Nat Hazards (2013) 69:1607–1627
DOI 10.1007/s11069-013-0766-z

ORIGINAL PAPER

An overview of US state drought plans: crisis or risk management?

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Received: 18 March 2013 / Accepted: 28 June 2013 / Published online: 9 July 2013

Abstract Recent severe drought events across the nation have raised our concerns over society's changing and increasing vulnerability to droughts. All levels of governments have taken actions to plan for the slow-onset, long-lasting and spatially extensive drought hazard. The progress of drought planning at the state level is especially impressive over the past decade due to the dramatic growth of drought plans. To date, almost all states have drought plans, but previous studies indicated these plans are still heavily relying on the reactive crisis management approach to deal with ongoing droughts rather than the proactive risk management approach toward building drought resilience. No study so far has empirically examined how well all of these state plans are and to what extent these plans incorporated risk management theory and practices on a national basis. Thus, this study develops a drought risk coding protocol to systematically assess the 44 latest state drought plans' quality in risk management. An inventory of the state drought plans is also established to demonstrate their quality, content and characteristics. The results indicate that state drought plans typically address emergency responses well, while they are generally weak in establishing strong goals, mitigation and adaptation, public involvement, plan updates and implementation. Lastly, recommendations are provided for drought officials to develop, enhance or revise drought plans toward a risk management approach.

Keywords Drought plan · State · Crisis management · Risk management · Resilience

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1 Introduction

Drought is generally defined as a natural hazard that results from a lack of participation long enough to cause a serious hydrological imbalance (IPCC 2012; Mishra and Singh 2010; Wilhite and Buchanan 2005; Wilhite et al. 2007). Many believe that drought is the most complex, but least understood and affects the most people among all natural hazards (Wilhite 2002). Rather than considering it as a hazard, drought is actually a normal part of climate and occurs in not only arid regions but also those that are always considered humid (Wilhite and Buchanan 2005). Whether drought becomes a disaster depends on its social, economic and environmental impacts. In the United States, drought impacts are substantial and it is estimated an annual drought losses of 6–8 million dollars on average (FEMA 1995; Wilhite et al. 2000). Droughts have caused over 210 billion dollars in the United States since 1980, without considering other noneconomic impacts (e.g., social stress, environmental degradation) that could hardly be quantified (Lott and Ross 2006; Wilhite et al. 2007). Recent severe drought events in the United States reveal the nation's vulnerability to drought and lack of drought readiness. In 2011, Texas alone brought about almost 7.62 billion dollars of agricultural losses, becoming the costliest drought in state history (Fannin et al. 2011).

Associated with the urgent agenda of climate change, drought will be more than likely to intensify and increase in frequency during the twenty-first century, sharing the same trend with other natural hazards (IPCC 2012). Sheffield et al. (2012) argue that this expected increased intensity of drought is overestimated because of those advocates' simplified method of projection. The lack of consensus on drought-related issues is mainly due to drought's complexity therefore resulting in confusion within the scientific and policy communities (Sivakumar and Wilhite 2002). Although such uncertainty remains to be resolved in the context of all natural hazards, planning before its occurrence has been proven to be effective in mitigating impacts and reducing losses associated with drought as well as other natural hazards (Burby 2005, 2006; Burby et al. 2000; Hayes et al. 2004; Nelson and French 2002; Wilhite 1997).

Since drought has more than 150 definitions and is largely nonstructural and spatially extensive, local governments may lack the awareness as well as coping capacity for drought mitigation (Wilhite and Glantz 1985; Wilhite et al. 2005). Even though the Federal Emergency Management Agency (FEMA) and many planning scholars stated that "all (hazard) mitigation is local" (FEMA 1995; Ivey et al. 2004; Schwab 2010; Tang et al. 2011a), considering drought's scenarios in the United States or even globally, local governments may not be able to play the primary role in drought preparedness planning at the time due to their lack of information, resources and political will to cope with such a complex hazard. Having recognized this, along with the sprawl of drought disasters across the nation, most state governments have already established state drought plans to facilitate drought planning within their jurisdictions and to improve coordination with adjacent jurisdictions. States with a drought plan have grown significantly from only 3 in the early 1980s to 47 in 2011 (Wilhite 2011). Such a dramatic growth in the number of state drought plans indicates an increased concern of droughts at that level and also suggests their effectiveness and benefits in enhancing drought preparedness.

Nevertheless, earlier studies found these state plans to be largely reactive in nature, known as taking a "crisis management" approach toward droughts (Wilhite 1997; Wilhite et al. 2000). The ineffectiveness of the crisis management approach, which largely aims at addressing ongoing drought impacts, is widely known, and the actions that various government agencies took were usually untimely and poorly coordinated (Wilhite 2011).

Given the recent severe drought episodes and drought's increasingly intensified economic, social and environmental impacts in the United States, it is imperative to move from a reactive crisis management approach, which is known to be ineffective, untimely and poorly coordinated, to a proactive risk management tact that emphasizes around preparedness planning and mitigation actions before, during and after drought events (NCDC 2012; Wilhite 2011; Wilhite et al. 2000). Although a number of studies have been conducted to provide guidance in reducing drought risk by encouraging the transition from crisis to risk management (Fontaine et al. 2012; Hayes et al. 2004; Wilhite 1997, 2011; Wilhite et al. 2000), only 11 of the 47 existing state drought plans are believed to have increasingly emphasized mitigation (risk) rather than response (crisis) (Wilhite 2011; NDMC 2012). Fontaine et al. (2012) conducted research in the 17 western states and found that their plans were generally response-oriented (crisis management), and their state officials were less willing to allocate resources for mitigation as compared to response. Some previous studies have provided some insight into the quality and quantity of state drought plans (Svoboda and Tang 2011; Fontaine et al. 2012; Jacobs et al. 2005; Wilhite 2011), yet no study has empirically analyzed all of these existing state drought plans on a national basis. How well these existing state drought plans are and to what extent risk management actions are incorporated into these drought plans also remain unknown.

