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Drought-Stricken U.S. States Have More Comprehensive Water-Related Hazard Planning

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Abstract
Despite the devastating impacts of droughts, the United States lacks a national drought plan. This leaves states to address droughts in water, hazard, and stand-alone plans which are designed to reduce drought vulnerability and to prepare government, industry, and society to cope with the impacts. Yet, there is limited empirical research that evaluates the comprehensiveness of these plans, specifically in terms of whether they include preparedness and mitigation measures or triggers for action and response. To fill this gap, this study's first aim was to establish an evaluation framework based on principles from the drought mitigation literature. The study then evaluated 171 state-level plans with the framework, and simultaneously collected interview data to contextualize the results. In a final step, the scores were employed in a statistical analysis of whether states with higher physical exposure to drought have more comprehensive planning. The study finds states that have experienced more frequent and severe drought plan more comprehensively, suggesting that the occurrence of drought may be an intrinsic driver for planning. The study concludes that planning and preparing for droughts is a necessary but complex undertaking requiring interdisciplinary, interagency efforts that the U.S.' decentralized, federalist political system is suited to address. If generalization is warranted, the results suggest that the physical occurrence of drought can act as a policy catalyst.

Keywords Drought exposure · Decision making triggers · Drought hazard planning · Water policy · Drought preparedness · Drought mitigation

1 Introduction

Droughts are expensive and disruptive natural disasters, second only to tropical cyclones, accounting for $249.7 billion in adjusted losses for the United States (U.S.) between 1980 and 2019 (NOAA NCEI 2020). In the last century, warming has been linked with disruptions to the water cycle, and anthropogenic drivers such as land use change have made

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droughts longer and more intense; unfortunately, this is expected to worsen (Dai 2011; van Loon et al. 2016). Communities in the U.S. tend to react with short-term responses to drought, rather than using longer-term proactive measures to reduce future drought vulnerability (Jedd 2019). This sets up a risky situation, especially for the western U.S., which now faces aridification due to increasing temperatures (Overpeck and Udall 2020). Planning for drought is key to protecting communities, ecosystems and economies from devastating losses (Tsakiris 2017; Wilhite et al. 2005).

Drought mitigation reduces the likelihood that droughts will become disasters. Examples of mitigation measures include early warning systems, improved short-term/seasonal water forecasts, water demand reduction or conservation, additional water supply infrastructure (groundwater extraction or reservoir storage), community connection to public water systems, and public education programs (Wilhite et al. 2014). Drought planning can involve identifying and reducing overall drought vulnerability (mitigation as outlined in Schwab 2013), or determining which actions will be taken during droughts (response as outlined in Fontaine et al. 2014). Mitigation or response measures are ideally recorded in a reference document stating when they should be employed, and by whom. Relevant decision-makers include public and private organizations such as state governments, environmental agencies and organizations, regional or local resource managers, municipal water suppliers, wildfire managers, public health departments, nonprofits, agricultural producers and equipment dealers, energy and hydropower producers, or recreation and tourism companies (National Drought Mitigation Center 2020a, b).

It is common for state-level planning processes to include inter-sectoral participation. California offers an example of a state where, since 2014, local agencies are required by law to engage multiple types of actors through the use of public hearings (California Department of Water Resources 2022). This type of multi-stakeholder involvement can be complex, and require skilled facilitation, especially when there is uncertainty about water availability (Schramm et al. 2022). The variation in California's climate, terrain, and population centers makes drought planning more critical; the locations and timing of rain and snow are mismatched from where and when water is needed. Generally, precipitation occurs in the northern part of the state and along the Sierra Nevada mountain range during the winter. However, water is needed throughout the state for urban and agricultural needs, especially during the hotter summer months. Dairy, grapes, and almonds are the top-grossing agricultural products (California Department of Food and Agriculture 2020), all of which are dependent on a steady water supply. Cattle and orchards require a minimum amount of water to survive from one year to the next, and cannot be fallow or paused. Groundwater fills this need when surface water is not readily available. However, these groundwater reserves are chronically over-drafted, especially during dry years (Dogan et al. 2019). Recent exposure to drought prompted the major policy shift toward locally-governed groundwater sustainability agencies (GSAs). During the prolonged drought in California from 2011 to 2019,[1] the worst occurring from August 2013 through February 2017,[2] the Sustainable Groundwater Management Act (SGMA) was enacted, requiring GSAs to develop groundwater management plans by 2022 and reach sustainability (to eliminate "overdraft" of groundwater withdrawal rates that exceed replenishment) by 2040 (Hanak et al. 2015). The SGMA-mandated plans in California involve local water users: thus, they have the potential to improve upon

[1] The drought lasted 376 weeks, according to NIDIS https://www.drought.gov/drought/states/california

[2] We describe the most intense period of the drought as the presence of D3 and/or D4 conditions in any portion of the state, as specified by the U.S. Drought Monitor.

the failures of central governmental approaches to prevent groundwater over-abstraction (Molle and Closas 2020). California's planning approach is geared toward preventing over-consumption and preventing conflict between water users during droughts. SGMA is touted as a model for how state law could be used to ensure that local level planning occurs in other states (Kiparsky et al. 2017).

