided in such a manner that it provides a safety net for those elements of society that are most vulnerable while promoting self-reliance and the principles of a national drought policy based on the concept of risk reduction.

As a direct result of the increase in drought frequency, severity and duration, and the narrowing of the gap between water supply and demand, there has been a remarkable increase in the impacts associated with drought in both developing and developed countries. Although agriculture has typically been the first and most affected sector, many other sectors, including energy production, tourism and recreation, transportation, urban water supply, and the environment, have also experienced significant losses.

Despite the increase in droughts and spiraling impacts, no concerted efforts have been made at the global level to initiate a dialogue on the formulation and adoption of national drought policies that provide a framework for a proactive, risk-based management for dealing with drought events. Without a coordinated national drought policy that includes comprehensive monitoring, early warning and information systems, impact assessment procedures, risk management measures, drought preparedness plans, and emergency response programs, nations will continue to respond to drought in a reactive, crisis management mode. Countries that have not developed such systems, even in part, to develop and inform strategic response options often illustrate a broader lack of institutional flexibility and preparedness and thus higher vulnerability (IPCC, 2012).

In order to address the issue of national drought policy, the World Meteorological Organization (WMO), the Secretariat of the United Nations Convention to Combat Desertification (UNCCD) and the Food and Agriculture Organization of the United Nations (FAO), in collaboration with a number of partners, organized the High-level Meeting on National Drought Policy (HMNDP) in Geneva, Switzerland, 11–15 March 2013 (WMO, 2013a).

The goal of HMNDP was to provide practical insight into useful, science-based actions to address key drought issues and various

* Corresponding author. Tel.: +1 402.472.4270.
E-mail addresses: dwilhite2@unl.edu (D.A. Wilhite), mannavas@gmail.com (M.V.K. Sivakumar), Roger.Pulwarty@noaa.gov (R. Pulwarty).

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strategies to cope with drought. National governments must adopt policies that engender cooperation and coordination at all levels of their administration in order to increase their capacity to cope with extended periods of water shortage resulting from drought. The ultimate goal of this effort is to create more drought resilient societies and ensure food security and the sustainability of natural resource systems at the domestic level.

2. The Enigma of drought

Drought differs from other natural hazards in several ways. First, drought is a slow-onset natural hazard often referred to as a creeping phenomenon (Gillette, 1950). Because of the creeping nature of drought, its effects accumulate slowly over a substantial period of time. Therefore, the onset and end of drought is difficult to determine and scientists and policy makers often disagree on the basis (i.e., criteria) for declaring an end to drought. Should drought's end be signaled by a return to normal precipitation and, if so, over what period of time does normal or above-normal precipitation need to be sustained for the drought to be declared officially over? Do precipitation deficits that emerged during the drought event need to be erased for the event to end and how much moisture will it take and over what time period? Do reservoirs and ground water levels need to return to normal or average conditions? Impacts linger for a considerable period of time following the return of normal precipitation, so is the end of drought signaled by meteorological or climatological factors or diminishing impacts?

Second, the absence of a precise and universally accepted definition of drought adds to the confusion about whether or not a drought exists and, if it does, its degree of severity. Realistically, definitions of drought must be region and application (or impact) specific (Wilhite and Glantz, 1985). This is one explanation for the scores of definitions that exist. For this reason, the search for a universal definition of drought is of little value. Policy makers are often frustrated by disagreements among scientists on whether or not a drought exists and its degree of severity.

Third, drought impacts are nonstructural and spread over a larger geographical area than are damages that result from other natural hazards. Quantifying the impacts and providing disaster relief are far more difficult tasks for drought than for other natural hazards since these impacts can filter through economies and the environment for months, years and even decades. These characteristics of drought have hindered development of accurate, reliable, and timely estimates of severity and impacts (i.e., drought early warning and information systems) and, ultimately, the formulation of drought preparedness plans and drought policies. It is difficult for emergency managers that are tasked with the assignment of responding to drought to deal with the impacts because droughts often have large spatial coverage in comparison to floods, tropical storms, earthquakes, and other natural hazards and impacts vary by type and magnitude within the drought-affected area because of different economic, social, and environmental system vulnerabilities.

Drought is a temporary aberration, unlike aridity, which is a permanent feature of the climate. Seasonal aridity (i.e., a well-defined dry season) also needs to be distinguished from drought. There is considerable confusion among scientists and policy makers on the differentiation of these terms. For example, Pessoa (1987) presented a map illustrating the frequency of drought in Northeast Brazil in his discussion of the impacts of and governmental response to drought. For a significant portion of the Northeast region, he indicated that drought occurred between 81 and 100% of the time. Much of this region is arid and drought is an inevitable feature of its climate. But, drought is a temporary feature of climate so it cannot, by definition, occur 100% of the time.

Drought must be considered a relative, rather than absolute, condition. It occurs in both high and low rainfall areas and virtually all climatic regimes. The impacts of drought are, at times, enormous and result in economic and environmental impacts as well as personal hardship. Some countries are now finding it prudent to develop or consider national strategies and policies to manage droughts more effectively. Although this approach might be expected in drought-prone nations like Australia, South Africa, the United States, and India, it is less expected in Malaysia, China, and many European countries—areas normally considered as having a surplus of water.

The impacts of drought appear to be increasing in both developing and developed countries, a clear sign of unsustainable resource use and growing pressures on natural resources. Many factors are contributing to this trend and will be discussed in greater detail later in this paper. Adding to the concern regarding increasing societal vulnerability is concern over how the threat of climate change may increase the frequency, severity and, in the case of drought, duration of these extreme climatic events in the future. As pressure on finite water supplies and other limited natural resources continue to build, more frequent and severe droughts are cause for concern in both water short and water surplus regions where conflicts within and between countries are growing over access to a safe and dependable water supply. Reducing the impacts of future drought events is paramount as part of a national development strategy and a climate change adaptation plan.

Drought, like all natural hazards, has both a natural and social dimension. In most cases the social dimension is the factor that turns a hazard into a disaster. The risk associated with drought for any region is a product of both the region's exposure to the event (i.e., probability of occurrence at various severity levels) and the vulnerability of society to the event (Blaikie et al., 1994). The natural event (i.e., meteorological drought) is a result of the occurrence of persistent large-scale disruptions in the global circulation pattern of the atmosphere (Nicholls et al., 2005). Exposure to drought varies spatially and there is little, if anything, we can do to alter drought occurrence. Vulnerability, on the other hand, is determined by social factors such as population changes, population shifts (regional and rural to urban), demographic characteristics, technology, government policies, environmental awareness and degradation, water use trends, and social behavior. These factors change over time and thus vulnerability is likely to increase or decrease in response to these changes. Subsequent droughts in the same region will have different effects, even if they are identical in intensity, duration, and spatial characteristics, because the drought event is overlying a society that differs from the one that existed during a prior drought event.