To remove this deficiency, our study tends to explore the overall quality of state drought plans across the nation with a goal of providing insights for state drought officials and to highlight and encourage them to enhance their plans. First, we conducted the research by developing a coding protocol from the leading literature (Hayes et al. 2004; Knutson et al. 1998; Svoboda and Tang 2011; Wilhite 1997, 2002, 2011; Wilhite et al. 2000, 2005) in drought preparedness planning to examine the quality of existing state drought plans in risk management. We also reviewed, coded and generated statistical analysis for the 44 latest state drought plans against the protocol. Thirdly, these 44 state drought plans were also inventoried to clearly demonstrate their content and characteristics. Finally, the article concludes with a discussion regarding how these plans can be enhanced, and policy implications and recommendations are also given.

2 Method

2.1 Research sample

The sample in this study consists of 44 current state drought plans (available for review on February 3, 2013, as electronic copies), which are housed on the National Drought Mitigation Center's (NDMC) Web site. The rest 6 states' drought plans are either in the process of development or unavailable to acquire. The sampled 44 states were shown on Fig. 1.

2.2 State drought plan evaluation protocol

An evaluation protocol was developed to measure whether or not, and to what degree these existing drought plans have moved from a crisis to risk management approach. Earlier research provides a strong foundation into reducing drought risk (Hayes et al. 2004; Knutson et al. 1998; Svoboda et al. 2010; Wilhite 1997, 2011; Wilhite et al. 2000, 2007). Hayes et al. (2004) presented a drought risk analysis framework that filled a gap by providing a simplified and flexible drought risk model. This framework was adapted to this research by keeping the key components and organizing and selecting actions proposed by

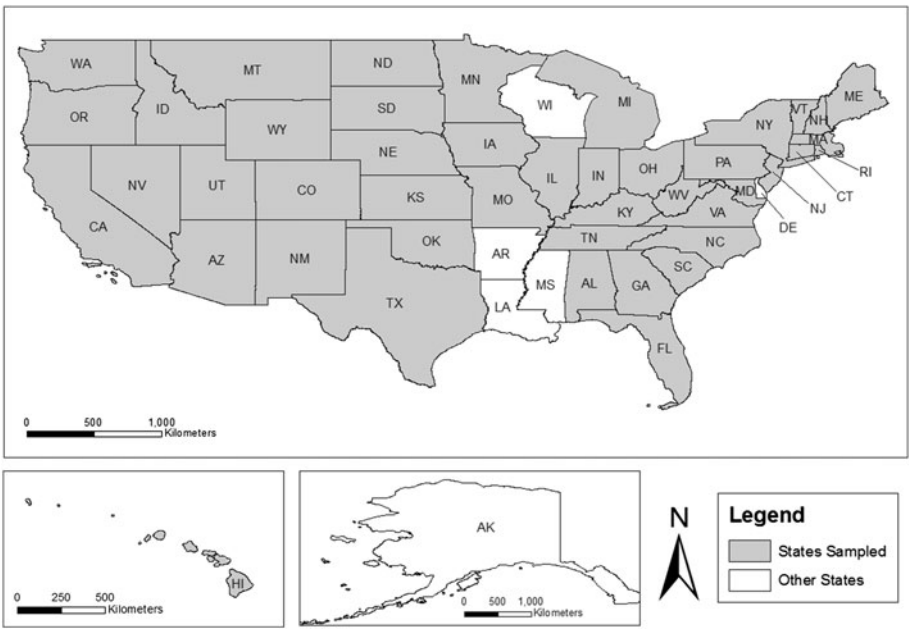

Fig. 1 State drought plans sampled

previous drought researches into each component in order to develop a comprehensive drought risk coding protocol. The major reason of this framework was selected because it integrates and balances various scientific concepts of risk management and is consistent with previous drought planning literature findings (Hayes et al. 2004; Knutson et al. 1998; Wilhite et al. 2007). This simplified and comprehensive analysis model that combines *hazard analysis*, *vulnerability analysis* and *risk management* techniques enables us to measure a drought plan's ability to identify and understand drought risk as well as determine their existing planning capacity to manage that risk (Hayes et al. 2004; Knutson et al. 1998). This section aims to provide the rationale of selecting indicators for the drought plan evaluation protocol, and specific indicators in each plan component are presented in the Tables 3, 4 and 5 with results.

Hazard analysis component measures the plans' capability to understand the probability of occurrence and frequency of droughts. The plans should recognize the impacts that drought would cause on their regions and record their previous drought events to further analyze their vulnerability (Svoboda et al. 2010; Wilhite 1997). Since population growth and subsequent development in terms of increasing water demand and land use changes would likely intensify drought conditions, hazard analysis components should also account for population characteristics and water-use patterns in order to identify possible future challenges (Hayes et al. 2004; Wilhite 2011). In addition, developing specific criteria for drought-related actions is critical in linking mitigation actions to various identified drought impacts in the assessment process (Knutson et al. 1998; Wilhite 1997). Finally, drought plans should also conduct a drought climatology analysis on the probability of annual drought events so as to provide planners with a new perspective with an aim of helping them act in a proactive way (Knutson et al. 1998; Svoboda et al. 2010).