The benefits of drought planning have been established (Wilhite et al. 2000; WMO and GWP 2014), research has shown some form of drought planning to be underway in almost all U.S. states (Fu et al. 2013; Fontaine et al. 2014; Fu et al. 2013), and comparative case studies evaluate the reasons for success and failure (Botterill 2013). Nonetheless, there is a lack of comprehensive evaluation of the quality of plans across the U.S. No study, to our knowledge, has coded drought plan content in a way that makes it possible to comparatively rank the comprehensiveness of all states' drought, water, hazard, and climate plans.

This study describes four types of U.S. drought plans and how they can limit damage. A motivating factor for creating this dataset was to discover whether there is variation and, if so, why some states have a more comprehensive approach to planning for droughts, despite the fact that there is no national-level requirement to do so.[3] The hypothesis is that, though states are not required to plan for drought, they do so because of the threat that it poses to natural resources, the economy and citizens' well-being and livelihoods. In other words, *the study tests whether states with longer and more intense drought (and more damaging impacts) have a higher tendency for comprehensive planning*. Drought planning also has broader benefits that overlap with other issues including water, natural disasters, energy, and climate mitigation/adaptation. Therefore, *the assumption that states will strive for comprehensive drought plans independent of financial resources, i.e., income tax revenues, is also tested*.

Responsibilities for governing water are shared between federal and state agencies. Federal programs provide tax incentives for efficient water use, and subsidies for farmer losses caused by droughts (Stakhiv et al. 2016). Meanwhile, state and local governments are responsible for water delivery and wastewater removal, but share responsibilities like water delivery, dam construction and reservoir management with the federal government (Stoutenborough and Vedlitz 2014). When drought is framed as an agricultural issue, it is possible to have a relatively straightforward set of national policy solutions (for the Australian example, see Botterill 2013). Drought, however, as an American policy issue, goes beyond agriculture to municipal water supply, energy, and ecosystems (Botterill 2013). Therefore, federal, state, and local authority for drought is fragmented. This is supported by a tendency to give states a high degree of independence in natural resource planning. The Western Governors' Association (2018) claims that states are the "preeminent authority on water management within their boundaries," with rights to surface and groundwater management.

Another complicating factor to establishing a national drought policy is regional variation in water availability, drought conditions, risks, and response options (Congressional Research Service 2013). As with other natural resources, water availability varies by state. A state's elevation, climate, groundwater supplies, surface water storage capacity, anthropogenic demand for water, along with underlying environmental, social, economic,

[3] The authors do not wish to imply that there is no national legislation that accounts for drought planning. The Federal Emergency Management Agency (FEMA) does require hazard mitigation planning, of which drought is a component. However, the authors view drought planning as a more comprehensive endeavor that takes place in stand-alone plans, water plans, and climate action plans, in addition to hazard plans.

cultural, and physical factors influence how susceptible a state is to drought (Hagenlocher et al. 2019). State planners have numerous climate datasets at their disposal, including paleoclimate records and seasonal forecasts, and some planners claim that using this data "depoliticizes" actions surrounding drought mitigation (Finnessey et al. 2016). A vast array of data about drought risk (Svoboda et al. 2015), however, does not automatically lead to the political will to plan for this hazard (Botterill 2013). Without a national drought policy, Wilhite et al. (2014) claim that drought management will continue to be reactionary and crisis-driven. Ideally, drought mitigation planning should contain elements of monitoring, vulnerability assessment, and response actions (World Meteorological Association and Global Water Partnership 2014).

The classic 10-step method for drought planning relies on political mobilization (Wilhite et al. 2005). Under this method, the first step is for a state leader, such as the governor, to appoint a drought task force. The task force oversees a drought plan's development and implementation, and makes recommendations when the plan is activated during droughts (Wilhite et al. 2005). This idealized process relies on the individual initiative of a state leader or legislative body, and the willingness of experts and officials to serve on the task force. In empirical evaluations of state drought planning efforts, state plans were found to address emergency response during a drought crisis, but lacked mitigation actions to address the risks of future droughts (Fu et al. 2013). This suggests that some idealized dimensions of drought planning may be more difficult to achieve in practice, due to factors such as the lack of a federal mandate and resource constraints.

2 Establishing an Evaluation Framework and Defining the Dataset

This study establishes a framework to objectively evaluate state plans and then employs it in the analysis of drought related plans for the time period 2000–2021. The evaluation framework was designed with consideration of the key elements that drought plans should contain, using the American Planning Association's (APA) drought guidelines (Schwab 2013), as well as independent consultation with experts in the area of drought mitigation. The APA guidelines include response steps during a drought crisis, but also mitigation steps with an emphasis on land use planning, encouraging conservation and reducing water demand (Schwab 2013).

2.1 The Evaluation Framework

Having a clear drought definition – which enables monitoring – is a pre-condition for assessing which sectors, organizations, and individuals would be vulnerable to drought impacts, so these are the first and second criteria in the evaluation framework. Wilhite et al.'s (2000, 2005) planning process argues for the inclusion of specific preparation measures. This is the third item in the framework. An expert recommendation was to distinguish measures for water supply and water conservation, corresponding to items four and five. The literature on drought planning includes triggers, or pre-set indicator levels for action, which is the sixth item. Results from item 7 show the range of actions that states currently use to respond to droughts.