All types of drought originate from a deficiency of precipitation (Wilhite and Glantz, 1985), although other factors such as high winds, high temperatures, and low relative humidity may exacerbate the drought's severity. When this precipitation deficiency spans an extended period of time (i.e., meteorological drought), its existence is defined initially in terms of these natural characteristics. However, the other common drought types (i.e., agricultural, hydrological, and socioeconomic) place greater emphasis on human or social aspects of drought and the management of natural resources, highlighting the interaction or interplay between the natural characteristics of the event and human activities that depend on precipitation to provide adequate water supplies to meet societal and environmental demands (Fig. 1). For example, agricultural drought is defined more commonly by the availability of soil water to support crop and forage growth than by the departure of normal precipitation over some specified period of time.

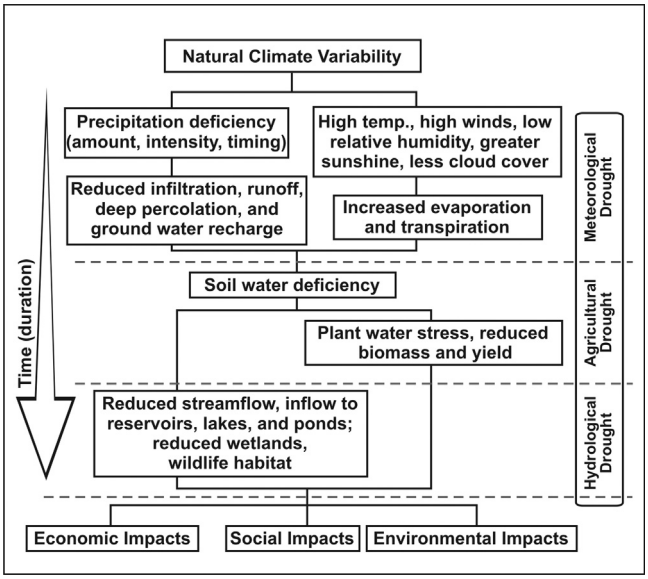

Fig. 1. Drought types, causal factors and their usual sequence of occurrence. *Source*: National Drought Mitigation Center.

Hydrological drought is even further removed from the deficiency of precipitation since it is normally defined in terms of the departure of surface and subsurface water supplies from some average condition at various points in time. Like agricultural drought, there is not a direct relationship between precipitation amounts and the status of surface and subsurface water supplies in lakes, reservoirs, aquifers, and streams because these components of the hydrological system are used for multiple and competing purposes (e.g., irrigation, recreation, tourism, flood control, hydroelectric power production, domestic water supply, protection of endangered species, and environmental and ecosystem preservation). There is also considerable time lag between departures of precipitation and when these deficiencies become evident in these components of the hydrologic system. Recovery of these components is also slow because of long recharge periods for surface and subsurface water supplies. In areas where the primary source of water is from snowpack, such as in the western United States, the determination of drought severity is further complicated by infrastructures, institutional arrangements, and legal constraints.

Socioeconomic drought differs markedly from the other types because it associates the supply and demand of some economic good or service with elements of meteorological, agricultural, and hydrological drought. Socioeconomic drought is associated directly with the supply of some commodity or economic good (e.g., water, hay, hydroelectric power) that is dependent on precipitation. Increases in population can substantially alter the demand for these economic goods over time. This concept of drought supports the strong symbiosis between drought and its impacts on human activities. Thus, the magnitude of drought impacts could increase because of a change in the frequency of meteorological drought, a change in societal vulnerability to water shortages, or both.

The interplay between drought and human activities raises a serious question with regard to our attempts to define it in a meaningful way. It was previously stated that drought results from a deficiency of precipitation from expected or "normal" over a season or longer period of time that results in insufficient water to meet the demands of human activities and the environment. Conceptually, this definition assumes that the demands of human activities are in balance or harmony with the availability of water supplies during periods of normal or mean precipitation. If development demands exceed the supply of water available, the result can be that demand exceeds supply even in years of normal precipitation. This can result in a situation of human-induced drought that is apart from the drought types previously discussed, a phenomenon commonly known as water scarcity.

Drought is also related to the timing (i.e., principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness of the rains (i.e., rainfall intensity, number of rainfall events). Thus, each drought event is unique in its climatic characteristics, spatial extent, and impacts (i.e., no two droughts are identical). The area affected by drought is rarely static during the course of the event. As drought emerges and intensifies, its core area or epicenter shifts and its spatial extent expands and contracts throughout the duration of the event. A comprehensive drought early warning and information delivery system is critical for tracking these changes in spatial coverage and severity. As has been noted, (Monnik, 2000; Pulwarty and Verdin, 2013) the main constraints on early warning information system implementation include:

- Lack of a national and regional drought policy framework;
- Limited coordination institutions that provide different types of drought early warning, risk management and risk reduction, that results from a national policy; and
- Inadequate social impact indicators to form part of a comprehensive early warning system and inform policy response.

2.1. Characterizing drought and its severity

Droughts differ from one another in three essential characteristics: intensity, duration, and spatial coverage. Intensity refers to the degree of the precipitation shortfall and/or the severity of impacts associated with the shortfall. It is generally measured by the departure of some climatic parameter (e.g., precipitation), indicator (e.g., reservoir levels) or index (e.g., Standardized Precipitation Index) from normal and is closely linked to duration in the determination of impact. Another distinguishing feature of drought is its duration. Droughts usually require a minimum of two to three months to become established but then can continue for months or years. The magnitude of drought impacts is closely related to the timing of the onset of the precipitation shortage, its intensity, and the duration of the event.

Droughts also differ in terms of their spatial characteristics. The areas affected by severe drought evolve gradually, and regions of maximum intensity (i.e., epicenter) shift from season to season. From a planning perspective, the spatial characteristics of drought have serious implications. Nations should determine the probability that drought may simultaneously affect all or several major crop-producing regions or river basins within their borders and develop contingencies if such an event were to occur. Likewise, it is important for governments to calculate the chances of a regional drought simultaneously affecting agricultural productivity and water supplies in their country as well as adjacent or nearby nations on whom they are dependent for food supplies. A drought policy and preparedness plan that depends on the importation of food from neighboring countries may not be viable if a regional-scale drought occurs.

