BAMS
Essay

Equity, Justice, and Drought

Lessons for Climate Services from the U.S. Southwest

Christina Greene and Daniel B. Ferguson

KEYWORDS:
Social Science;
North America;
Drought;
Climate services

ABSTRACT: Drought is a complex hazard, with many interconnected impacts on environment and society. Droughts are difficult to monitor as they are slow-moving events with impacts that are not always visible. There is an increasing call to study and monitor droughts as a human–environment process and to provide climate services that can inform proactive decision-making on drought. While climate services strive to make droughts visible and therefore manageable for society, many of the equity issues that arise during periods of drought remain largely invisible. In this article we explore inequity in drought impacts in the U.S. Southwest, focusing on agriculture, household water security, and wildfires. Drawing from lessons in the literature on equity, environmental justice, and climate services as well as our experience researching drought impacts in the Southwest, we recommend that climate services can support drought decision-making that addresses equity issues by 1) integrating both physical and social dimensions of drought in climate services, 2) investing in engagement and trust building with diverse communities, and 3) better integrating place-based knowledge to reconcile scaling challenges. With the acceleration of the warming and drying of many parts of the world, there is an ever-increasing need to focus on reducing inequities in drought preparedness and response, which we propose starts with production of drought information that is more reflective of how droughts are experienced across all parts of society.

https://doi.org/10.1175/BAMS-D-22-0185.1
Corresponding author: Christina Greene, cgreene@arizona.edu
In final form 11 August 2023

AFFILIATIONS: Greene—Climate Assessment for the Southwest, The University of Arizona, Tucson, Arizona; **Ferguson**—Climate Assessment for the Southwest, and Department of Environmental Science, The University of Arizona, Tucson, Arizona

The U.S. Southwest is facing significant, long-term threats from increasing aridity (Cook et al. 2015; AghaKouchak et al. 2015). As the region continues to dry, the risks that arise from periodic droughts are also increasing (Overpeck and Udall 2020), raising the stakes substantially for drought preparation, mitigation, and response activities. Because drought is a complex hazard that is slow moving and impacts a range of social and ecological systems on different temporal and spatial scales, it is notoriously difficult to define (Redmond 2002), monitor (Bachmair et al. 2016), and ultimately manage. In the face of this complexity the climate research and climate services communities tend to rely on drought indicators that are primarily focused on availability of moisture in a given system. How systems respond to dry conditions—drought impacts—has proven to be a much more difficult to monitor (Meadow et al. 2013; Lackstrom et al. 2013; Bachmair et al. 2016). The concept of climate services is commonly conceived of as the provision of climate data and information designed to improve decision-making (Vaughan and Dessai 2014). In the case of drought, the development of climate services that can directly inform a wide range of decisions is limited without a better connection between dry conditions and societal impacts.

There are a variety of climate services available in the Southwest that are designed to help people, private industries, and governments plan for and manage drought. First among these is the U.S. Drought Monitor (USDM), which is a weekly map depicting drought conditions across the United States that is collaboratively developed by a group of regional weather and climate experts (Svoboda et al. 2002). The USDM is explicitly designed to integrate multiple drought indicators, reflect regional perspectives, and depict multiple drought time scales. Two USDM affiliated products—the Drought Impact Reporter (Smith et al. 2014) and the Community Collaborative Rain, Hail and Snow (CoCoRaHS) network's recent implementation of drought impacts monitoring (Lackstrom et al. 2017)—further aim to provide information of on-the-ground drought impacts, though neither has yet been widely adopted in the Southwest. While the USDM, the Drought Impact Reporter, and the CoCoRaHS network are all well-established climate services, they are nonetheless limited in their ability to depict the full range of drought conditions or impacts. Because the USDM is used as a trigger for some U.S. Department of Agriculture drought relief programs (Rippey et al. 2021), it is a climate services product that has been directly informing relief funding decisions across the United States (including in the Southwest) since 2008, though only for a narrow range of people and systems impacted by drought.