Vulnerability analysis component represents the degree to which plans understand their biophysical and social vulnerability to drought in their regions. As drought is a complex issue involving both supply and the demand for water, drought plans should assess their regional water availability on a continuous basis to better understand their vulnerability to water shortages (Hayes et al. 2004; Knutson et al. 1998; Wilhite 1997). Indicators were selected from the literature to measure the drought plans' analysis on their water resources including water quality and quantity, analyze groundwater use, assess water supply vulnerability and inventory and monitor reservoirs (Knutson et al. 1998; Svoboda et al. 2010). Moreover, drought does not just affect agriculture, but also results in dramatic environmental and social impacts (Wilhite 2011). Therefore, understanding various impacts in drought vulnerable areas can help reduce vulnerability because it provides a sound basis for policies through addressing drought causality (Hayes et al. 2004). Lastly, drought plans should also inventory natural resources within vulnerable areas and research drought's relationship with other hazards, especially wildfire, so as to conduct a comprehensive vulnerability analysis (Knutson et al. 1998; Wilhite 1997).

Risk management component measures whether or not these plans translate the information obtained through the hazard and vulnerability analysis into drought mitigation as well as adaptation actions. Seven sub-components consisting of 30 criteria were developed in this component analysis based on previous studies regarding drought risk management and plan evaluation (Botterill and Hayes 2012; Fu and Tang 2013; Hayes et al. 2004; Knutson et al. 1998; Svoboda et al. 2010; Svoboda and Tang 2011; Wilhite 1997; Tang et al. 2008, 2010, 2011a, b). We summarize them as the below seven categories: (1) Legislation and public policies are widely used in reducing drought risk at various levels of government, and they enable governments to execute their legislative and political power to enhance drought preparedness (Knutson et al. 1998; Wilhite 1997). (2) Water conservation itself has become a significant issue in current planning agendas (Balling and Gober 2007; Campbell 2004; Wilhite 2011). To avoid undesirable water losses, water conservation programs can maintain and improve the adaptive ability of water supply systems to meet demand even during drought. (3) Supply augmentation also strengthens the water systems adaptive capacity to meet the growing demand and to resolve the demand conflicts during periods of insufficient supply (Ivey et al. 2004; Knutson et al. 1998; Wilhite 1997). (4) Public education and participation play a significant role in gathering valuable public inputs and in conducting educational programs regarding regional drought risk and impacts, the benefits of drought planning and the stakeholders' role in enhancing drought resilience (Hayes et al. 2004; Knutson et al. 1998; Svoboda et al. 2010; Wilhite 1997). (5) Intergovernmental coordination provides the effective mechanism to cope with such a complex, cross-boundary, spatial extensive and dynamic drought hazard (Tang et al. 2011b; Wilhite 2002; Wilhite et al. 2000). (6) Others in this risk management component deals with indicators considered as critical elements in previous studies to reduce drought risk but they are too specific to become sub-components and do not easily fall into other categories (Hayes et al. 2004; Knutson et al. 1998; Wilhite 1997). (7) Implementation assures that these drought plans are to be translated into specific tasks and to be carried out by designated agencies (Brody 2003; Svoboda et al. 2010; Tang et al. 2011b; Wilhite 2011).

2.3 Evaluation procedure and calculation method

Overall, 44 indicators were developed for the coding protocol. We chose to use a 0–1 scale to measure the indicators in each of the three categories instead of the 0–2 ordinal scale

that has been widely adopted by various studies (Berke and French 1994; Brody 2003; Tang et al. 2008, 2011a, b) as a means of avoiding personal bias to the greatest extent possible. Any indicator that is not mentioned in the plan receives a score of 0. Unlike 0–2 ordinal scale that involves a subjective process of distinguishing indicators that receive a score of 1 from those that are scored 2, an indicator that is considered either minimally or thoroughly will all receive a score of 1. Such a 0–1 scale cannot distinguish the indicators that are thoroughly addressed in the plans from those that are just minimally mentioned, but it will undoubtedly increase the reliability of the results by reducing personal bias during the evaluation process. This "cursory" approach is a good first brush attempt in understanding a plan's quality to address risk management. In addition, a three-step evaluation procedure is applied to further increase the reliability and accuracy of the results. This evaluation procedure involves the following steps. First, all the plans were scanned and then coded by the reviewer in order to generate preliminary results. Secondly, a key word search method was adopted to confirm or revise the preliminary results. Lastly, all the plans are reevaluated one more time in order to enhance the accuracy of the results.

After the plans were coded using the three-step evaluation procedure, we conducted a statistical analysis to interpret the results based on work done in previous studies (Berke 1996; Berke and French 1994). First, the scores for all of the indicators in each of the three plan components are summed. Secondly, the sum of the scores in each component is divided by the total possible score individually. Thirdly, the fractional scores of the three plan components were multiplied by 10 to make them fit a 0–10 scale. Utilizing our three plan components, the maximum attainable score for one state drought plan is 30. Thus, the total possible score range for each drought plan is 0–30. Additionally, we further analyzed each indicator to understand the adoption of them individually. To do this, the percentage of each indicator was derived by dividing the sum of each of the 44 indicators by the total possible score (44 in this case as each indicator was on a scale of 0–1 and 44 indicators were in the protocol).

