ASSESSING DROUGHT IN TERMS OF RISK

Effective drought risk management is based in conveying drought information and data in such a way that communities actively learn and adapt, while seeking to prevent and mitigate drought risk. Processes that build capacity across social, institutional, and scientific communities can lead to better assessment of drought risk and actions that lead to risk reduction. Determining a common understanding of drought risk as a product of drought as a hazard, exposure to the hazard, and levels of vulnerability (loss of assets/resources), can help with informed decision-making. Drought risk and mitigation is at the center of social-ecological systems, as drought hazard and human activities and decisions (e.g., land and water use/management) are intertwined, and those activities can exacerbate or alleviate risk.

Decision-makers in the U.S., who depend upon federal drought assessment tools (e.g., U.S. Drought Monitor, U.S. Drought Portal), are concerned about drought impacts on systems that differ in their ecological, economic, cultural, or other sensitivities. One way to provide actionable information about drought is to provide assessments that better capture the drought risk across these systems. Assessing drought risk is complex due to the variations in on-set (slow to fast), duration and extent of drought. Additionally, droughts can be compounded by the co-occurrence of other hazards (e.g., heatwaves, wildfires, flooding). These pose both direct and indirect impacts which can accumulate, affecting livelihoods and having deleterious impacts or consequences to individuals, communities, and systems. The biophysical and human context together determine the impacts of drought. Assessing drought risk is complex, and not all impacts are easily measured or quantified. Importantly, drought does not need to reach extreme levels, to have extreme risk, due to compounding impacts. Thus, drought risk requires an iterative approach that accounts for communities (e.g., infrastructure, water conveyance), economic livelihoods, and ecosystem services. These risk assessments need to be linked to vulnerability assessments to best understand those most at risk and levels of coping and capacity to respond and adapt. These risk and vulnerability assessments are needed for informed decision-making and the development and prioritization of actionable information. Drought risk is dynamic and is intended to acknowledge and account for non-stationarity in both the biophysical and human contexts. Improving drought risk assessments calls for identifying and quantifying the whole cost of drought, across social-ecological systems. Tools to address drought risk and promote adaptation can be utilized for those sectors at greatest risk. Tools like decision calendars can clarify timescales for decisions and periods where resources, crops, animals, or sectors might be at greater risk. Drought risk assessments and drought conditions need to be better linked to resource management decisions and decision calendars to inform how and when to provide more actionable information. Climate reference periods used for drought assessment can be adaptable and based on the experience of producers, water managers, forest managers, communities, etc. during drought.

Priority Actions:

1. Integrate the effects of land use and water management practices (historic, status-quo and adaptive) into drought risk assessments. For example, soil degradation and depletion of organic matter can lower water infiltration rates, soil storage capacity, and groundwater recharge rates potentially exacerbating the impacts of drought and enhancing drought risk.
2. Examine factors contributing to the adaptive capacity of a community, sector, or system to inform an appropriate selection of period of reference for drought assessment.
3. Conduct focus groups with urban and rural planners, resource managers and sociologists, agricultural and labor economists, and other interested social scientists to develop a more informed human dimension of drought effects.
4. Develop methods for addressing observation and information gaps, including capturing data from other knowledge systems, synthesis and summaries of information from disparate sources, and methods for integration of non-digital and analog data and information.
5. Conduct a review or study on how people perceive drought and aridity across sectors and regions. Specifically, identify modalities in reference periods and seek to determine how region, sector, and personal experience, memory, and knowledge influence perceptions of drought.
6. Fund impact-focused research to evaluate indicators in the context of adaptation practices and shifts due to climate change, given that these shifts can result in additional risk.

Research Questions:

1. What geographically and culturally-relevant techniques can identify, contextualize and classify dynamic drought risk?
2. What are the variations in personal perceptions of drought and aridity and how do these perceptions vary across regions, sectors and experience with drought? Do factors like safety nets, community support, communication methods, etc. play into drought perception? Can personal perceptions inform reference period selection for drought assessment?
3. What are the spatial, temporal and sectoral variations in drought risk assessments? What are the drought indicators and early warning signs of drought, used in these variations?
4. What facets of risk (hazard, exposure and vulnerability) are transforming with respect to a changing climate and environmental context (e.g., land degradation)? How does this transform decision-making with respect to population growth, agriculture, and land and water use changes?
5. Can socially-relevant, temporally and spatially analogous drought events be defined to help communities understand their drought risk? Can sector-specific and community-specific drought analogs be used to inform decision-making?

6. Would climate analogs—places and times globally that are climatologically similar to future conditions—assist in illustrating drought risk and potential mitigation strategies when planning for future change?
7. How can current understanding of climate non-stationarity be incorporated into assessments of extreme events of the past to better understand current and future risk? Can paleoclimate records provide a better understanding of past variability and drought to strengthen our understanding/detection of current non-stationarity?
8. What is the timeline for disseminating drought information to best support robust decisions and resource management actions on the ground? How does this vary by sector (e.g., municipal, agricultural, recreational, ecological)?

HIGHLIGHT: IMPACT-BASED MONITORING OF DROUGHT AND ITS CASCADING HAZARDS

Recent studies have highlighted the importance of integrating drought impact monitoring into drought-related hazard assessments (AghaKouchak et al., 2023). This shift to assessments focused on impacts more closely link drought to physical or societal impacts such as crop yield, food security, energy generation, while connecting drought to compounding or cascading hazards such as heatwaves, wildfires, floods and debris flows. Impact-based monitoring of drought can improve drought assessment to be more relevant to stakeholders and decision-makers involved in drought planning and response. Impact-based monitoring accounts for the impacts to different systems that are often not included in approaches used in the past, and more closely links assessment to the whole social-ecological system, from personal experiences to ecosystem impacts. Furthermore, accelerating and improving the integration of impacts into drought assessment is dependent on collection of consistent impact data across sectors and communities. This approach provides the opportunity to address some of the concerns about gaps in observation systems and *in-situ* monitoring data. Moving to impact-based monitoring would also open up the possibility of linking forecasts and outlooks to projected impacts, improving assessments of drought risk and communication, and education and support for adaptive strategies to improve drought mitigation and whole systems resilience.

There are various advancements highlighted in this report to implement impact-based monitoring. Progressing beyond a reactive approach to drought response to proactive drought risk management, can reduce harm and future risk, while creating resilience to the changing nature of drought as a hazard. Various adaptive measures offer opportunities for building future drought resilience which include linking early warning systems to impacts; understanding the role of resource management with water supply dynamics, availability and demand; standardizing data; and using artificial intelligence. These cross-cutting themes can be encompassed with improvements to impact-based drought monitoring, while other new data science approaches can extract and synthesize data on physical and societal drought impacts. Moving toward impact-based drought assessment to support informed decision-making will depend on addressing the research needs articulated in this report as well as current challenges with assessment approaches that are exacerbated by climate change.