Droughts Challenge Water Resource Management and Policy

Elaine Wheaton, M.Sc.
Adjunct Professor, Climate Scientist, University of Saskatchewan, Saskatoon, Canada

Summary
Droughts are among the world's worst hazards and pose serious threats and immense challenges to many people, the economy, and the environment. Major droughts are harsh reminders of the great importance of water. This paper gives an overview of the current realities of drought and implications for program and policy formulation. Three main aspects of the current situation are described, including the peculiarities of drought characteristics, changing drought patterns driven by global warming, and links with policy. The nature of drought continues to be elusive and knowledge gaps exist across drought phases (e.g., onset, peak, decline) as well as for drought origins, areas, migrations, and causes. Drought monitoring, prediction, impacts, vulnerability, and adaptation are receiving some attention in research and policy, but efforts must be improved. One of the greatest challenges is integrating policy with drought/climate science. The goal is to reduce negative effects and exploit benefits. Recommendations are organized by three main topics: (i) present and past droughts, (ii) future droughts, and (iii) adaptation. The most significant goal is to address how individuals and society can best adapt to drought and water scarcity.

Current realities

Major droughts are stern reminders of the crucial importance of water. Droughts bring immense challenges, including water scarcity. Current and future climate and socioeconomic trends are increasing pressure on water resources. This places pressure on communities and policy makers to make more informed decisions. Decisions based on the data describing "old" normal and more stable climates are no longer suitable and could be misleading or even dangerous.

Droughts are one of the world's greatest hazards and pose serious threats to society, economy, and the environment. Most other natural hazards (e.g., hailstorms, blizzards, tornados) are different in nature (e.g., have rapid onsets), but droughts can develop slowly. This makes early warning for drought more difficult than with other weather hazards.

Three main aspects of the current situation are (i) droughts can be characterized much better, (ii) drought intensity, frequency, and other characteristics are being driven by global warming, and (iii) drought information can be used better and integrated into programs and policies. Given the necessity of water resources, more attention is needed to accelerate improvement of drought research and the integration of improved understanding into policies and programing. The basic question is how can individuals and society best adapt to drought and water scarcity? Adaptation includes adjustments in natural and human systems in response to actual or expected climatic stimuli or their effects. The goal of adaptation is to moderate harm and exploit opportunities.

Scientific opportunities and challenges

Recent research provides several new lessons with important implications for monitoring and adaptation to drought. Some examples include: (i) drought seems to migrate from multiple centers (e.g., from northern United States into the Canadian Prairies), (ii) drought may be expanding its range into areas previously less visited by drought, (iii) drought may peak in the winter and persist into the warm season, (iv) shifts from drought to periods of intense rain can occur; however, this may not end the impacts as some droughts have long lags, and (v) droughts have similarities, but each appears to have differences, such as causes and perhaps changing causes. Drought prediction is difficult, but has increasing importance. The lack of

knowledge about future drought is large and is a barrier to action or an excuse for business as usual.
Climate change is expected to increase the frequency, intensity and extent of moderate to extreme drought in several regions. It is likely that this effect has already been occurring. Future probable droughts are likely to be similar or even longer than the severe and intense drought during 2001 to 2002 that affected much of the Great Plains of North America and western United States (Figure 1). This figure shows only the core of the severe drought, and more moderate drought affected a much greater area. Other surprises could also occur with less stable climates. For example, more intense rainstorms are also possible now because of changes to the hydrological cycle. Extreme rainfall and resultant flooding also results in damage. In summary, society needs to prepare for more extreme wet times and dry times (Figure 2). Uncertainty about the future is often used as an excuse for ignoring the warnings about upcoming drought, but because the future is inherently uncertain, making decisions under uncertainty is necessary.

Droughts can bring a host of other problems in addition to water scarcity. These include increased risks of fire, increased soil erosion, water quality degradation, and habitat deterioration, as well as pests and diseases. Most sectors are sensitive to drought, including agriculture, energy production, tourism, manufacturing, transportation, and health.

All this information and more are required to better plan and prepare for drought. Many research opportunities exist because drought is complex and also appears to be neglected by researchers (e.g., lack of funding and training) and by policy makers. People who make their living from the land, for example, seem to recognize drought earlier than policy makers. Further examination of the nature of droughts include understanding their spatial and temporal aspects, such as onset, peak and declining phases, duration, origin, migrations, areas, and causes. Scientific opportunities and challenges exist in each of the categories of drought characteristics including monitoring, prediction, impacts and vulnerability assessment, and adaptation.

One of the greatest challenges is integrating policy with drought/climate science to protect water supplies and address socioeconomic sustainability. Scientists warn that the nature of drought and other climate extremes seems to be changing and more changes are expected with global warming. Challenges include the need for many more stakeholders (e.g., natural and social scientists, economists, engineers, developers, designers, policy makers) to work cooperatively in teams on both drought and other climate hazards. These teams require institutional and other required support. Future drought may bring several surprises that require much more innovative research, communication, and proactive integration of science and policy to achieve the goal of adaptation.