3 Results

3.1 Overall drought plan content and characteristics

The fact that nearly all states already have a drought plan shows that the elected officials and planners at the state level are taking droughts seriously, but there is still significant room for improvements (see Table 1). The results of this study are consistent with previous studies that found state drought plans to be largely response-oriented with a widely varied

Table 1 Summary of plan quality and performance

Components[a]	Number of indicators	Minimum	Maximum	Mean	SD
1. Hazard analysis	6	0.0	10.0	4.8	2.48
2. Vulnerability analysis	8	0.0	10.0	5.4	2.18
3. Risk management	30	1.6	9.4	4.8	1.81
Total[b]	44	4.0	26.8	15.1	5.41

[a] Component score range 0–10

[b] Total score range 0–30

scope and depth (Fontaine et al. 2012; Wilhite 2011). The mean score of the 44 state drought plans was only 15.1 (50.3 % of the total possible score at a scale of 0–30), and their quality ranged from a low of 4 (13.3 % of the total possible score at a scale of 0–30) to a high of 26.8 (89.3 % of the total possible score at a scale of 0–30). All three plan components received values near the mean score. The *vulnerability analysis* component received a mean score of 5.4 (54 % of the total possible score at a scale of 0–10), which is only 0.6 higher than the other two plan components, *hazard analysis* and *risk management*, which both received a mean score of 4.8 (48 % of the total possible score at a scale of 0–10). To further understand each state's plan content and characteristics, this study inventoried the 44 state drought plans researched and selected five categories (1. prediction and early warning, 2. recognition of drought impacts, 3. water conservation target, 4. funding identified and 5. plan update) to preliminarily demonstrate these plans' content and characteristics, respectively (See Table 2). The quality of drought plans coded in this study was also included in the inventory analysis.

States receiving a total score of more than 20 on scale of 0–30 were Colorado (26.5), Hawaii (26.0), California (24.4), Arizona (22.5), New York (22.1), Texas (21.2), Idaho (21.1), Montana (20.9), Rhode Island (20.9), Missouri (20.6) and Nebraska (20.0). In fact, 8 of the 11 plans that received the highest scores were designated as mitigation-based plans in previous studies (Wilhite 2011), which largely verifies the validity and effectiveness of our coding protocol in examining and identifying a drought plan's quality in addressing a risk management approach. Plans that received the lowest scores were typically plans that heavily emphasized drought response. Almost none of the suggested actions in our protocol were found in these short response-oriented plans therefore rendering these plans with a very low score.

Even though the scope and depth of drought prediction and early monitoring systems varied widely from states to states, only eight of the 44 states sampled failed to mention the inclusion of a drought early warning system to predict and/or monitor drought before its onset. Half of the plans (22 out of 44 plans) did not identify drought impacts in their plans or identified only some general impacts from other sources. Other plans specified regional impacts summarized from previous drought events. For example, the Arizona Drought Preparedness Plan (2004) described their drought impacts by sectors (e.g., energy, health and water quality) in their own regional context. States are encouraged to identify their own drought impacts through post-drought assessments, thereby building up their own database for future drought vulnerability analyses as well as appropriate mitigation actions. States that solely rely on a national drought early warning and information system, such as the US Drought Monitor (Svoboda et al. 2002) or National Integrated Drought Information System (NIDIS) (2012) for drought monitoring, should expand their scope to identify regional drought impacts and establish regional monitoring frameworks that are most suitable for a regional basis taking into account their own situation.

Of all the state plans analyzed, only California established specific water conservation goals aimed at achieving a 20 % per capita reduction by 2020. Nine other states mandate water conservation measures during severe drought conditions. Considering the role of water conservation as a key component in most drought plans, only a few plans (10 out of 44 plans) established a specific goal for actions. Twelve plans listed specific financial sources for drought mitigation and plan implementation, and thirteen plans identify some funding, leaving the rest of the states without a funding section in the plans. The lack of financial support in most plans suggests that little money was allocated to drought planning between droughts events. Also, twenty-four states failed to specify a timeframe for the next update of their plans, while some other states in the research sample devoted themselves to

Table 2 Drought plan content and characteristics

States	plans	Plan quality				Prediction and early warning?	Recognition of drought impacts?	Water conservation target	Funding identified	Plan update
		HA[a]	VA[b]	RM[c]	Total[d]					
AL	Alabama Drought Management Plan 2004	5.0	7.5	5.0	17.5	Yes	Yes	None	No	At least every 5 years
AZ	Arizona Drought Preparedness Plan 2004	6.7	7.5	8.3	22.5	Yes	Yes	Not specific	Some	Annually Update as needed
CA	California Drought Contingency Plan 2010	8.3	8.8	7.3	24.4	Yes	Yes	20 % per capita reduction by 2020	Some	Review and update along with California Water Plan
CO	Colorado Drought Mitigation and Response Plan 2011	10.0	7.5	9.3	26.8	Yes	Yes	None	Yes	3 years State Plan update cycle
CT	Connecticut Drought Preparedness and Response Plan 2003	5.0	6.3	5.3	16.6	Yes	Some	Goals vary according to drought stages	No	Not mentioned
FL	Florida Drought Action Plan 2007	8.3	2.5	4.7	15.5	No	No	Goals vary according to water management districts	No	TBD if drought continues and intensifies
GA	Georgia Drought Management Plan 2003	3.3	5.0	5.0	13.3	Yes	No	None	No	At least every 5 years
HI	Hawaii Drought Plan 2005	8.3	10.0	7.7	26.0	Yes	Yes	None	Yes	At least every 5 years
ID	Idaho Drought Plan 2001	6.7	8.8	5.7	21.2	No	Yes	None	Yes	Not mentioned
IL	State of Illinois Drought Preparedness and Response Plan 2011	6.7	5.0	4.0	15.7	No	Yes	None	No	Not mentioned
IN	Indiana's Water Shortage Plan 2009	5.0	5.0	7.0	17.0	Yes	No	Goal varies according to water shortage stages	No	Every 2 years (minimum) or every 5 years (maximum)
IA	Iowa Water Plan 2009	0.0	3.8	2.7	6.5	No	No	None	No	Not mentioned
KS	Kansas Drought Operation Plan 2012	5.0	3.8	4.7	13.5	Yes	Yes	Not specify	Some	Review or update as necessary