3. The challenge of drought early warning and information systems

Early warning systems (EWS) aim to reduce vulnerability and improve response capacities of people at risk. Governments maintain EWS to warn their citizens and themselves about

impending hazards, resulting for example, from health, geologic or climate and weather-related drivers. Seasonality already provides decision makers with clear indications of regions that are potentially at risk. Decision-making quality depends in part on the information available and the manner in which this information is processed by individuals, groups and systems (ICSU, 2008). As noted by Pulwarty (2007), the timing and form of climatic information inputs (including forecasts and projections), and access to trusted guidance and capability to interpret and implement the information and projections in decision-making processes, are as important to individual users as improvements in prediction skill.

Numerous natural indicators of drought should be monitored routinely to determine drought onset, end, and spatial characteristics. Severity must also be evaluated continuously on frequent time steps. Although droughts originate from a deficiency of precipitation, it is inadequate to rely only on this climatic element to assess severity and resultant impacts. Effective drought early warning systems must integrate precipitation data with other data such as streamflow, snowpack, ground water levels, reservoir and lake levels, and soil moisture in order to assess drought and water supply conditions. For most locations, drought forecasting and early warning is still a linear process based on a "sender–receiver" model of risk communication. It is more effective to design drought early warning and information systems (DEWIS) that rely on multiple physical indicators and climatic indices in combination with social indicators. Effective DEWIS are an integral part of efforts worldwide to improve drought management and preparedness and must be the foundation of mitigation plans and a national drought policy.

Drought by itself does not trigger an emergency. Whether it becomes an emergency or disaster depends on its impact on local communities and the environment. And that, in turn, depends on the vulnerability of people and the environment to such a "shock". Drought results in substantial impacts in both developing and developed countries, although the characteristics of these impacts differ considerably. The ability to cope with drought also varies considerably from country to country and from one region, community, or population group to another. Assessments of drought early warning and information systems (DEWIS) illustrate that the most successful: (1) integrate social vulnerability indicators with physical variables across timescales; (2) embrace risk communication as an interactive social process and; (3) support governance of a collaborative framework for early warning across spatial scales (Pulwarty and Verdin, 2013). Monitoring coping responses, that is the sequential or hierarchical strategies that households use to fend off hunger and preserve their productive assets, is critical but still in its infancy primarily because local observers are needed to determine the meaning of scarcity responses. Thus, the governance context in which DEWIS are embedded is key.

4. Changing climate, changing vulnerabilities: Building society resilience through national drought policies

Natural disasters are a consequence of the interactions between the weather and climate extremes and the vulnerability of human and natural ecosystems to such extremes. Research shows that the frequency and magnitude of extreme events is on the rise. According to WMO (2013b), the world experienced unprecedented high-impact climate extremes during the 2001–2010 decade, which was the warmest since the start of modern measurements in 1850. The decade ending in 2010 was an unprecedented era of climate extremes, as evidenced by heat waves in Europe and Russia, droughts in the Amazon Basin, Australia, and East Africa, and huge storms like Tropical Cyclone Nargis and Hurricane Katrina. Exposure and vulnerability to natural hazards is increasing as more people and physical assets are located in areas of high risk.

According to the data provided by the Centre for Research on the Epidemiology of Disasters (CRED), during the decade 2001–2010, more than 370,000 people died as a result of extreme weather and climate conditions, including heat waves, cold spells, drought, storms, and floods. This was 20% higher than 1991–2000 (CCSP, 2008).

Droughts affect more people than any other natural hazard owing to their large scale and long-lasting nature. The decade 2001–2010 saw droughts occur in all parts of the world. Some of the highest-impact and long-term droughts struck Australia (in 2002 and other years), East Africa (2004 and 2005, resulting in widespread loss of life), and the Amazon Basin (2010) with negative environmental impacts (Sivakumar, 2013). In the Sahel, the 2012 cereal crop was 26% lower than the 2011 crop. More than 10 million people remain food insecure in the region and 1.4 million children are at risk of acute malnutrition. A prolonged dry season has resulted in widespread crop failure in 2013 across Namibia, and the Namibian government estimates that the 2013 harvest will produce 42% less than the 2012 harvest. An estimated 780,000 people – approximately one third of Namibia's entire population – are now classified as food insecure. Of these, 330,000 people are in need of urgent support, according to the government of Namibia, which declared a state of emergency on 17 May 2013. Severe drought in 2013 plagued northeast Brazil, where some areas have received no rain in more than a year and over 400,000 households faced freshwater shortages.

Data from Munich Re, the world's largest reinsurance firm, shows a dramatic increase in the number of natural catastrophes attributable to meteorological and hydrological events worldwide over the period from 1980 to 2012, while geophysical events have remained relatively constant over that same time period (Hoppe, 2013). The number of natural catastrophes resulting from meteorological events increased from approximately 180 in 1980 to more than 400 in 2012. Hydrological events have followed a similar trend, increasing from approximately 100 in 1980 to more than 300 in 2012. The data show a considerable degree of variability during this time period, but the trend in meteorological and hydrological events reflects the current science of climate change regarding projections for an increased frequency of extreme climate events, including drought. More effective risk-based reduction policies and measures must be developed if governments are to reduce the impacts associated with droughts and other extreme climatic events in the future.

4.1. Defining drought policy

As a beginning point in the discussion of national drought policy, it is important to identify the various types of drought policies that are available and have been utilized for drought management. The approach most often followed by both developing and developed nations is post-impact government (or nongovernment) interventions. These interventions are normally relief measures in the form of emergency assistance programs aimed at providing money or other specific types of assistance (e.g., livestock feed, water, food) to the victims (or those experiencing the most severe impacts) of the drought. This reactive approach is seriously flawed from the perspective of vulnerability reduction since the recipients of this assistance are not expected to change behaviors or resource management practices as a condition of the assistance. Although providing a safety net for those people or sectors most vulnerable to drought is a high priority, the challenge is to do it in a manner that reinforces the tenets of a drought risk

reduction strategy. For example, livestock producers that do not maintain adequate on-farm storage of feed for livestock as a drought management strategy will be those that first experience the impacts of extended precipitation shortfalls. These producers will be the first that turn to the government or other organizations for assistance in order to maintain herds until the drought is over and feedstocks return to adequate levels. This reliance on the government for relief is contrary to the philosophy of encouraging self-reliance through producer investment in creating improved coping capacity. Government assistance or incentives that encourage these investments would be a philosophical change in how governments respond and would promote a change in the expectations of livestock producers as to the role of government in these response efforts. The more traditional approach of providing relief is also flawed in terms of the timing of assistance being provided. It often takes weeks or months for assistance to be received, at times well beyond the window of when the relief would be of greatest value in addressing the impacts of drought.