Policy issues
The motivations for policy action on drought are many. Some of the most important include the basics, such as food and water security. Safety is also at risk, with drought-related increases in fire and conflict, for example. A main goal of drought research and monitoring and associated policy development is to ensure sufficient water resources for people, the economy, and the environment. How prepared are current leaders for the next big droughts? The three main questions include: (i) What is the status of past and present droughts and their impacts? (ii) What will drought be like in the future (i.e., next week to next decades)? (iii) What is being done and what more can be done to best adapt to current and future drought? Each of these questions is addressed in turn:

Actions on **current drought** characteristics and impacts require better:

- monitoring and communication capabilities. The most sensitive sectors need to be involved, including agriculture, water, and the environmental departments of all government levels. Severe droughts cause ripple effects from biophysical through socioeconomic sectors, then local to continental levels, so almost everyone is affected. These actions lead to the motivation for the next main steps.
- assessments of past droughts for further information about characteristics and causes.
- tracking of water budgets, including supplies and use.
- social, physical science, and policy teams to use the observed data on drought, its causes and impacts to improve monitoring, modeling, and prediction of drought, impacts, vulnerabilities, and adaptations.

Enhanced understanding of **future possible droughts** and impacts requires improvement of:

- capability to predict droughts (climate) and its impacts, including worst-case scenarios because of the severe impacts of droughts.
- impact assessments, including analysis of possible adaptation options and their effectiveness (question 3).

Preparation to **adapt** to future droughts requires opportunities through enhanced:

- attention and capability to understand and use monitoring and projection information. This requires formal and informal institutions at local to national levels to have additional training and expertise.
- use of the information in many tools, including risk management, decision making under uncertainty, scenario analysis, gaming, and strategic planning.
- natural, social, technical, infrastructure, economic, and other capitals.
- testing and improving adaptations, including planning, preparation, and implementation.
- speed of incorporation of new knowledge into policy and programming.
- ways to overcome documented barriers to adaptation, including lack of funds, research, knowledge of water supplies and use, as well as resistance to change, apathy, denial, and over-confidence.

A main challenge is that droughts are irregular, complex, misunderstood, sneaky, and are expected to become worse. It is very disruptive, costly, and dangerous to ignore droughts until they are fully affecting communities, the economy, and the environment. Even with advanced technology, communities and countries are still vulnerable to droughts. Recent Canadian research is documenting local to regional concerns about drought and other climatic extremes. It is clear that drought must be taken much more seriously by policy makers to avoid and/or deal with their impacts. More effort and care is required to monitor droughts and their effects, to be able to predict their occurrences and warn people. Adaptation requires considerable effort and support in many realms of science and policy.

References

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Figure 1: Spatial patterns of major droughts in North America using the summer (June, July, August) Palmer Drought Severity Index Isoline of -3 (severe drought). (Wheaton, E. 2003. Canadian droughts of 2001 and 2002. Comparing the 2001 and 2002 droughts with other droughts. Prepared for Agriculture and Agri-Food Canada. Saskatchewan Research Council, Saskatoon, SK.)

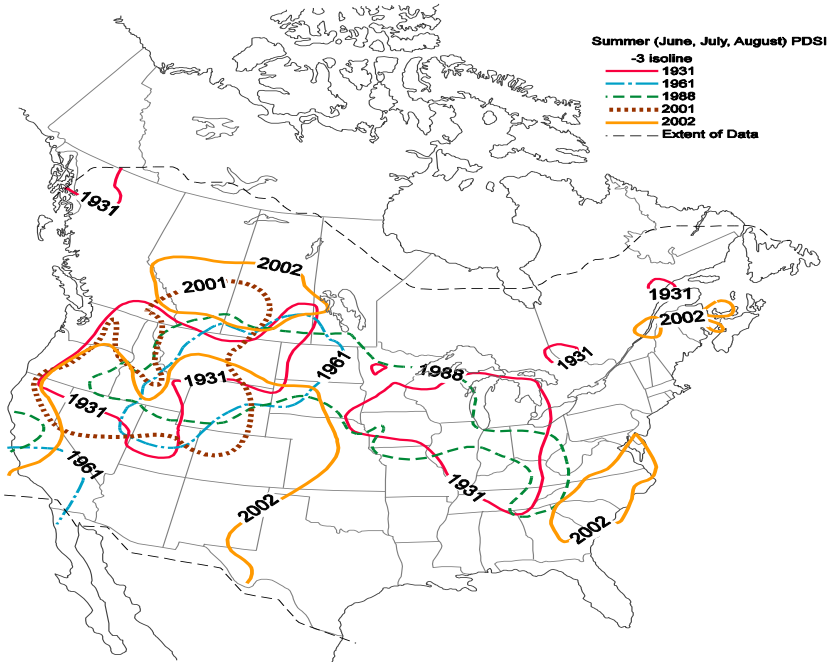

Figure 2: Global warming indicates that dry times/places become drier; wet times/places become wetter. Adaptation must be much improved to adequately deal with the next droughts. (Wheaton, E., Bonsal, B., Wittrock, V. (2013). Future Possible Dry and Wet Extremes in Saskatchewan, Canada. Prepared for the Saskatchewan Water Security Agency. University of Saskatchewan, Saskatoon, SK.)