The generally narrow depictions of drought by the climate research community too often mean that climate services have significant blind spots in terms of who is impacted and how they are experiencing drought. A wide range of environmental inequities therefore arise because many of the impacts of drought, especially among disadvantaged communities, are typically invisible to the scientific community. As social science researchers working with the Climate Assessment for the Southwest (CLIMAS), a NOAA Climate Adaptation Partnership (CAP)/Regional Integrated Science and Assessments (RISA) program, we witness the ways in which drought unjustly impacts some households and communities more than others in the

Southwest. In this essay we draw from our research experience and a review of the drought literature to highlight drought inequality in agriculture, water security, and wildfire in the region. Guided by Lemos and Dilling's (2007) challenge to address equity concerns in climate services, we argue that climate services for drought should seek to reveal and integrate previously invisible impacts. We offer a practical set of recommendations for drought climate services that we believe can help a wider range of people in the region adapt and thrive in the coming decades.

Climate services, equity, and justice

Equity and environmental justice are key concepts for planning and implementing socially just climate responses (Klinsky et al. 2017). Though often used interchangeably in the climate literature, the terms equity and justice have different implications for planning, implementing, and evaluating climate actions (Ikeme 2003; Chu and Cannon 2021). Equity in climate adaptation describes the equal access to environmental goods and services regardless of identity or background (Ikeme 2003; Chu and Cannon 2021). In climate services, equity denotes the equal distribution of and access to climate data and information that can inform decision-making. Environmental justice, on the other hand, recognizes that marginalized groups are disproportionally vulnerable to climate impacts and risks due to structural racism and discrimination that limits their cultural, political, and socioeconomic rights (Shi et al. 2016; Chu and Cannon 2021). Justice in climate services requires understanding the root causes behind the vulnerabilities of minority groups and addressing institutionalized inequities that limit access to climate data and information useful for making decisions that affect their well-being (Tripati et al. 2024).

Questions around equity and justice in climate services initially arose with the development of seasonal climate forecasts. The increased skill in El Niño–Southern Oscillation (ENSO) forecasts in the 1980s opened new possibilities for climate information to guide decision-making and reduce societal impacts from the associated El Niño and La Niña weather phenomena. The production and distribution of these seasonal climate forecasts was prioritized by the international community as a tool for decreasing the devastating impacts of ENSO-related droughts and floods in countries with populations vulnerable to these hazards (Broad et al. 2002; Lemos and Dilling 2007; Pfaff et al. 1999). However, the distribution of the forecast did not lead to equitable benefits for all groups and communities. Many underserved groups did not have access to the forecasts or resources to respond to a forecast (Archer 2003). In Peru, where fish stocks decline under El Niño conditions, fishing companies laid off fishermen in response to forecasts (Broad et al. 2002). In northeastern Brazil, drought forecasts encouraged banks to deny credit to small farmers ahead of the planting season (Lemos 2003). From the uneven experience with the distribution of seasonal climate forecasts, Lemos and Dilling (2007) challenge climate services with two equity and justice questions: 1) Are disadvantaged communities benefiting from climate services, and 2) are climate services reinforcing or increasing inequality?

Despite the early scholarship highlighting disparities in access to climate information and limits to the positive outcomes from that information in many communities, equity and justice remains largely overlooked in the current proliferation of climate services (Lugen 2020). Climate service efforts have largely focused on providing more refined data instead of leading to decisions that increase societal benefits (Findlater et al. 2021). The questions raised by Lemos and Dilling (2007) remain central to understanding equity and justice in contemporary climate services. Unequal access to and participation in climate services continues to lead to unequal benefits. For example, Furman et al. (2014) found that as a result of the legacies of slavery and racism, African American farmers in southeastern United States have been traditionally excluded from cooperative agricultural extension services and continue to lack access to appropriate climate services. Another study—which involved interviews with Tribally affiliated respondents—concluded that while there are benefits for Tribes that collaborate with climate service organizations, collaborations can also be potentially harmful as they can undermine Tribal sovereignty, appropriate Tribal data and knowledge, and conflict with Tribal values, priorities, and ways of knowledge development (Kalafatis et al. 2019). These and many other examples in the United States and abroad lead to questions around the neutrality of climate services (Vaughan and Dessai 2014), and the role of climate services in reproducing and reinforcing vulnerabilities and inequities (Nost 2019). Building modern equitable climate services, therefore, requires close attention to who is most impacted by climatic conditions, how those communities value and use information provided by the scientific and operational climate services communities, and addressing structural inequities that often prevent marginalized groups from benefiting from climate information.