A second type of drought policy approach is the development of pre-impact government programs that are intended to reduce vulnerability and impacts. In the natural hazards field, these types of programs or measures are commonly referred to as mitigation measures. Mitigation in the context of natural hazards is different from mitigation in the context of climate change, where the focus is on reducing greenhouse gas (GHG) emissions. Drought mitigation measures are numerous but appear to be less obvious to many people, including policy makers, when associated with drought since impacts are generally nonstructural. Mitigation measures for many other natural hazards (e.g., earthquakes, floods, hurricanes) are often largely structural. Drought mitigation measures would include establishing comprehensive early warning and information systems, improving seasonal forecasts, increasing emphasis on water conservation (demand reduction), increasing or augmenting water supplies through greater utilization of ground water resources, constructing reservoirs, interconnecting water supplies between neighboring communities, drought planning, and awareness building and education. A more exhaustive list of these measures was compiled through a survey of states and other entities in the United States following several drought episodes in the late 1980s and early 1990s (Wilhite and Rhodes, 1993). Insurance programs, currently available in many countries, would also fall into this category of policy types.

The final type of policy response is the development and implementation of preparedness plans and policies, which would include organizational frameworks and operational arrangements developed in advance of drought and maintained between drought episodes by government or other entities. This approach represents an attempt to create greater institutional capacity focused on improved coordination and collaboration within and between levels of government and with stakeholders in the plethora of private organizations with a vested interest in drought management (i.e., communities, natural resource districts or managers, utilities, agribusiness, farm organizations, and others).

4.2. Principle elements of a drought risk reduction policy framework

Drought policy options should be provided in each of four principle areas: (1) risk and early warning, including vulnerability analysis, impact assessment, and communication; (2) mitigation and preparedness, including the application of effective and affordable practices; (3) awareness and education, including a well-informed public and a participatory process; and (4) policy governance, including political commitment and responsibilities (UNISDR, 2009). Another important component of this framework is the inclusion of policy options for emergency response and relief. In all cases, when severe drought occurs, governments and other organizations must provide some form of emergency relief to those sectors most affected. It is critically important, as a part of a drought risk reduction policy, for this assistance to be provided in a form that does not run counter to the goals and objectives of the national drought policy, which would include a strong emphasis on the sustainability of the natural resource base.

The development and implementation of a drought policy is intended to alter a nation's approach to drought management. Over the past decade, drought policy and preparedness has received increasing attention from governments, international and regional organizations, and nongovernmental organizations. The organization of the HMNDP is a culmination of this increasing awareness and concern by many organizations, agencies, and governments. Simply stated, a national drought policy should establish a clear set of principles or operating guidelines to govern the management of drought and its impacts. The policy should be consistent and equitable for all regions, population groups, and economic sectors and consistent with the goals of sustainable development. The overriding principle of drought policy should be an emphasis on risk management through the application of preparedness and mitigation measures (Wilhite et al., 2005a). The policy must reflect regional differences in drought characteristics, vulnerability, and impacts. The goal of the policy is to reduce risk by developing better awareness and understanding of the drought hazard and the underlying causes of societal vulnerability. As stated previously, the principles of risk management can be promoted by encouraging the improvement and application of seasonal and shorter-term forecasts, developing integrated monitoring and drought early warning systems and associated information delivery systems, developing preparedness plans at various levels of government, adopting mitigation actions and programs, creating a safety net of emergency response programs that ensure timely and targeted relief, and providing an organizational structure that enhances coordination within and between levels of government and with stakeholders.

As vulnerability to drought has increased globally, greater attention has been directed to reducing risks associated with its occurrence through the introduction of planning to improve operational capabilities (i.e., climate and water supply monitoring, building institutional capacity) and mitigation measures that are aimed at reducing drought impacts. This change in emphasis is long overdue. Typically, when a natural hazard event and resultant disaster has occurred, governments and donors have followed with impact assessment, response, recovery, and reconstruction activities to return the region or locality to a pre-disaster state. Historically, little attention has been given to preparedness, mitigation, and prediction/early warning actions (i.e., risk management) that could reduce future impacts and lessen the need for government intervention in the future. Because of this emphasis on crisis management, society has generally moved from one disaster to another with little, if any, reduction in risk. This concept is expressed in the Cycle of Disaster Management (Fig. 2). If more emphasis is placed on the risk reduction portions of this cycle, the impacts associated with drought and other disasters, and thus the need for government interventions in the form of emergency relief measures, will be reduced.

4.3. Drought policy objectives

The objectives associated with a national drought policy will, of course, vary from nation to nation but, in principle, will likely reflect some common themes. These objectives would likely

- Encourage vulnerable economic sectors and population groups to adopt self-reliant measures that promote risk management;

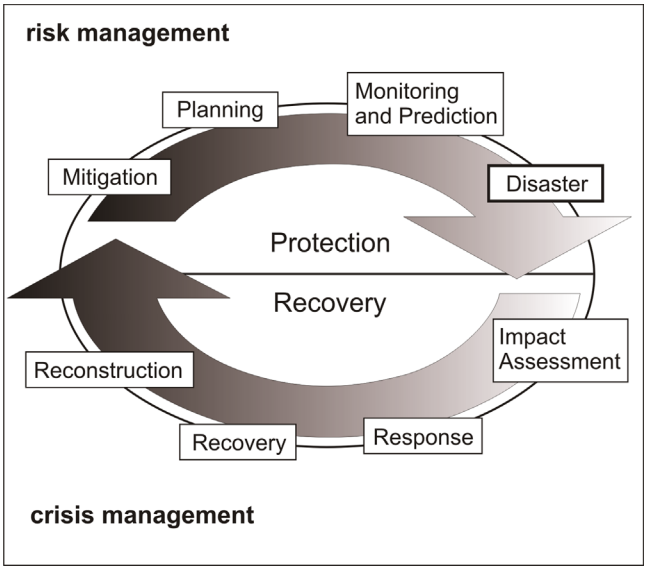

Fig. 2. Cycle of disaster management.
Source: National Drought Mitigation Center.

- Promote sustainable use of the agricultural and natural resource base; and
- Facilitate early recovery from drought through actions consistent with national drought policy objectives.

The goals or tenets of national drought policy, as stated in the documents prepared leading up to the high-level meeting on national drought policy (World Meteorological Organization, 2013a), were:

- Proactive mitigation and planning measures, risk management, public outreach, and resource stewardship;
- Greater collaboration to enhance the national/regional/global observation networks and information delivery systems to improve public understanding of, and preparedness for, drought;
- Incorporation of comprehensive governmental and private insurance and financial strategies into drought preparedness plans;
- Recognition of a safety net of emergency relief based on sound stewardship of natural resources and self-help at diverse levels; and
- Coordination of drought programs and response efforts in an effective, efficient and customer-oriented manner.