A final included tenet of drought mitigation planning is that it should be incorporated with other closely related issue areas. A state's drought planning receives a higher evaluation score when it is linked to other issue areas, including water quantity and quality,

climate change, and natural hazards. This puts drought under the directive of a range of agencies including but not limited to natural resource conservation, emergency management, agricultural production, water supply, water quality, hydrological engineering, energy supply, and meteorological and climate monitoring. These linkages were included as items 8 and 9 in the evaluation framework.

To summarize, the evaluation framework considers the following: how drought is described; the given definition of drought; explicit acknowledgement of drought impacts; drought preparation measures; mitigation actions for water availability, conservation and efficiency; indicators linked to actions or measures; response actions; coordination with other jurisdictions, agencies, or plans. For an elaboration, see Table 1.

2.2 Defining the Dataset: Types of State-Level Drought Plans

There are four main plan types with drought-related scope. The institutional design varies, but there is convergence around creating a drought-specific task force in addition to creation of and coordination with other monitoring and planning efforts at the local level within a state. Plans ideally provide a comprehensive overview of a state's natural resources and water supplies, with an indication of water needs from various sectors. Actions are largely voluntary and incentive-based, intended to provide education and assistance (Schwab 2013). Plans may identify and recommend future policy options such as regulations or budgetary allocations for water-related programs (e.g. California Water Plan). These different types of plans indicate an integration with water, climate, and hazard issue areas. Jordan and Lenschow (2010) define environmental policy integration as a process of protecting the environment while also considering economic competitiveness and social development imperatives. Under this definition, the stand-alone drought plan could be seen as weakly integrated, while the hazard planning approach is more fully integrated with the overarching goal of protecting society from costly damages.

Drought-specific plans outline the impacts of drought and ways to manage the risks or losses associated with it, before or after a drought occurs. *Drought mitigation plans* focus on the pre-drought stage. They might consider land use patterns, population distribution and growth, water storage potential, and the needs of vulnerable social groups. Mitigation actions could include a vulnerability assessment that addresses water storage and consumption across sectors, or establishing a task force or monitoring committee (Wilhite et al. 2000). *Drought response plans*, on the other hand, address a specific function of state government: contingency guidance for during or after a drought. These plans may be connected to emergency management and/or water planning procedures and may identify specific actions (e.g. water use restrictions) when drought reaches a certain intensity or extent, according to a pre-identified indicator's threshold (a trigger).

A water plan monitors the supply or quality of water resources within a state. It can also include management rules, but rarely does. A water plan may investigate supply or make conservation recommendations. The focus depends on geographic, climatic, and demographic characteristics. If a state is dependent on snowpack for its water supply, the water plan may include a focus on climate monitoring. If a state has plentiful surface and groundwater, a plan may focus on maintaining the quality of these resources in population centers. A water plan may specify actions if drought threatens water sources, water use, storage, and the ability to meet the population's needs. Information about entities that manage surface and groundwater–like conservation districts, irrigation districts, or public water suppliers–may be included.

Table 1 The plan scoring criteria used in our analysis, and an elaboration of each. The elaboration shows the questions that we used in coding the plans for our dataset

Criterion	Elaboration of the measurement, line of reasoning, and/or data recorded for each criterion	Basis for inclusion
1. Drought Definition	*Does the plan define or describe drought, or how its effects threaten human, natural, or physical assets within the state?*	Lloyd-Hughes (2014)
2. Does it address drought, or outline drought's impacts?	*How does the plan specifically acknowledge or address aspects of planning for drought or its impacts?*	National Drought Mitigation Center (2020a, b), Noel et al. (2020)
3. General Drought Preparedness	*Does the plan include enactable measures to generally be more prepared for drought? Ideally, these measures would be enacted in advance of a drought, and could involve establishing a drought task force, identifying resources for managing and mitigating drought, an action plan, or public education*	Wilhite et al. (2000), Wilhite et al. (2005), (Tsakiris 2017)
4. Mitigation focus on Water Supply	*Does the plan discuss the availability or adequacy of water resources and their ability to meet demand?*	Schwab (2013), Finnessey et al. (2016), Stakhiv et al. (2016)
5. Mitigation focus on Water Conservation	*Does the plan outline strategies for reducing water use, increasing efficiency, or decreasing waste? These could be long- or short- term*	Schwab (2013), Stakhiv et al. (2016)
6. Triggers for action	*Are particular drought indicators connected to actions or measures outlined in the plan?*	Bachmair et al. (2016), Steinemann and Cavalcanti (2006), Fontaine et al. (2014)
7. Drought Response	*Does the plan outline response actions during drought (e.g. reducing demand)? Are reactive measures outlined as a form of pre-planning?*	Western Governors' Association (2018)
8. Coordination with other jurisdictions about drought	*Does the plan bring in multiple organizations across levels?*	Federal Emergency Management Agency (2019)
9. Linkage(s) with other drought related plans	*Does the plan mention other plan documents?*	Stakhiv et al. (2016), Congressional Research Service (2013)