Table 2 continued

States	plans	Plan quality				Prediction and early warning?	Recognition of drought impacts?	Water conservation target	Funding identified	Plan update
		HA[a]	VA[b]	RM[c]	Total[d]					
KY	Kentucky Drought Mitigation and Response Plan 2008	6.7	6.3	5.7	18.7	Yes	Yes	None	No	Not specify
ME	State of Maine Standard Hazard Mitigation Plan 2010	3.3	5.0	3.3	11.6	No	Some	None	Yes	Review annually and revise within 3 years
MD	Maryland Statewide Water Conservation Advisory Committee 2000	5.0	5.0	5.0	15.0	Yes	No	Reduction goal varies according drought stages	No	Annually update
MA	Massachusetts Drought Management Plan 2001	5.0	5.0	5.0	15.0	Yes	Some	None	No	Not mentioned
MI	Drought Response Plan 1988	1.7	6.3	2.0	10.0	No	Some	None	No	Not mentioned
MN	Minnesota Statewide Drought Plan 2009	1.7	5.0	4.3	11.0	Yes	No	Goal varies according to drought phases	No	Not mentioned
MO	Missouri Drought Plan 2002	8.3	6.3	6.0	20.6	Yes	Yes	Goal varies according to phases	Some	Not mentioned
MT	The Montana Drought Response Plan 1995	5.0	8.8	7.3	21.1	Yes	Yes	Not specify	Yes	Update lists of responsible agencies and their respective actions annually
NE	Nebraska's CARC Drought Mitigation and Response Plan 2000	6.7	6.3	7.0	20.0	Yes	Yes	None	Yes	Not mentioned
NV	State of Nevada Drought Response Plan 2012	1.7	0.0	2.3	4.0	Yes	Yes	None	No	Not mentioned
NH	New Hampshire Drought Management Plan 1990	6.7	5.0	3.3	15.0	Yes	Yes	None	No	Not mentioned

Table 2 continued

States	plans	Plan quality				Prediction and early warning?	Recognition of drought impacts?	Water conservation target	Funding identified	Plan update
		HA[a]	VA[b]	RM[c]	Total[d]					
NJ	State of New Jersey Drought Emergency Plan 1991	1.7	3.8	4.0	9.5	No	No	Maximum 50 GDP in Phase II for residential	No	Not mentioned
NM	New Mexico Drought Plan 2006	1.7	1.3	4.3	7.3	Yes	No	None	Some	Update annually
NY	New York State Drought Plan 1988	8.3	7.5	6.3	22.1	Yes	Yes	None	Yes	Not specify
NC	North Carolina Drought Assessment and Response Plan 2005	1.7	3.8	3.3	8.8	Yes	Some	None	Some	Not mentioned
ND	North Dakota Drought Contingency Plan 1981	0.0	5.0	1.7	6.7	No	No	None	No	Not mentioned
OH	State of Ohio Drought Incident Annex 2012	3.3	7.5	4.7	15.5	Yes	Some	None	Some	Review annually and update at least every 4 years
OK	Oklahoma Drought Management Plan 1997	5.0	6.3	4.3	15.6	Yes	No	None	Yes	Not mentioned
OR	Drought Annex to State Emergency Operation Plan 1991	5.0	3.8	4.0	12.8	Yes	No	None	Some	Not mentioned
PA	Pennsylvania State Water Plan 2009	5.0	3.8	7.3	16.1	Yes	No	Reduction goal varies according to emergency conditions	Some	Update over the next 5 years
RI	Rhode Island Drought Management Plan 2002	6.7	7.5	6.7	20.9	Yes	Yes	None	Yes	Not mentioned
SC	South Carolina Drought Response Plan 2009	5.0	1.3	4.0	10.3	Yes	Some	None	Yes	Update annually
SD	State of South Dakota Hazard Mitigation Plan 2008	6.7	5.0	2.7	14.4	Yes	Yes	None	Yes	3 years update cycle

Table 2 continued

States	plans	Plan quality				Prediction and early warning?	Recognition of drought impacts?	Water conservation target	Funding identified	Plan update
		HA[a]	VA[b]	RM[c]	Total[d]					
TN	Drought Management Plan 2010	5.0	2.5	4.3	11.8	Yes	Yes	None	Some	Not mentioned
TX	State Drought Preparedness Plan 2005	6.7	7.5	7.0	21.2	Yes	Yes	None	Some	Review annually and revise if appropriate
UT	Utah Drought Response Plan 1993	3.3	6.3	4.0	13.6	Yes	Some	None	Yes	Not mentioned
VT	Incident Annex 7 Drought Management 2009	5.0	5.0	4.7	14.7	Yes	Some	None	Some	Not mentioned
VA	Virginia Drought Assessment and Response Plan 2003	3.3	3.8	3.7	10.8	Yes	No	Reduction goal varies according to drought stages	No	Not mentioned
WA	Drought Contingency Plan 1992	0.0	2.5	5.7	8.2	Yes	Not specify	None	Yes	Not specify
WV	Annex U Drought 2008	3.3	7.5	2.3	13.1	Yes	Yes	None	No	Not mentioned
WY	Wyoming Drought Plan 2003	3.3	5.0	3.7	12.0	Yes	Yes	None	Some	Not mentioned

[a] Hazard analysis (HA) on a scale of 0–10

[b] Vulnerability analysis (VA) on a scale of 0–10

[c] Risk management (RM) on a scale of 0–10

[d] Total on a scale 0–30

updating their plans from annually to every 5 years. Some states like Colorado, Hawaii, California and Arizona did improve their plans through introducing risk management into their drought plans to enhance regional resilience but thirty-two states are still in a status of crisis management as reflected through their drought response plans (32 out of 44 plans that received scores lower than 60 % of the total score).