Drought preparedness or mitigation planning, as an integral part of drought policy, can take many forms and approaches. It is important to note that planning must occur on multiple government levels from local to national, and the objectives of these policies at the local, state, or regional levels must reflect the goals of national drought policies. Stakeholders must be engaged at all levels. Drought planning should also occur at the river basin scale, so the result may be overlapping authorities with political jurisdictions.

Drought planning can be defined as actions taken by individual citizens, industry, government, and others before drought occurs with the purpose of reducing or mitigating impacts and conflicts arising from drought. It can take the following forms: response planning or mitigation planning. In the United States, where drought planning at the state level has become widespread over the past 25 years, most state drought plans first began as response plans—i.e., reactive plans that implemented actions when drought emerged, often with the goal of formulating requests for assistance from the federal government, most often the U.S. Department of Agriculture. Over the past 10 years, there has been an impressive shift of emphasis toward mitigation planning by many states. Currently, 47 of the 50 U.S. states have drought plans, and 11 of these states are placing an ever-increasing emphasis on mitigation as a primary means of reducing societal vulnerability (National Drought Mitigation Center, 2013). Interestingly, a greater emphasis on mitigation planning has necessarily resulted in increased pressure for scientists to provide more timely information in the form of better seasonal forecasts, improved decision support tools, and higher resolution analysis for natural resource managers, government officials, and policy makers.

One of the tools that has been instrumental in providing guidance in the development of drought preparedness plans in the United States is a 10-step planning process originally proposed in 1991 (Wilhite, 1991) and subsequently modified on numerous occasions to incorporate a greater emphasis on mitigation in the planning process (Wilhite et al., 2000, 2005b). These steps are listed in Fig. 3.

In brief, Steps 1–4 of the 10-step planning process focus on making sure the right people are brought together, have a clear understanding of the process, know what the drought preparedness plan must accomplish, and are supplied with adequate data to make fair and equitable decisions when formulating and writing the actual drought plan. Step 5 describes the process of developing an organizational structure or framework for completion of the tasks necessary to prepare the plan. The plan should be viewed as a process, rather than a discrete event that produces a static document. A risk assessment is undertaken in conjunction with this step in order to construct a vulnerability profile for key economic sectors, population groups, regions, and communities. Steps 6 and 7 detail the need for ongoing research and coordination between scientists and policy makers. Steps 8 and 9 stress the importance of promoting and testing the plan before drought occurs. Finally, Step 10 emphasizes revising the plan to keep it current and making an evaluation of the plan's effectiveness in the post-drought period. Although the steps are sequential, many of these tasks are addressed simultaneously under the leadership of a drought task force and its complement of committees and working groups. These steps, and the tasks included in each, provide a "checklist" that should be considered and may be completed as part of the planning process.

The organizational structure proposed in support of this 10-step planning process is shown in Fig. 4. This structure includes the formation of a drought task force to coordinate the drought planning process, both during the development stage and the implementation stage, and a monitoring committee and a risk assessment committee. This structure has worked effectively in most states, although it has been modified or adapted to the specific needs of each of the states with drought plans.

The description of the 10-step process below is summarized from Wilhite et al. (2005b), which is available on the website of

1. Appoint a drought task force or committee
2. State the purpose and objectives of the drought mitigation plan
3. Seek stakeholder input and resolve conflicts
4. Inventory resources and identify groups at risk
5. Prepare and write the drought mitigation plan
6. Identify research needs and fill institutional gaps
7. Integrate science and policy
8. Publicize the drought mitigation plan, Build awareness and consensus
9. Develop education programs
10. Evaluate and revise drought mitigation plans

Fig. 3. 10-Step drought planning process.
Source: National Drought Mitigation Center.

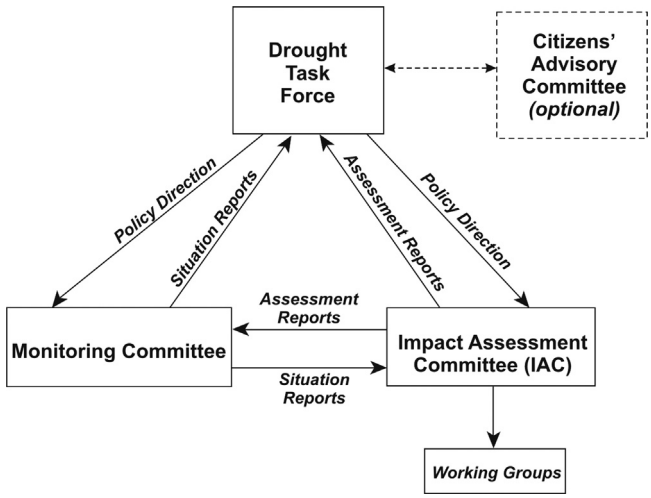

Fig. 4. Organizational structure or framework for drought preparedness plans. *Source*: National Drought Mitigation Center.

the National Drought Mitigation Center (NDMC) (http://drought.unl.edu/portals/0/docs/10StepProcess.pdf.)

4.3.1. Step 1: Appoint a drought task force

A key political leader initiates the drought planning process through appointment of a drought task force. Depending on the level of government developing the plan, this could be the president or prime minister, a provincial or state governor, or a mayor. The task force has two purposes. First, the task force supervises and coordinates development of the plan. Second, after the plan is developed and during times of drought when the plan is activated, the task force coordinates actions, implements mitigation and response programs, and makes policy recommendations to the governor or other appropriate political leader.

The task force should reflect the multidisciplinary nature of drought and its impacts, and it should include appropriate representatives of government agencies (provincial, federal) and universities where appropriate expertise is available. For provinces or states, the governor or appropriate political official should have a representative on the task force. Environmental and public interest groups and others from the private sector can be included on the task force (see Step 3), as appropriate. These groups would be involved to a considerable extent in the activities of the working groups associated with the Risk Assessment Committee discussed in Step 5. The actual makeup of this task force would vary considerably depending on the principal economic and other sectors affected, the political infrastructure, and other factors. The task force should include a public information official who is familiar with local media's needs and preferences, and a public participation practitioner who can help establish a process that includes and accommodates all stakeholders or interest groups.

4.3.2. Step 2: State the purpose and objectives of the drought mitigation plan

As its first official action, the drought task force should state the general purpose for the drought preparedness plan. Government officials should consider many questions as they define the purpose of the plan, such as the following:

- Purpose and role of government in drought mitigation and response efforts;
- Scope of the plan;
- Most drought-prone areas of the state/nation;
- Historical impacts of drought;
- Historical response to drought;
- Most vulnerable economic, social, and environmental sectors;
- Role of the plan in resolving conflict between water users and other vulnerable groups during periods of shortage;
- Current trends (e.g., land and water use, population growth) that may increase/vulnerability and conflicts in the future;
- Resources (human and economic) that the government is willing to commit to the planning process;
- Legal and social implications of the plan; and
- Principal environmental concerns caused by drought.