Historically, the stand-alone drought plan has been the focus of the drought planning literature (Wilhite et al. 2014, 2005; Steinemann and Cavalcanti 2006), but over time, other types arose. Federal disaster assistance eligibility is contingent on states having hazard mitigation plans. These plans must be updated and resubmitted every five years (FEMA 2019). A multi-hazard hazard mitigation plan represents a process of engaging agencies from state government to assess and mitigate risks. The plan identifies hazards in a series of profiles, and ideally includes actions to reduce risk from these hazards. Under the Stafford Act (Title III, Sect. 322)[4] states must have these plans to be eligible for increased Federal disaster relief funding (PL 93–288). Hazard plans have a drought profile with impacts of past droughts (except for Alaska), and sometimes includes an assessment of vulnerability to future droughts. The degree to which drought is addressed may depend on how it is ranked or prioritized amongst a range of other natural hazards.

A climate action plan is the newest type to address drought. It considers the impacts of climate change, such as prolonged or more intense drought or increased evapotranspiration. For example, some states are dependent on snow water, and earlier melting or reduced snowpack are causes for concern. A plan could include preparation, adaptation, or mitigation measures such as greenhouse gas emissions reduction and energy conservation. Unlike hazard mitigation plans, climate plans are discretionary (not required) and vary widely. This variation makes it difficult to quantitatively evaluate or compare them.

3 Methods

The framework was used to create an original dataset of plan evaluation scores. This dataset then became the input for investigating the drivers of planning, namely, in asking whether states that have experienced longer and more intense drought have a more comprehensive planning approach. There is also an exploration of the alternative hypothesis related to the existence of a threshold of financial capacity that states need in order to plan. To populate the plan database, plans were collected using web-available resources of state agencies responsible for hazard management, agriculture, environment, water, and natural resources. In some cases, the responsible planners from these agencies were directly contacted. Of a possible 200 plans (four plan types across 50 states), this analysis includes 171 climate, drought, water, and multi-hazard plans.[5] The study period is from January 2000 through June 2021.[6] All plans were scored on the nine framework criteria from the drought mitigation literature (elaborated above in Sect. 2.1). Scores for individual plans ranged from 0 to 9, with an average score of 4.7 across plans. The cumulative score for each plan type is listed in Appendix Table 2.

Additional data were obtained to test hypotheses related to whether experiencing more droughts or having a higher per capita income led to higher planning scores. Average values for each state's drought exposure were compiled using the mean Drought Severity and Coverage Index (DSCI) (Smith et al. 2020) from the National Drought Mitigation Center

[4] The Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 93-288: https://www.fema.gov/media-library/assets/documents/15271

[5] We found that 34 states did not have climate plans, 16 did not have water plans, and 8 did not have current stand-alone drought plans. All states have multi-hazard plans.

[6] We found more planning underway than earlier literature suggests (e.g. in Fu et al. 2013), broadening our reach to hazard, water, and climate plans.

for January 2000–June 2021. These values indicate the average status classification according to the U.S. Drought Monitor, with potential values ranging from 0 to 500 (Akyuz 2017). State income tax revenue data is from the Federation of Tax Administrators (2018).

Inferential statistical analysis in the form of Pearson's r, product-moment correlation, was used to test the relationship between past drought exposure and planning comprehensiveness. Tests were run separately in SPSS and in R open-source software in order to ensure accuracy.

To supplement the statistical analysis, the study includes data from structured interviews with drought planners from five state agencies that either were in the midst of updating their drought plan (2019) or had updated it (2018). These participants are cited anonymously as P1-P5. Two interviews were with planners in the early stages of updating. These are cited anonymously as P6 and P7. E-mail inquiry was used with two other states to check accuracy. These survey respondents are cited anonymously as S1 and S2. All interviews and inquiries were conducted by the lead author.

The curated plans are publicly accessible via an interactive web-based map. Users can click on a state to access plans and the leading agency for drought in the state, contact information for officials, and the most recent Drought Monitor data (Matteson 2020).[7]

4 Results

All states have experienced drought, though there is considerable range. The planning scores also vary greatly. The numerical variation in the input variables allowed for a statistical (correlation) analysis. First, the southwestern states have experienced more drought, on average, throughout 2000–2021 relative to the other states. Arizona, Nevada, New Mexico, Utah, and California have had the most. Some states have had relatively less, such as Alaska, Ohio, New York, Pennsylvania, and West Virginia. For the planning scores, which also vary greatly, coastal and southwestern states tend to be higher, with the exception of Indiana and Missouri, which scored in the top 16%. The plan totals range from 0 in Alaska to 30 in Montana. Maps in Fig. 1 display the input data and the output residuals.