3.2 Plan components

3.2.1 Hazard analysis

Most states (70 %) detailed drought impacts in their plans, while only half of the states (55 %) recorded their previous drought experiences (see Table 3). Almost all of the states that mentioned previous droughts just indicated the disasters' severity and time scale without giving any further analysis on the affected sectors, specific impacts or estimated losses. Even drought-prone regions like Arizona and Texas only minimally described their previous experiences with drought disasters without having detailed explanations about specific impacts or estimated economic losses in the plans, demonstrating a lack of post-drought assessments in almost all states (Fontaine et al. 2012). Few plans (14 %) research, or predict, the likelihood of occurrence of droughts in their regions, which generally indicates a lack of risk assessment and understanding of how often their regions can be affected. Nearly half of the plans (48 %) studied mentioned water-use patterns and for those that do address these patterns they are detailed, but only a few plans (23 %) recognized their increasing water demand associated with the growth and/or predicted future

Table 3 Indicator-based scores for the hazard analysis component

Indicators	Percentage (%)
1.1 Understand drought and its impacts	70
1.2 Historical records of drought	55
1.3 Identify likelihood of occurrence of drought	14
1.4 Identify water-use patterns	48
1.5 Growth and upcoming challenges	23
1.6 Develop criteria for drought-related actions	77

Table 4 Indicator-based scores for vulnerability analysis component

Indicators	Percentage (%)
2.1 Analyze water quality and quantity	80
2.2 Analyze use of groundwater	75
2.3 Research drought impacts to identify vulnerable sectors	45
2.4 Analyze causality of regional drought impacts	9
2.5 Undertake water supply vulnerability assessment	55
2.6 Inventory and monitor natural resources within relevant areas	45
2.7 Research relationship between drought and wildfires	52
2.8 Inventory and monitor reservoirs	68

Table 5 Indicator-based scores for risk management component

Indicators	Percentage (%)
Legislation and public policy	
Establish a state water bank	14
Legislate to protect in-stream flow	20
Legislate to protect and manage groundwater	18
Regulate new development (e.g., land use restrictions and urban boundary)	18
Require water agencies to develop water contingency plans	55
Water conservation	
Water conservation goal	23
Establish incentives for water conservation	30
Encourage voluntary water conservation	86
Implement water conservation measures	77
Improve water use and conveyance efficiencies	43
Implement water metering and leak detective programs	57
Supply augmentation	
Issue emergency permits for water use	39
Identify new/alternative water supply sources	32
Encourage water recycling/reusing projects	30
Public education and participation	
Public participation in drought planning	32
Establish a drought information center	27
Conduct water conservation outreach programs	73
Organize workshops on drought-related topics	43
Intergovernmental coordination	
Establish program with other agencies (e.g., federal, state and local)	98
Encourage developing of local drought plans	41
Keep media updated about new conditions and plans	73
Linkage to other plans and documents	59
Others	
Develop early warning system	82
Identify data sources and assess data quality	57
Establish guide for emergency responses	68
Implementation	
Establish drought task force	86
Identify funding and technical assistant programs	59
Timetable identified for implementation	5
Identify agencies' responsibility	89
Continuously monitor, assess and update	53

water consumption. Not surprisingly, as most plans are typically established for response, 77 % of the plans have developed specific criteria for response actions in case of drought disasters.

3.2.2 Vulnerability analysis

Since drought is normally associated with the availability, or lack thereof, of water, state drought plans generally conducted an analysis of water quality and quantity (80 %), groundwater (75 %) and regional reservoirs (68 %) (see Table 4). In addition, over half of the plans (55 %) conducted water supply vulnerability assessments to be prepared and informed in case of water shortages. States normally recognized the significance of monitoring water resources within the region in their plans, while drought's other potential impacts as well as their vulnerable sectors were addressed less often (45 %). In addition to water resources, other natural resources like vegetation and wildlife were moderately mentioned (45 %). Only 52 % of the plans researched drought's relationship with wildfires. Given the fact that wildfires often occur during droughts when the weather is extremely dry, leading to potentially large economic and environmental losses, it is necessary for other states to take the issue into consideration rather than totally ignoring it in the drought plans. It is not surprising that few states (9 %) analyzed the causes of earlier droughts given a lack of reliable information regarding drought's onset and end, various impacts, and factors that affect the hazard and a systematic analysis of post-drought impacts.

3.2.3 Risk management

The seven categories within the risk management plan component were analyzed, respectively (see Table 5). These plans performed well in facilitating drought monitoring and declaration, disaster response, institutional communication and coordination, while specific actions regarding reducing drought risk were minimally, or moderately, addressed in these plans.

3.2.4 Legislation and public policy

Indicators in this category received little attention, indicating that state governments leave these options for localities themselves to decide. Only a few states mentioned establishing a state water bank (14 %), legislating to protect in-stream flow (20 %) and groundwater (18 %) or regulating urban development (18 %). Over half of the states (55 %) require water agencies to develop contingency plans. From a top-down planning model, such a lack of strong legislation and policy in drought-related actions hardly urges localities to act so as to build better resilience to drought.