A generic statement of purpose for a plan is to reduce the impacts of drought by identifying principal activities, groups, or regions most at risk and developing mitigation actions and programs that reduce these vulnerabilities. The plan is directed at providing governments with an effective and systematic means of assessing drought conditions, developing mitigation actions and programs to reduce risk in advance of drought, and developing response options or safety nets that minimize economic stress, environmental losses, and social hardships during drought.

The task force should then identify the specific objectives that support the purpose of the plan. Drought plan objectives will vary within and between countries and should reflect the unique physical, environmental, socioeconomic, and political characteristics of the region in question. For a provincial, state, or regional plan, objectives that should be considered include the following:

- Collect and analyze drought-related information in a timely and systematic manner.
- Establish criteria for declaring drought emergencies and triggering various mitigation and response activities.
- Provide an organizational structure and delivery system that assures information flow between and within levels of government.
- Define the duties and responsibilities of all agencies with respect to drought.
- Maintain a current inventory of government programs used in assessing and responding to drought emergencies.
- Identify drought-prone areas of the state/region/nation and vulnerable economic sectors, individuals, or environments.
- Identify mitigation actions that can be taken to address vulnerabilities and reduce drought impacts.
- Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.
- Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the Internet).
- Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation.
- Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the state or region.

4.3.3. Step 3: Seek stakeholder participation and resolve conflict

Social, economic, and environmental values often clash as competition for scarce water resources intensifies. Therefore, task force members must identify all citizen groups (stakeholders) that have a stake in drought planning and their interests. These groups must be involved early and continuously for fair representation and effective drought management and planning. Discussing concerns early in the process gives participants a chance to

develop an understanding of each other's viewpoints, and to generate collaborative solutions. Although the level of involvement of these groups will vary notably from location to location, the power of public interest groups in policy making is considerable. In fact, these groups are likely to impede progress in the development of plans if they are not included in the process. The task force should also protect the interests of stakeholders who may lack the financial resources to serve as their own advocates. One way to facilitate public participation is to establish a citizen's advisory council as a permanent feature of the drought plan, to help the task force keep information flowing and resolve conflicts between stakeholders.

State or provincial governments need to consider if district or regional advisory councils need to be established. These councils could bring neighbors together to discuss their water use issues and problems and seek collaborative solutions. At the provincial level, representatives of each district council should be included in the membership of the provincial citizens' advisory council to represent the interests and values of their constituencies. The provincial citizens' advisory council can then offer recommendations and direct concerns to the task force as well as respond to requests for situation reports and updates.

4.3.4. Step 4: Inventory resources and identify groups at risk

An inventory of natural, biological, and human resources, including the identification of constraints that may impede the planning process, may need to be initiated by the task force. In many cases, much information already exists about natural and biological resources through various provincial and federal/national agencies. It is important to determine the vulnerability of these resources to periods of water shortage that result from drought. The most obvious *natural* resource of importance is water; where it is located, how accessible is it, of what quality is it? *Biological resources* refer to the quantity and quality of grasslands/rangelands, forests, wildlife, and so forth. *Human resources* include the labor needed to develop water resources, lay pipeline, haul water and forage for livestock, process citizen complaints, provide technical assistance, and direct citizens to available services.

The task force must also identify constraints to the planning process and to the activation of the various elements of the plan as drought conditions develop. These constraints may be physical, financial, legal, or political. The costs associated with plan development must be weighed against the losses that will likely result if no plan is in place. The purpose of a drought plan is to reduce risk and, therefore, economic, social, and environmental impacts. Legal constraints can include water rights, existing public trust laws, requirements for public water suppliers, liability issues, and so forth.

In drought planning, making the transition from crisis to risk management is difficult because, historically, little has been done to understand and address the risks associated with drought. To solve this problem, areas of high risk should be identified, as should actions that can be taken before a drought occurs to reduce those risks. Risk is defined by both the exposure of a location to the drought hazard and the vulnerability of that location to periods of drought-induced water shortages (Blaikie et al., 1994). Drought is a natural event; it is important to define the exposure (i.e., frequency of drought of various intensities and durations) of various parts of the region to the drought hazard. Some areas are likely to be more at risk than others. Vulnerability, on the other hand, is affected by social factors such as population growth and migration trends, urbanization, changes in land use, government policies, water use trends, diversity of economic base, cultural composition, and so forth. The drought task force should address these issues early in the planning process so they can provide more direction to the committees and working groups that will be developed under Step 5 of the planning process.

4.3.5. Step 5: Prepare and write drought plan

This step describes the process of establishing relevant committees to develop and write the drought preparedness plan. The plan should have three primary components: monitoring, early warning and information delivery, and prediction; risk and impact assessment; and mitigation and response. It is recommended that a committee be established to focus on the first two of these needs; the drought task force can in most instances carry out the mitigation and response function. The suggested organizational structure for the plan is illustrated in Fig. 4.

These committees will have their own tasks and goals, but well-established communication and information flow between committees and the task force is a necessity to ensure effective planning. More detail on the composition of these committees and their focus is included in Wilhite et al. (2005a) and on the NDMC's website: http://drought.unl.edu/portals/0/docs/10StepProcess.pdf

The purpose of the risk assessment process is to identify those sectors, population groups, or regions most at risk from drought, the most likely impacts, and appropriate mitigation actions that will reduce those impacts. The final outcome of this risk assessment process is the development of a vulnerability profile that establishes who and what is at risk and why. The steps in this process include the following:

1. Identify impacts of recent and historical droughts.
2. Identify drought impact trends.
3. Prioritize impacts.
4. Identify mitigation actions that could reduce short- and long-term impacts.
5. Identify triggers to phase in and phase out actions during drought onset and termination.
6. Identify agencies and organizations to develop and implement actions.

A checklist of historical, current, and potential drought impacts is available as a guide to government entities involved in this plan development process on the following web link:http://drought.unl.edu/portals/0/docs/10StepProcess.pdf

4.3.6. Step 6: Identify research needs and fill institutional gaps

As research needs and gaps in institutional responsibility become apparent during drought planning, the drought task force should compile a list of those deficiencies and recommend possible remedies to the appropriate person or government body. Step 6 should be carried out concurrently with Steps 4 and 5. For example, the Monitoring Committee may recommend establishing an automated weather station network or networking existing automated weather stations. Another recommendation may be to initiate research on the development of a climate or water supply index to help monitor water supplies and trigger specific actions by government.