Drought and inequity in southwest United States

The U.S. Southwest, as outlined by the U.S. National Climate Assessment (Gonzalez et al. 2018), includes the states of Arizona, California, Colorado, New Mexico, Nevada, and Utah. With the hottest and driest climates in the United States, droughts are common events that can last months to years (Steenburgh et al. 2013). The region boasts significant social and cultural diversity, encompassing approximately one-third of the U.S.–Mexico border and is home to 182 federally recognized Tribes that live in and manage a large portion of the landscape. This diversity carries with it the historical legacies of colonization and socioeconomic marginalization based on race, ethnicity, and gender that continue to shape how people experience drought in the Southwest today. For example, many of the Indigenous communities in the region were forcibly displaced to areas with limited rainfall and poor water access (Redsteer et al. 2013). The border region between Mexico and the United States has high rates of poverty, water insecurity, substandard housing, and health inequalities (Wilder et al. 2013). The Southwest is also home to many small rural communities that are dependent on agriculture and other climate vulnerable livelihoods (Gowda et al. 2018; Theobald et al. 2013). These and other structural inequalities create a “climate gap” in the Southwest, whereby disadvantaged communities experience disproportionate climate impacts (Wilder et al. 2016). This climate gap is not only unjust, but also often rendered invisible by drought science and climate services communities. Below we briefly highlight three areas where social inequities translate into disproportionate drought experiences in the Southwest: agriculture, household water security, and wildfires.

Drought and agriculture. When considering the effects of drought on agriculture, it is critical to consider not only the amount of food grown and economic loss, but also the impacts on a system where people do not have the same access to natural resources and income. The production of drought information for agriculture is often produced for conventional farmers and ranchers, while overlooking the broader impacts of drought on different groups within agriculture. The land dispossession of Native Americans, enslavement of Black Africans, and structural discrimination against immigrants and women created significant inequities in agriculture that continues to shape unequal access to land, water, and agricultural support and services (Schelhas 2002; Minkoff-Zern and Sloat 2017; Curley 2019; Waddell 2019). Horst and Marion’s (2019) analysis of U.S. agricultural census data from 2012 to 2014 demonstrated the stark disparities according to race, ethnicity, and gender that remain within agriculture. White people owned 98% of farmland and made 98% of farm-related income. Meanwhile, farmers of color were more likely to operate smaller farms, lease instead of own land, and generate less income. These racial disparities in access to land and natural resources in agriculture translate into more severe drought impacts for groups farming with more limited resources.

The drought experiences of farmworkers are an example of the disproportionate and often invisible impacts of drought within agriculture. During California's 2012–16 drought, farmers in the San Joaquin Valley were largely able to adapt by increasing groundwater pumping and switching to high-value crops (Faunt et al. 2016; Tortajada et al. 2017). On the other hand, a study in the region reported drought impacts on employment, health, and well-being of farmworkers (Greene 2018). Due to language barriers and concerns over work authorization status, many farmworkers were not able to access social services and drought assistance programs (Greene 2021). The drought vulnerability of farmworkers has also been documented in Arizona, where farmworkers are often unable to access health care and food assistance during times of unemployment during droughts (Vásquez-León 2009). Indigenous farmworkers from Mexico and Central America, many who do not speak Spanish, experience significantly more barriers in accessing services and assistance (Holmes 2013; Méndez et al. 2020; Vásquez-León 2009).

The 2012–16 California drought also highlighted inequities in drought experiences among urban farms. Urban agriculture is promoted as a site of social and environmental justice that can increase access to healthy food in urban environments for marginalized communities (Horst et al. 2017). Diekmann et al. (2017) found that the drought had uneven impacts across urban farms and gardens, depending on how different water retailers responded to drought conditions. Many community gardens faced increased water prices and outdoor watering restrictions, impacting their ability to grow food.

The equity challenge for climate services in agriculture is to develop new ways to monitor drought that accounts for the unequal ways in which drought impacts minority farmers, urban farmers, and farmworkers. There is a need for drought climate information that considers disparate experiences and accounts for multiple languages, cultural contexts, and access to internet and technology.