3.2.5 Water conservation

Although most states encouraged voluntary water conservation (86 %) and implemented some sort of water conservation techniques (77 %), the lack of a specific goal (23 %) and/or financial incentives (30 %) for water conservation may question their overall effectiveness and implementation statewide. Nearly half of the drought plans sampled mentioned improving water use and conveyance efficiencies (43 %) and implementing water metering and leak detective programs (57 %). However, few plans conducted follow-up assessments to demonstrate these actions' implementation and effectiveness. To sum up, the lack of goals, incentives and follow-up reports regarding water conservation in these drought plans may cast doubt upon their implementation and/or effectiveness.

3.2.6 Supply augmentation

The indicators in this category were minimally addressed; 39 % of the plans addressed water use emergency permits, 32 % of them seek out new/alternative water supplies and only 30 % identified water recycling/reuse as an option for augmenting water supply without detailed information. It indicates that many states are satisfied with the availability of water resources and supply and therefore they may find it unnecessary to prepare for water shortages. However, we know this is typically not the case during droughts. With our growing population, land use changes and changing climate, the vulnerability of all regions to droughts and other hazards are changing accordingly or even increasing dramatically. Neither the increasing demand for water nor the occurrences of droughts are completely predictable. Such uncertainty may render these states and localities vulnerable, and more states must seriously consider this before it is too late.

3.2.7 Public education and participation

Many states (73 %) emphasized its importance and benefits by encouraging the public to conserve water through outreach programs. Given the limited amount of resources allocated for drought mitigation, the workshops for drought (43 %) are believed to be infrequently hosted. Only 32 % of the plans sampled indicated that stakeholder participation was taken into account during the planning process, while others were heavily response-oriented as expected. A limited number of states (27 %) established a drought information system that integrates reliable information regarding regional drought early warning and water supply status that was previously scattered across the internet into one official Web site, which is continuously updated. Relying on public outreach may hardly make significant progress in increasing public awareness of droughts, and therefore, states should expand their budget as well as their planning toolkits in order to continuously educate their stakeholders about the serious impacts of drought and thus the benefits of planning for droughts. Involving the public during the planning process is believed to be especially significant and beneficial with regard to droughts, which are often misunderstood by the public (Svoboda and Tang 2011; Wilhite et al. 2000).

3.2.8 Intergovernmental coordination

Recognizing droughts as a complex and cross-boundary hazard, almost all states (98 %) have established some drought programs with other agencies at various levels of government as a means of enhancing their overall planning capacity. Less than half (41 %) of the plans suggested that localities should develop their own drought plans because they realized how drought impacts vary significantly at the local level due to different regional economic, social and environmental context and also due to the limitations of state drought plans in directly addressing region-specific planning. Many state (59 %) plans sampled demonstrated their linkages to other plans (e.g., state water plans) rather than developing a stand-alone plan that is only utilized when droughts occur, but most of these linkages were superficial given the lack of detailed descriptions or examples. Most states (73 %) identified dissemination of information to users mainly through their official Web sites as a key measure in updating current drought conditions as well as their drought plans in addition to access to other relevant resources. Surprisingly, no states applied the newer social media tools (e.g., Facebook, Twitter, YouTube) as a means of informing the public with the most updated drought conditions and plans revisions.

3.2.9 Others

The majority of drought plans (82 %) developed drought monitoring systems, but the ways they monitored droughts, and the drought triggers that were selected, varied widely among these plans. It is understandable that these plans chose various drought monitoring criteria due to the distinct regional differences in vulnerability to droughts. However, fewer plans (57 %) took the next step in identifying how they should inventory, assess or acquire drought-related data/information in order to monitor droughts. Over half of the plans (68 %) set clear guidelines for actions during various emergency drought stages. Overall, the plans that had developed drought monitoring systems and established emergency respond guidelines were the most detailed with those drought plans describing how identified drought stages were triggered and what actions should be taken.

3.2.10 Implementation

It is difficult to know how these drought plans were implemented because very few of them issued progress reports in the plans or indicated other reports regarding plan implementation. Although most states established drought task forces (86 %), which clarified individuals' as well as agencies' responsibility (89 %) for droughts, fewer states specified financial and/or technical support for addressing future droughts (59 %) and demonstrated a desire to continuously update the plans (53 %), casting doubts on the level of implementation of these drought plans. In addition, virtually few plans (5 %) listed timelines for the drought mitigation actions that were mentioned in the plans.

4 Discussions

With the increasing awareness of drought at various levels of government due to the severe droughts of the last two decades, almost all states have now developed a drought plan. By systematically evaluating the 44 latest state drought plans, this study identified a wide range of scope and depth among these plans and the selected indicators in the protocol were variously adopted in the plans. Although some states have established impressive plans aimed toward a proactive risk management approach, most of the state drought plans are still heavily crisis-oriented in nature with very few plans focused on, or implementing, drought mitigation and adaptation.