4.3.7. Step 7: Integrate science and policy

An essential aspect of the planning process is integrating the science and policy of drought management. The policy maker's understanding of the scientific issues and technical constraints involved in addressing problems associated with drought is often limited. Likewise, scientists generally have a poor understanding of existing policy constraints for responding to the impacts of drought. In many cases, communication and understanding

between the science and policy communities must be enhanced if the planning process is to be successful.

Good communication is required between the two groups in order to distinguish what is feasible from what is not achievable for a broad range of science and policy issues. Integration of science and policy during the planning process will also be useful in setting research priorities and synthesizing current understanding. The drought task force should consider various alternatives to bring these groups together and maintain a strong working relationship.

Communication between researchers and practitioners, while necessary, is not sufficient. Current crisis-driven drought management approaches create significant impediments to proactive planning, and create institutional and behavioral barriers to change. The difficult challenge of creating a collaborative framework and implementing adaptive strategies at scales ranging from local communities to watersheds to hydrologic basins spanning multiple states requires a broad range of science policy responses. Such approaches yield quantitative comparisons of risks from the range of plausible future scenarios and allow for a priori evaluation of potential impacts of management decisions. In this context an effective risk management approach would include a timely and user-oriented early warning system and a focal point for dialogue between leadership and those affected. The National Integrated Drought Information System (NIDIS) is a major step in this direction (NIDIS, 2007). Proactive processes and outcomes rely on information, infrastructure and information supported by:

- Leadership and partnerships that ensure the successful implementation of an integrated national drought monitoring and forecasting system; and
- A framework for capacity development and education for those affected by drought and for those who study drought, on how and why droughts occur, how droughts impact human and natural systems, and what actions can be undertaken to mitigate drought impacts.

Partnering with local communities on drought risk management and involving them at all stages in mitigation of drought impacts is vital and also resource-intensive.

4.3.8. Step 8: Publicize the drought mitigation plan, build public awareness and consensus

If there has been good communication with the public throughout the process of establishing a drought plan, citizens may already have better-than-normal awareness of drought and drought planning by the time the plan is actually written. Themes to emphasize in writing news stories during and after the drought planning process could include:

- How the drought plan is expected to relieve impacts of drought in both the short and long term. Stories can focus on the human dimensions of drought, such as how it affects a farm family; on its environmental consequences, such as reduced wildlife habitat; and on its economic effects, such as the costs to a particular industry or to the overall economy.
- What changes people might be asked to make in response to different degrees of drought, such as restricted lawn watering and car washing, or not irrigating certain crops at certain times.

In subsequent years, it may be useful to do “drought plan refresher” news releases at the beginning of the most drought-sensitive season or as droughts are emerging, letting people know whether there is pressure on water supplies and reminding them of the plan's existence, history, and any associated success stories. It may be useful to refresh people's memories ahead of time on circumstances that would lead to water use restrictions.

During drought, the task force should work with public information professionals to keep the public well informed of the current status of water supplies, whether conditions are approaching “trigger points” that will lead to requests for voluntary or mandatory use restrictions, and how victims of drought can access assistance. All pertinent information should also be available on the drought task force's website so that the public can get information directly from the task force without having to rely on mass media.

4.3.9. Step 9: Develop education programs

A broad-based education program to raise awareness of short- and long-term water supply issues will help ensure that people know how to respond to drought when it occurs and that drought planning does not lose ground during non-drought years. It would be useful to tailor information to the needs of specific groups (e.g., elementary and secondary education, small business, industry, homeowners, and utilities). The drought task force or participating agencies should consider developing presentations and educational materials for events such as a water awareness week, community observations of Earth Day, relevant trade shows, specialized workshops, and other gatherings that focus on natural resource stewardship or management.

4.3.10. Step 10: Evaluate and revise drought mitigation plan

The final step in the planning process is to create a detailed set of procedures to ensure adequate plan evaluation. Periodic testing, evaluation, and updating of the drought plan are essential to keep the plan responsive to the needs of the state and its citizens. To maximize the effectiveness of the system, two modes of evaluation must be in place.

4.3.10.1. Ongoing evaluation. An ongoing or operational evaluation keeps track of how societal changes such as new technology, new research, new laws, and changes in political leadership may affect drought risk and the operational aspects of the drought plan. Drought risk may be evaluated quite frequently while the overall drought plan may be evaluated and revised less often. An evaluation under simulated drought conditions (i.e., drought exercise) is recommended before the drought plan is implemented and periodically thereafter. Drought planning is a process, not a discrete event.

4.3.10.2. Post-drought evaluation. A post-drought evaluation, or audit, documents and analyzes the assessment and response actions of government, nongovernmental organizations, and others, and provides for a mechanism to implement recommendations for improving the system. Without post-drought evaluations, it is difficult to learn from past successes and mistakes, as institutional memory fades.

Post-drought evaluations should include an analysis of the climatic and environmental aspects of the drought; its economic and social consequences; the extent to which pre-drought planning was useful in mitigating impacts, in facilitating relief or assistance to stricken areas, and in post-recovery; and any other weaknesses or problems caused by or not covered by the plan. Attention must also be directed to situations in which drought-coping mechanisms worked and where societies exhibited resilience; evaluations should not focus only on those situations in which coping mechanisms failed. Evaluations of previous responses to severe drought are also a good planning aid.

To ensure an unbiased appraisal, governments may wish to place the responsibility for evaluating drought and societal response to it in the hands of nongovernmental organizations

such as universities and/or specialized research institutes. One issue, is ensuring that lessons identified by these non-governmental organizations are then actually tested and, where appropriate, incorporated into planning and practice.

5. Conclusions

For the most part, responses to drought in all parts of the world have been reactive, representing the crisis management approach. This approach has been ineffective (i.e., assistance poorly targeted to specific impacts or population groups), poorly coordinated, and untimely; more importantly, it has done little to reduce the risks associated with drought. In fact, the economic, social, and environmental impacts of drought have increased significantly in recent decades. A similar trend exists for all natural hazards.

It is argued here that the administrative structure and support for ongoing collaboration between research and management proactive planning are critical. Governments and communities often lack capacity to deal with catastrophic droughts or to act during a window provided by an event. Clearly, while institutions may matter, in many cases they are simply not in place (before or after an event) (IPCC, 2012). The danger is that such systems risk being driven by a "disaster response" and 'issue-attention cycles" rather than being part of the learning needed to ensure resilience in socio-economic conditions.

This paper is intended to set the stage for a new paradigm for drought management—one focused on risk reduction and imbedded within a framework for national drought policy that all governments can follow in order to move from crisis to risk-based management. The goal of this new paradigm is to lessen societal vulnerability and, therefore, build resilience to future episodes of drought. Given projections of an increase in the occurrence and severity of extreme climate events for many regions, it is imperative that nations now move toward a more risk-based approach to drought management. However, even if the frequency, severity and duration of droughts do not change in the future for some locations, the ineffectiveness of past attempts to manage drought strongly suggests the need for a paradigm shift.