Drought and household water security. Drought climate services have the potential to highlight and mitigate equity and justice concerns in household water security in the Southwest. There is a growth in studies examining water insecurity in the United States that centers the ways in which water inequality is shaped by race, ethnicity, and class (Jepson and Vandewalle 2016; Meehan et al. 2020; Wescoat et al. 2007). Household water security is multidimensional and includes not only water access (physical access, affordability, and reliability), but also water quality and emotional and cultural relationships with water (Jepson 2014). The lack of a plumbed connection to potable water is one of several ways that water insecurity is experienced by a household. A study by Deitz and Meehan (2019) examined the spatial and sociodemographic distribution of households lacking a plumbed connection to potable water in the United States. Their work identified several hotspots of "plumbing poverty," which are shaped by race, ethnicity, and class. Within the Southwest, these hotspots include Indigenous households in Arizona and New Mexico, Hispanic households along the U.S.–Mexico border, renters in California, and mobile homes in Colorado and New Mexico. The Southwest also has an unequal distribution of access to safe drinking water, with many communities of color reliant on small water systems and private wells that frequently do not meet water safety standards (Balazs and Ray 2014; Christian-Smith et al. 2012; Pace et al. 2022a).

Drought impacts on household water security in the United States occur through two main pathways: 1) groundwater depletion affecting water availability and quality for households dependent on private wells and 2) water availability for community water systems

(Mullin 2020). In the Southwest, drought can create and exacerbate existing household water insecurities, especially for rural households dependent on private wells. For example, water insecurity in California's Central Valley is shaped by a combination of hydrogeology, contamination of groundwater from agricultural fertilizers, and a history of policies that excluded communities of color from access to drinking water and other municipal services (Balazs and Ray 2014; Pannu 2020). Today there remains significant racial and ethnic disparity in access to safe drinking water in the region (London 2021; Pace et al. 2022a). During the 2012–16 drought, increased groundwater pumping for agriculture led to water shortages and well failures for households and small water systems (Jasechko and Perrone 2020; Pauloo et al. 2020). Affected households in the region struggled with water access and subsequent impacts on health and well-being (Greene 2021, 2018). The impacts of the drought on water security were not limited to the Central Valley: small drinking water systems that serve rural communities faced significant challenges in responding to the drought (Klasic et al. 2022) and low-income households in urban centers struggled with increase drought charges on water (Feinstein et al. 2017).

Residential water quality is an understudied impact of drought. In New Mexico, testing of household wells along the southern New Mexico border indicated an increase in concentration of harmful contaminants during a drought (Ward et al. 2017). Concerns around drought and water access and quality are also prevalent among Tribes in the Southwest, where seizure of Tribal lands and water resources along with a lack of investment in physical infrastructure leads to enduring water insecurity today (Wilson et al. 2021). Drought amplifies challenges for Tribes that contend with Tribal water rights litigation, water diversions, and contamination from mining, industry, and agriculture (Chief et al. 2016; Cozzetto et al. 2013).

Existing drought climate services such as the U.S. Drought Monitor focus on impacts on water at a regional scale—portraying drought as a uniform event that spans counties and watersheds. However, the distribution of potable water to households is not an equitable process, one that becomes even more disparate during dry periods. Drought climate services can further illuminate the uneven ways in which drought disrupts unequal water systems by increasing focus on disparate impacts on households within the same community. By doing so climate services can help support drought responses from community to the federal scale as well as preparation in areas that might otherwise be overlooked.

Drought and wildfires. Increasing wildfire risk in the Southwest requires a more concerted effort to develop drought climate services that consider equity and justice within a much broader range of impacts and impacted groups than in the past. The wildfire regime across the West—and specifically the Southwest—has been shifting substantially over the last three decades, with the frequency, size, and intensity of fires increasing (Iglesias et al. 2022; Wasserman 2020). Recent research has shown that although the majority of people most exposed to wildfire risk have reasonability high levels of capacity to respond and recover (Palaiologou et al. 2019), there are many groups with limited adaptive capacity who are at far higher risk of significant negative outcomes to wildfire events (Collins and Bolin 2009; Davies et al. 2018; Méndez et al. 2020; Pierce et al. 2022). For example, undocumented workers, renters, uninsured homeowners, low-income residents unable to afford traditional mitigation options, and residents of low-quality homes are all far more likely to experience severe or even devastating impacts from a wildfire than their neighbors with more resources and better access to information and services. Outdoor workers and socially vulnerable groups are often disproportionally exposed to health impacts from wildfire smoke (Méndez et al. 2020; D'Evelyn et al. 2022).