Results show that past drought correlates with planning scores. The top tercile of drought exposure (mean DSCI of 96 or higher) has a higher median planning score (median = 20.2), and none of the states in it scored below 11. In the first and second terciles, the median is 16.5 and 21, respectively. Figure 2 shows the positive correlation, which is characterized by discrete trends within terciles. The spread in the scores in the lower tercile shows some states, such as Indiana, Connecticut, Rhode Island and New Jersey, do not experience as much drought but nonetheless have relatively comprehensive plans. The Pearson correlation coefficient between drought planning scores (excluding climate plans) and exposure to drought is 0.356, significant at the $p < 0.05$ (0.011) level with $t\text{-}statistic = 2.639$, and $df = 49$.

The alternate hypothesis, that a state's tax base can lead to improved planning, was not supported. The top five tax revenue states were North Dakota, Vermont, Hawaii, Connecticut, and New York. These states collected between $4,795 and $5,666 per resident each

[7] This interactive tool is accessible at https://drought.unl.edu/droughtplanning/ under "Information by State".

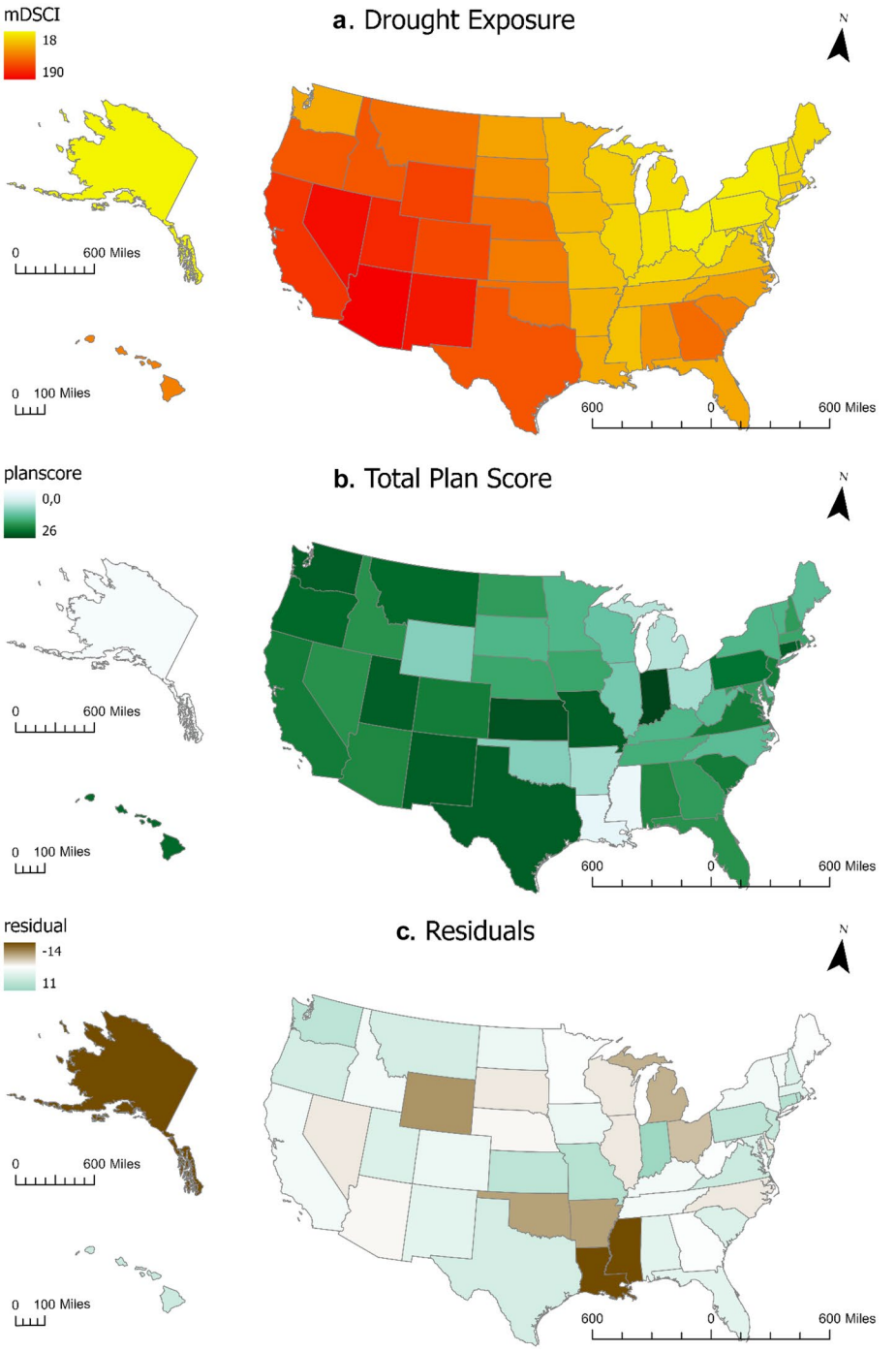

Fig. 1 Input data and residuals mapped onto the states for comparison. The dependent variables are shown in tiles **a** and **b**. The residuals of the correlation between drought exposure and planning scores are displayed in tile **c**