This paper presents an overview of the concept and key principles of drought policy and provides a process or template for the development of national drought policies and preparedness plans that nations can use to improve their level of preparedness for drought, with the ultimate goal of reducing societal vulnerability to this pervasive natural hazard. The goal of this policy and preparedness planning process is to change significantly the way we prepare for and respond to drought by placing greater emphasis on risk management and the adoption of appropriate mitigation actions. The planning process described in this paper is considered to be a generic process that can be adapted to the current institutional capacity of nations, whether developed or developing. The development of a national drought policy and supporting preparedness plans should be viewed as an ongoing process, continuously evaluating the successes and failures (or shortcomings) of the policy and plans and making appropriate modifications, as necessary. Governments at all levels must undertake this task in partnership with stakeholders throughout the process to maximize the effectiveness of the outcomes.

References

Blaikie, P., Cannon, T., Davis, I., Wisner, B., 1994. At Risk: Natural Hazards People's Vulnerability, and Disasters. Routledge Publishers, London

CCSP, 2008. Weather and climate extremes in a changing climate. Regions of focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. In: Thomas, R. Karl, Gerald, A. Meehl, Christopher, D. Miller, Susan, J. Hassol, Anne, M. Waple, William, L. Murray (Eds.), Department of Commerce. NOAA's National Climatic Data Center, Washington, D.C., USA, p. 164

Gillette, H.P., 1950. A Creeping Drought Under Way. In: Water and Sewage Works, March, pp. 104–105.

Hoppe, P., 2013. Pers. Commun.

ICSU, 2008. A Science Plan for Integrated Research on Disaster Risk: Addressing the Challenge of Natural and Human-induced Environmental Hazards. International Council for Science, Paris, France, ISBN: 978-0-930357-66-5 p. 66

IPCC, 2012. Special Report on Managing the Risk of Extreme Events and Disasters to Advance Climate Change Adaptation. Cambridge University Press, Cambridge, UK p. 582

Monnik, K., 2000. Role of drought early warning systems in South Africa's Evolving Drought Policy. In: Wilhite, D.A., Sivakumar, M.V.K., Wood, D.A. (Eds.), Early warning systems for drought preparedness and drought management. Proceedings Lisbon, Portugal, 5–7 September 2000. World Meteorological Organization, Geneva, Switzerland, pp. 53–64

National Drought Mitigation Center. 2013. Status of State Drought Planning. 〈http://drought.unl.edu/portals/0/docs/10StepProcess.pdf〉.

Nicholls, N., Coughlan, M.J., Monnik, K., 2005. The challenge of climate prediction in mitigating drought impacts. In: Wilhite, D.A. (Ed.), Drought and Water Crises: Science, Technology, and Management Issues. CRC Press, Boca Raton, Florida, pp. 33–52 (Chapter 2)

NIDIS. 2007. The National Integrated Drought Information System Implementation Plan: A Pathway for National Resilience, 34 pp. 〈www.drought.gov〉.

Pessoa, D., 1987. Drought in Northeast Brazil: impact and government response. In: Wilhite, D.A., Easterling, W.E. (Eds.), Planning for Drought: Toward a Reduction of Societal Vulnerability. Westview Press, Boulder, Colorado, pp. 471–488 (Chapter 28)

Peterson, T.C., Hoerling, M.P., Stott, P.A., Herring, S., 2013. Explaining extreme events of 2012 from a climate perspective. Bull. Am. Meteorol. Soc. 94, S1–S74.

Pulwarty, R., S., 2007. Communicating agroclimatological information, including forecasts, for agricultural decisions, Guide to Agrometeorological Practices. World Meteorological Organization, Geneva, Switzerland 〈http://www.wmo.ch/web/wcp/agm/RevGAMP/〉

Pulwarty, R., Verdin, J., 2013. Crafting early warning information systems: the case of drought. In: Birkmann, J. (Ed.), Measuring Vulnerability to Natural Hazards: Towards Disaster Resilient Societies, second ed. United Nations University Press, pp. 124–147

Sivakumar, M.V.K., 2012. High-level Meeting on National Drought Policy. CSA News, December. American Society of Agronomy, Madison, Wisconsin, USA

Sivakumar, M.V.K., 2013. Weather and climate extremes: need for and importance of the Journal. Weather Clim. Extremes 1, 1–3.

UNISDR, 2009. Drought Risk Reduction Framework and Actions. United Nations. International Strategy for Disaster Reduction, Geneva, Switzerland

Wilhite, D.A., 1991. Drought planning: a process for state government. Water Resour. Bull. 27, 29–38.

Wilhite, D.A., Glantz, M.H., 1985. Understanding the drought phenomenon: the role of definitions. Water Int. 10, 111–120.

Wilhite, D.A., Rhodes, S.L., 1993. Drought mitigation in the United States: progress by state government. In: Wilhite, D.A. (Ed.), Drought Assessment, Management, and Planning: Theory and Case Studies. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 237–252 (Chapter 13)

Wilhite, D.A., Hayes, M.J., Knutson, C., Smith, K.H., 2000. Planning for drought: moving from crisis to risk management. J. Am. Water Resour. Assoc. 36, 697–710.

Wilhite, D.A., Pulwarty, R.S., 2005. Drought and water crises: lessons learned and the road ahead. In: Wilhite, D.A. (Ed.), Drought and Water Crises: Science, Technology, and Management Issues. CRC Press, Boca Raton, Florida, pp. 389–398 (Chapter 15)

Wilhite, D.A., Botterill, V., Monnik, K., 2005a. National drought policy: lessons learned from Australia, South Africa, and the United States. In: Wilhite, D.A. (Ed.), Drought and Water Crises: Science, Technology, and Management Issues. CRC Press, Boca Raton, Florida, pp. 137–172 (Chapter 6)

Wilhite, D.A., Hayes, M.J., Knutson, C.L., 2005b. Drought preparedness planning: building institutional capacity. In: Wilhite, D.A. (Ed.), Drought and Water Crises: Science, Technology, and Management Issues. CRC Press, Boca Raton, Florida, pp. 93–136 (Chapter 5)

WMO, 2013a. High-level Meeting on National Drought Policy. World Meteorological Organization, Geneva, Switzerland 〈http://www.hmndp.org〉

WMO., 2013b. Global Climate 2001–2010: A Decade of Climate Extremes—Summary Report. WMO No. 1119, World Meteorological Organization, Geneva, Switzerland.