A major component of wildfire environmental justice is "equal and meaningful access to environmental information and participation in decision making" (Thomas et al. 2022, p. 4).

Traditional drought climate services as they relate to wildfire have primarily been focused on forest managers, wildfire planners, and wildfire responders. However, environmental justice concerns in wildfire risk management remain largely overlooked (Adams and Charnley 2020; Martinez et al. 2023). There is a much broader spectrum of citizens and professional groups who would benefit from a more targeted and inclusive set of climate services for wildfire preparation and response. Targeted climate information about seasonal patterns and long-term trends as well as nuanced communication about the uncertainty in both climate modeling and weather and climate forecasting all have potential value to inform development of more wildfire-resilient communities. With the diversity of wildfire regimes across the Southwest, localized information on the impact of a changing climate on wildfire risk is vital for developing community wildfire planning (MacDonald et al. 2023).

One venue to bring a more inclusive set of climate services to the table is in the development and implementation of community wildfire protection plans (CWPPs). Common in the U.S. West since the early 2000s, CWPPs provide the opportunity for diverse input into how a community should plan for and respond to wildfires (Palsa et al. 2022). In practice, there are indications that these planning processes and products do not fully engage with groups that may be most at risk of significant impacts from wildfire, including non-English speakers and communities with high poverty rates (Ojerio et al. 2011). CWPPs may not be useful in all communities (Bennett 2022) and may be propagating homogeneity in fire planning by promoting standardized wildfire protection actions instead of promoting community involvement and responding to local social and environmental vulnerabilities (Abrams et al. 2016). CWPPs can be strengthened with the inclusion of information on how drought and climate will impact future fires instead of relying on past wildfire regimes. Climate services that fully engage the groups who are most vulnerable to wildfire risks in development and implementation of efforts like CWPPs can lead to more resilient social–ecological systems and greater equity in the resources available to protect and support those in fire-prone areas.

Social and economic inequities frame drought experiences across agriculture, household water security, and wildfire in the Southwest. Across these three examples, drought climate services largely fail to depict the ways in which some households and communities—largely communities of color that have been politically and economically marginalized—bear the disproportionate impacts of drought. To meet the information needs of people and governments seeking to address inequities in drought experiences and support more climate resilient communities, drought climate services need to transform to become more interactive, engaged, and responsive to equity and justice concerns in drought experiences. The production and distribution of drought information is not enough; climate services need to be designed and evaluated specifically to address equity and justice concerns.

Recommendations for improving drought climate services

We make three recommendations for climate services to inform decisions in drought planning and drought assistance that center equity and justice.

Integrate both physical and social dimensions of drought in climate services. Drought experiences vary between and within communities due to social, political, and economic relationships. Drought climate services, especially drought monitoring, continues to be dominated by physical indicators of drought that do not connect drought impacts with societal impacts or the multiple ways that social and economic processes produce and amplify drought (AghaKouchak et al. 2021; Bachmair et al. 2016; Savelli et al. 2022). The focus on drought as a physical process leads to mismatches between drought information and how drought is experienced by people (Goldman et al. 2016; Kchouk et al. 2022). For example, during research on the impact of the 2012–16 drought on farmworker communities a local government official pointed to the difficulty in securing drought relief for households when drought maps depicted that the drought was over (Greene 2018). While the region was no longer in a "meteorological drought," many households and communities were still struggling with access to water. Depictions of drought based on physical data alone also make drought appear to be a homogeneous process across space, obscuring the unequal ways in which drought is experienced (Savelli et al. 2022).