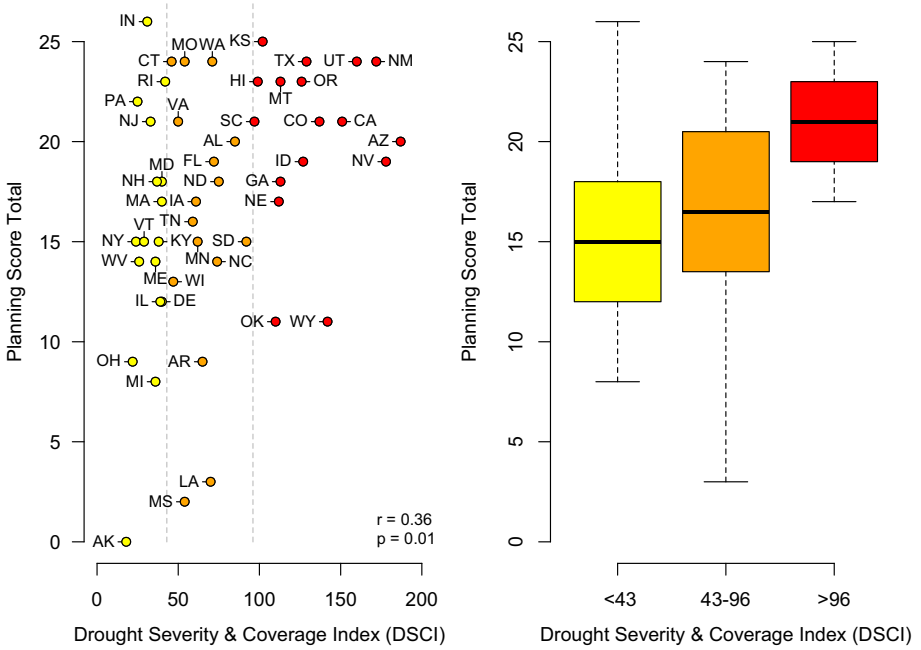

Fig. 2 Correlation plot (left) showing planning score total's (excluding climate plans) relationship with mean drought exposure (DSCI), and the mean planning score by tercile, with data spread in the box-and-whisker plot (right)

year. None of these states had the top drought planning score.[8] The Pearson correlation coefficient for planning scores and per capita tax revenue was 0.143 and did not meet the $p < 0.05$ threshold of significance (0.321). Therefore, statistically, the relationship between drought exposure and planning had low-moderate support, while the relationship between tax revenue and planning did not hold.

Drought-stricken states develop more comprehensive planning, regardless of financial resources. Our interview data reinforced this notion, with one planner stating "We are a semi-arid state and we have drought frequently. Nine out of every 10 years unfortunately the state is experiencing some level of drought, D1 or higher" (P1). In this state, the planner acknowledged that it is costly to update the drought plan regularly (estimated between $75,000-$100,000 in 2018) but that the agency simply "finds the money" (P1).

The exceptions to the drought exposure-planning score correlation were relatively temperate states that had more comprehensive planning (e.g. Indiana and Rhode Island). States with minimal drought exposure had lower drought planning scores, fitting the observed pattern (e.g. Alaska,[9] Mississippi and Louisiana).

[8] Here drought, water, and hazard plan totals are added together for "drought planning score." We exclude climate plans due to the correlation between climate planning scores (and existence of climate plans to begin with) and the political affiliation of a state's governor.

[9] Here we issue a note of caution. A change in governor seems to have been responsible for the removal of the climate action plan. Alaska previously had a climate action plan, but it was stricken from the record. For more detail see news coverage: https://www.arctictoday.com/deleting-policy-report-wont-stop-alaska-climate-change/

4.1 Qualitative Trends: An Increase in Multiple-Hazard Planning and Regional Scaling

The first main observable trend is that stand-alone drought plans are not updated as frequently as multi-hazard plans. This higher number of multi-hazard plans compared to drought plans, combined with statements from the interview data, point to a phase-out of singular drought-planning in favor of wider water and hazard scopes. This means that stand-alone drought plans are now poor indicators of a state's approach to preparing for and responding to drought. As states comply with federal natural hazard planning requirements for updates every five years, stand-alone drought plans have either been replaced (S2) or have not been updated (R4, R5) due to budgetary constraints or personnel requirements (R1, S1). In another case, the state level was no longer deemed the most appropriate: a state water planner mentioned having a drought plan that is out of date, but said that it may be abandoned and future state level drought planning would be more closely integrated with the climate plan, suggesting that stand-alone drought planning would happen at the local watershed level within the state (R6). The multi-hazard plan's drought component, then, would serve as the main planning element at the state level.

The second trend is toward scaling up to regional planning efforts. State planning is not entirely independent because planners collaborate across state lines in practitioner networks. Workshops facilitate interstate learning. Two planners from the same state mentioned that the National Integrated Drought Information System (NIDIS) and the Western Water Assessment have "been very helpful" in creating a network in the Southwest (P4). These state officials mentioned the value of learning from local water conservancy districts and utilities in other states. There is some evidence that states engage in regional learning and cooperation. An interstate planning workshop was held with the explicit purpose of developing and improving drought and water plans. In other instances content-borrowing occurred, such as using the same verbatim definition of drought (which is explicitly acknowledged in some plans, such as the Wyoming Drought Plan which refers to Colorado, New Mexico, and Montana's plans). Furthermore, results show neighbor effects of higher clustered scores in the Western and coastal states (see Fig. 1b).