As Findlater et al. (2021) point out, the "integration of social science is not a panacea for demand-driven climate services but a prerequisite" (p. 736). Social science does not guarantee that climate services will allow for better decisions around drought, but climate services are unlikely to improve without understanding the perceptions, behaviors, and decisions being made in response to drought. Social science research can also reveal how social and economic processes redistribute drought risks and impacts, which can lead to disproportionate drought impacts. There are a variety of frameworks, approaches, and methods in the social sciences that can illuminate the societal dimensions of drought such as participatory action research (Vadjunec et al. 2022), rapid assessments (Clifford et al. 2022), local climate knowledge (Clifford et al. 2020), political ecology (Kaika 2003; Shah et al. 2021), coproduction of climate knowledge (Meadow et al. 2015; Vincent et al. 2018), intersectional experiences with climate (Carr and Owusu-Daaku 2016; Walker et al. 2019), critical physical geography (Beray-Armond 2022; Lave et al. 2014), and Indigenous knowledge (Ifejika Speranza et al. 2010; Long et al. 2021; Nyong et al. 2007). Additional interdisciplinary approaches and frameworks combine physical drought data with critical social analysis to examine equity within the context of climate, such as the works of Savelli et al. (2022) and Rusca et al. (2023). These different frameworks can enable climate services to reveal hidden societal experiences, expose the root causes of inequity in drought, and allow climate services to empower disadvantaged communities with relevant climate information.

Integrating both physical and social science approaches to drought allows for the production of climate information that informs decision needs, especially for communities bearing high impacts of drought. Collaborative work between the Hopi Tribe in Arizona, social scientists, and physical scientists created a drought information system that integrated Indigenous expertise, local drought observations, and physical drought indicators such as precipitation (Ferguson et al. 2016). This transdisciplinary approach to drought was guided by the expressed needs and decisions being made by the Hopi Tribe Department of Natural Resources. Similarly, the Community Water Center, a community-based organization active in water and equity in California, partnered with social science researchers to engage with and understand the information needs and experiences of disadvantaged communities concerned with water quality and drought access (Pace et al. 2022b). The collaboration resulted in the Drinking Water Tool (https://drinkingwatertool.communitywatercenter.org/) that depicts potential impacts on groundwater supply from different drought scenarios for vulnerable communities. In these examples, climate services integrated both physical and social approaches to drought to empower groups who traditionally have been excluded from drought science.

Invest in engagement and trust building with diverse communities. The climate services literature increasingly emphasizes the need for higher levels of engagement between scientists and those in the broader society who can benefit from climate services (Andersson et al. 2020; Bojovic et al. 2021; Bruno Soares and Buontempo 2019; Daniels et al. 2020; Steynor et al. 2020). Generally that literature advocates for and provides evidence of the efficacy of transdisciplinary approaches to climate services (Steynor et al. 2020). The emphasis is frequently on the importance of building trust in transdisciplinary processes (Harris and Lyon 2013), which provides a necessary foundation for development of collaborative and—ideally—socially impactful climate services. Because of the complexity of drought as a phenomenon and the differential and often hidden impacts, development of practical and impactful drought information can especially benefit from more engaged approaches, including those that focus on building collaborative communities of practice that recognize and value different sorts of expertise and experience (Owen et al. 2019). Therefore, we propose that development of more equitable and ultimately impactful drought climate services in the Southwest should be built on contemporary approaches that engage directly with diverse groups in society who may benefit from drought information. The focus should shift toward a collaborative knowledge development framing and away from the traditional division between "providers" and "users" that is common in existing climate services development and provision (Bojovic et al. 2021; Daniels et al. 2020).

Moving toward a more engaged, process-based drought climate services framework creates opportunities for positive outcomes that go far beyond typical outputs like datasets, web-based tools, and information products. Societal impacts research has consistently demonstrated that a narrow view on outputs rather than outcomes (e.g., a broad range of impacts from the collaboration) misses significant benefits like collective learning, capacity building, and enduring connectivity among collaborators (Edwards and Meagher 2020; Muhonen et al. 2020). However, engaged science—especially when the goal is to work with typically underrepresented and historically disadvantaged communities—requires a commitment to respectful interactions, humility, and a robust ethical framework that recognizes power differentials and the limited time and other resources of nonacademic partners (Wilmer et al. 2021). Recent research that has looked closely at interactions between climate researchers and Indigenous communities has highlighted the persistence of extractive and potentially disruptive approaches that are a burden rather than a benefit to those communities (David-Chavez and Gavin 2018; Kalafatis et al. 2019). Those who seek to develop equitable and impactful drought climate services in the Southwest must learn these lessons and ensure that their work does not propagate unjust and inequitable outcomes, but rather creates opportunities for collaborative knowledge development that is built around respect and collective insight.