As planners become familiar with the latest research, whether it is about rapid-onset, flash droughts (Pendergrass et al. 2020) or methods of accounting for economic impacts, they saw the need for regional interstate coordination provided by the USDA Climate Hubs or NIDIS (R2, R3, R4). The NRCS provides federal-level condition monitoring (R6, R7). Integrated research efforts, and an awareness of flash droughts, does not always translate into actions that the planning process is well-suited to address, though. A state planner mentioned the critical dimension of timing, saying that "with flash droughts, impacts are occurring before the Task Force is activated" (R7). In this case, cattle ranchers had already noticed a lack of moisture for growing hay, and began selling livestock in May. However, the Drought Task Force did not meet until July. In another state, snowpack had looked "good and everything was fine" early in a recent year, but suddenly drought conditions set in by the beginning of summer (R6).

Planners use economic impact assessments conducted in conjunction with universities, state climatologists, NIDIS, and local partners like farm service agencies, water conservancy districts and utilities. As one planner saw it, a recent drought provided data on economic impacts for academic research at the regional level, which would then establish the need for more state drought planning efforts (R4).

5 Discussion

The results show a connection between a history of experiencing drought and the level of comprehensiveness of plans. When a state experiences drought year after year, there seems to be a strong incentive to make planning a priority. This is consistent with other studies that find droughts catalyze water policy reforms (Berbel and Esteban 2019), that droughts change stakeholders' support for state-level water policy (Craig et al. 2019), that stakeholders in drought-stricken regions of the world recognize the urgent need for drought mitigation planning (Jedd et al. 2021), and that increased drought experience can result in higher levels of public attention (Smith et al. 2020).

Furthermore, as Tsakiris (2017) suggests, we find support for the three stages of drought management planning: strategic, tactical, and emergency. These stages imply that a political entity is always in one of these situations: pre-planning (waiting for a drought), actively dealing with a drought, or addressing the most urgent dimensions of a drought that has reached disaster level. These stages may form an observable policy cycle that warrants further attention in future research. As an interviewee told us, all areas of that state had been in initial or continuous drought that year, which they said led to an emergency drought declaration by the governor and a renewed emphasis on planning. This was due to increased attention on the existing drought plan and the identification of areas for improvement (R4). In other words, when drought is a serious problem that causes damage for a state, planners make it a priority to address.

The findings should not be interpreted as an endorsement of a crisis response approach. Drought planning is a necessary but complex undertaking, ideally in advance, to prevent the worst impacts. If droughts become more frequent and intense, state planners may benefit from looking to the approaches of drought-stricken states. Early warning from improved seasonal forecasting, along with behavioral changes such as reducing water demand and conserving water, building additional and improving existing supply sources, and public education are all actions that can be integrated into state efforts. Key aspects of drought planning, such as impact monitoring or indicator selection for triggered response, are fundamentally local. State planning accommodates the unique water sources, uses and management regimes within various river basins.

Planning comprehensiveness was not always increased by a drier climate and/or being exposed to more droughts. There are notable exceptions in the results, with some states that comprehensively consider drought in multiple types of plans, despite having relatively lower levels of drought exposure. High-scoring plans employ a range of regularly collected monitoring data and explain how it will be used to determine when a drought is occurring. Multiple agencies are involved in condition monitoring and rule-making. They have standing drought task forces with clearly delineated membership status (e.g. direct equal, external advisory) and functional roles (e.g. monitoring, data coordination, action recommendation).

When viewed as an interdisciplinary (and scalar) challenge, it is not surprising that a comprehensive national drought policy has been impossible to achieve. Even if it were achievable, a national policy may not ameliorate the worst drought impacts. Around the world, centralized regulatory approaches have failed to prevent drought and water-related crises, e.g. groundwater over-abstraction (Molle and Closas 2020). The American

decentralized model of planning for drought fits with the delegation of water management authority historically granted to states. The lack of federal involvement in water governance allows states to choose between systems of allocation. Under a riparian rights regime, for example, property owners with streams or rivers on or adjacent to their land may divert water, while water users in a system of prior appropriation do not need to be adjacent to a water course to hold consumption rights. National drought mitigation policy proposals would have to consider these discrepancies in water laws and governance. For the time being, a "patchwork" of federal programs for crisis management (Congressional Research Service 2013) seems the most likely long-term national policy framework. In the absence of a U.S. federal directive, state planning is likely to remain a cornerstone of drought mitigation.

6 Conclusion

All U.S states have had at least some level of abnormal dryness or drought. In order to reduce the impacts of drought, all states have at least a minimal form of planning: whether that plan is in the form of a stand-alone drought, water, multi-hazard mitigation, or a climate action plan varies, and so does the level of comprehensiveness of states' overall preparedness. Planning ahead reduces the likelihood that droughts will become disasters. Early warning programs linked to improved seasonal forecasting, along with behavioral changes such as reducing water demand and conserving water, adding or improving supply sources, and educating the public are all actions that states have integrated into their efforts.

Until now, drought planning has been more comprehensive, and perhaps more urgently needed, in western U.S. states that experience drought more frequently. There was moderate statistical correlation that planning tends to be more comprehensive in drought-prone states (these states received a higher score in our evaluation). These results highlight a connection, but do not mean that having a drier climate (being exposed to more drought) is always linked to an increase in drought mitigation efforts. The discussion elaborated on the exceptions to this finding, pointing out that some drier, drought-exposed states lack comprehensive planning, and on the other hand, some temperate states without as much drought still consider drought exhaustively in multiple types of plans.

There are numerous challenges in achieving a unified national drought policy, and in the absence of such a federal directive, state planning is likely to remain a cornerstone of drought mitigation in the U.S. In the future, though, it is possible that states will scale up into increased levels of regional learning and cooperation. These results provide U.S.-specific context to earlier calls for national drought policies as a single, best approach for countries (Wilhite et al. 2014) by showing that there are unique differences between states' exposure to drought and their subsequent planning efforts. In sum, the study finds that planning and preparing for droughts is a necessary but complex undertaking that requires interdisciplinary, interagency efforts that the U.S.' decentralized, federalist political system is suited to address.

Appendix

Table 2 Plan score results, drought exposure values (DSCI), and per capita state tax revenues. Scores compiled from original content coding. Additional data obtained from the Drought Risk Atlas of the National Drought Mitigation Center (DSCI), and the Federation of Tax Administrators (per capita state tax revenues)

State	Climate score	Water score	Drought score	Multi-Hazard score	Total	State tax revenue per capita	Mean State DSCI
Alaska	0	0	0	0	0	1,803	18
Alabama	0	6	7	7	20	2,447	85
Arkansas	0	6	0	3	9	3,384	65
Arizona	0	7	9	4	20	2,397	187
California	6	5	8	8	27	4,368	151
Colorado	4	6	9	6	25	2,596	137
Connecticut	6	6	9	9	30	5,173	46
Delaware	4	2	5	5	16	4,616	40
Florida	5	7	7	5	24	1,984	72
Georgia	0	3	6	9	18	2,219	113
Hawaii	1	8	8	7	24	5,478	99
Iowa	0	5	6	6	17	3,370	61
Idaho	0	2	9	8	19	2,892	127
Illinois	0	0	8	4	12	3,598	39
Indiana	0	9	9	8	26	3,312	31
Kansas	0	7	9	9	25	3,315	102
Kentucky	0	1	7	7	15	2,986	38
Louisiana	0	0	0	3	3	2,450	70
Massachussets	3	3	7	7	20	4,588	40
Maryland	5	7	6	5	23	3,944	40
Maine	2	0	9	5	16	3,593	36
Michigan	0	2	0	6	8	2,816	36
Minnesota	0	6	4	5	15	4,736	62
Missouri	0	9	9	6	24	2,017	54
Mississippi	0	0	0	2	2	2,730	54
Montana	7	6	9	8	30	2,932	113
North Carolina	8	1	9	4	22	2,670	74
North Dakota	0	1	9	8	18	5,666	75
Nebraska	0	0	8	9	17	3,023	112
New Hampshire	1	5	9	4	19	2,092	37
New Jersey	5	9	5	7	26	4,270	33
New Mexico	0	6	9	9	24	3,395	172
Nevada	6	7	6	6	25	3,012	178
New York	6	0	8	7	21	4,795	24
Ohio	0	0	5	4	9	2,615	22
Oklahoma	0	6	0	5	11	2,577	110
Oregon	6	9	8	6	29	3,012	126
Pennsylvania	5	7	6	9	27	3,183	25

Table 2 (continued)

State	Climate score	Water score	Drought score	Multi-Hazard score	Total	State tax revenue per capita	Mean State DSCI
Rhode Island	0	9	7	7	23	3,336	42
South Carolina	0	8	8	5	21	2,260	97
South Dakota	0	0	8	7	15	2,261	92
Tennessee	0	4	6	6	16	2,436	59
Texas	0	8	9	7	24	2,078	129
Utah	0	7	9	8	24	2,687	160
Virginia	1	8	9	4	22	3,267	50
Vermont	0	1	8	6	15	5,486	29
Washington	6	9	9	6	30	3,772	71
Wisconsin	5	0	7	6	18	3,449	47
West Virgina	0	6	6	2	14	3,064	26
Wyoming	0	0	9	2	11	3,372	142

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Availability of Data and Materials The plan scoring database, including text and examples from plans on each of the coded criteria, is available upon request. Due to confidentiality agreements with interviewees, the interview data can only be made available to bona fide researchers subject to a non-disclosure agreement. Details of the data and how to access are available from the corresponding author.

Declarations

Ethical Approval This study was exempt from human subjects approval conducted in accordance with Helsinki Declaration as revised in 2013.

Consent to Participate All interview participants were informed of the interview purpose and gave verbal consent to participate by telephone, in lieu of written consent.

Competing Interests The authors have no competing interests to declare.

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