Better integrate place-based knowledge to reconcile scaling challenges. Matching spatial and temporal scales of climate services to the challenges people face on the ground represents a significant challenge for developing equitable and useful drought information to support community decision-making. Drought indices like the standardized precipitation index (SPI) can show multiple temporal scales and therefore capture some information about short- versus long-term dry conditions. However, in practical terms SPI is only able to present different ways of visualizing precipitation, not the way that precipitation deficits are experienced in various social and natural systems. Accurately capturing on-the-ground drought impacts at meaningful spatial scales is similarly difficult, with years of research highlighting the need for reliable and consistent monitoring of local drought impacts (Kchouk et al. 2022; Lackstrom et al. 2013; Meadow et al. 2013).

Overcoming the challenges of providing drought information at a scale that is relevant for local decision-making requires moving beyond traditional notions of scaling down data and toward a more place-based approach to knowledge development. While still not common, there are examples of committed work to integrate local and western scientific knowledge to better support both local decision-making and basic understanding of weather and climate conditions. For example, in the Canadian Arctic a long-term project has brought together Inuit community members with researchers to collaborate on integration of knowledge about local weather and climate to both advance knowledge of global change and support local decisions (Fox et al. 2020). In the context of drought, a recent project in Uganda demonstrated that local farmers' knowledge adds significant value to scientific forecasts, leading the researchers to "recommend that improved climate science and seasonal forecasting directly engage with local knowledge systems in the creation and dissemination of climate information" (Salerno et al. 2022, p. 678). Building on our recommendation above to focus drought climate services development on process and local engagement, we further suggest that recognizing and reckoning with scale mismatches in drought data and information requires a focused effort by the climate services community to both develop and integrate place-based knowledge. Development of contextual knowledge of the human and natural systems in the region(s) in which their research may be useful can be an important tool for researchers seeking to generate socially impactful knowledge (Ferguson et al. 2022). Beyond scaling issues, researchers' context knowledge can be useful for understanding how specific analyses might lead to significant societal outcomes. For example, a group of researchers seeking to better understand the relationships between air temperature and streamflow in the Southwest intentionally built on their long-term relationships with regional water management professionals to situate their research in the processes and ways of thinking about the hydrological system common among those practitioners. The result was a set of analyses that utilized a metric common in water management, but not common in hydroclimate research—runoff efficiency—that was directly meaningful to the practitioner community (Woodhouse et al. 2021). The contextual knowledge within the research team allowed them to look beyond their own scientific expertise and experiences and understand that their research will have far more utility and potential impact if they carry out analyses that are directly meaningful to the practitioners with whom they work. We recognize that there is a cost in the level of local engagement we suggest, but in the examples above the benefits of engagement included more uptake of the science that should lead to better societal outcomes.

Conclusions

Drought science is increasing engagement with drought as a human–environment event. However, drought climate services often overlook existing societal inequities in the experiences of drought. The disproportionate drought impacts in agriculture, water security, and wildfire for disadvantaged communities in the U.S. Southwest underscores the need for climate services to continue to engage with the challenge posed by Lemos and Dilling (2007)—Are disadvantaged communities benefiting from climate services? To help support communities who have been historically left out of climate knowledge development requires those working to develop climate services to see drought through multiple lenses and at different scales. It also requires respectful and ethical engagement *with* communities in ways that empower and inform decisions of disadvantaged communities instead of producing yet more data *about* disadvantaged communities. Greater integration of social science, investment in community engagement and trust building, as well as development of multiscalar place-based knowledge are three ways in which drought climate services can integrate equity and justice issues in drought climate services.

Acknowledgments. This work was supported by the National Oceanic and Atmospheric Administration's Climate Adaptation Programs, formerly the Regional Integrated Sciences and Assessments (RISA) program, through Grant NA17OAR4310288 with the Climate Assessment for the Southwest program at The University of Arizona.

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