The basic goals of these state drought plans is to generally, monitor, prepare for, respond to and recover from drought disasters (Wilhite 1997). As drought characteristics evolve with growing populations, urbanization, land use changes, climate change and many other unpredictable factors, the basic functions of the majority of these plans are no longer satisfactory and cannot meet the tasks of reducing drought risk and future impacts, which is even reinforced by recent drought episodes in the Midwestern United States in 2012. Wilhite (1997) had already found state drought plans to be reactive and urged them to take actions and identify vulnerable sectors in advance of the next drought. Wilhite et al. (2000) provided a revised planning framework for states to revise, or develop, a drought plan emphasizing drought mitigation and preparedness, broadly defined as a risk management approach. Recently, Schmidt and Garland (2012) introduced the newly rising theory of resilience into drought planning to help communities in Texas reduce their drought risk. These theories of enhancing drought planning are all directed at building drought resilience through a proactive approach rather than the dominating reactive

emergency management model used in most states. According to our results, this article identifies some of the main obstacles that these states need to overcome in order to enhance their plans as well as increase their resiliency to droughts.

4.1 Establish strong objectives and goals

We found only a few of existing drought plans set long-term goals or contain specific objectives aimed toward reducing drought risks. Goals and objectives in the plans reflect the vision that communities aspire to obtain. The lack of specific goals and objectives may lead to difficulties in a state's ability to formulate, adopt and implement drought mitigation and adaptation actions and programs. State drought plans should set strong goals and objectives in their plans by establishing specific targets (e.g., water conservation target) and specifying timelines for meeting these targets. If possible, progress reports or evaluations shall also be issued to examine whether or not the goals and objectives are being met as expected. Through this process, states and local jurisdictions can learn from their successes and failures from their recorded experiences as a way of developing and/or revising their plans accordingly.

4.2 Adopting more drought mitigation and adaptation actions

To a large degree, drought mitigation or adaptation measures have been addressed minimally at best. It is time to place more weight on mitigation and adaptation actions to reduce drought risks and build communities' resilience rather than reactively and repeatedly responding to this chronic disaster.

State drought plans overlook some mitigation and adaptation strategies such as mandating water conservation, protecting in-stream flow and finding new or alternative water supply sources that are necessary in order to reduce drought risks. In addition, these plans appear to be a checklist or guide than a "living" document. The actions in the plans are to be activated only if and when drought arrives while during normal periods these plans are often ignored. Actions taken in the plans are often voluntary rather than mandatory, except during times of severe or exceptional droughts. The general response characteristics found within response plans renders them ineffective in reducing drought risks and does not allow for the building of resilience in long term. States can learn from several suggested mitigation and adaptation strategies discussed in previous studies (Deoreo 2006; Knutson et al. 1998; Wilhite 1997, 2011) and from other states who have successfully documented their drought planning experiences (e.g., Colorado, Hawaii and Arizona) in order to revise their plans with stronger actions and steps that have been researched and found to be suitable by taking into account their own vulnerabilities.

4.3 Involve the public

State drought plans were written by state water offices, designated drought groups or through coordinated efforts among various departments and agencies. Most response plans lacked public participation and involvement during both the planning and implementation process. Plans that mentioned public participation were mostly aimed toward educational awareness and did not contain detailed schedules or timelines. Therefore, this only leaves limited options open for localities and only a few of them are believed to have actually implemented these types of options due to the shortage of resources, financial incentives

and/or lack of regulatory power. Most plans seem to have had a limited amount of influence on the public and the effectiveness and implementation of these plans are also questioned given the general lack of support from the public.

States need to expand their planning activities and emphasis toward actively involving stakeholders and the public in both the planning and implementation process for various reasons. First, states can gather valuable information from the public and stakeholder to enhance their understanding of the regional and local drought vulnerabilities that exist within their borders and across borders as well. As a result, by understanding their vulnerabilities to droughts along with an in-depth knowledge of how it impacts various sectors (e.g., water, agriculture, industry, tourism), mitigation and adaptation actions can be selected, effectively prioritized and implemented. Second, involving more stakeholders and the public will undoubtedly promote and heighten awareness as to the standing role of the plan. By increasing their influence on the public, drought plans are believed to be more actively implemented. Last but not least, the public involvement and participation process can also serve as a positive educational process to resolve their misunderstanding of the complexities of drought and helps to further demonstrate the severity of various drought impacts while underlining the benefits of drought planning.

4.4 Update plans regularly: open to changes

Nearly half of the state drought plans failed to specify the timeline for their next update. Plans are generally short term in nature as all hazards are hardly predictable and we must adapt to changes and revise the plans accordingly. Generally, plans that are not updated regularly can no longer effectively serve to address, or solve, problems and are mostly likely to worsen the situation due to the changing regional vulnerabilities, outdated techniques, lack of coordination and communication and so on. Thus, adopting and applying the latest resilience thinking into these plans through regular updating is an essential and often overlooked need. Adapting and learning from ongoing or previous hazard events is a key element of resiliency planning. This is especially true for droughts given their slow-onset, long-lasting and spatially extensive characteristics (Schmidt and Garland 2012). States need to recognize that drought characteristics and impacts are changing along with their changing social, economic and environmental context, or, in other words, their vulnerability to droughts. Regular updates of drought plans through learning and integration of past drought experiences will enable states to adapt their plan accordingly so as to continuously enhance their drought resilience in the long run through an adaptive planning approach.

4.5 Implementing the plans

Plan implementation has always been difficult to measure; thus, states are urged to provide follow-up reports or evaluations, to demonstrate their progress, or degree of implementation. These post-disaster implementation assessments, or evaluations, will generate valuable results, which can help to encourage and prioritize future mitigation activities.

As resilience planning is "a long-term process rather than an outcome or static state" (Schmidt and Garland 2012), most of the existing response-oriented drought plans do not enhance regional/local resilience and may continue to render their communities vulnerable to future droughts. States should implement the plans with suitable drought mitigation and adaptation strategies on a continuous basis as a way of building regional resilience in the long term (Wilhite 1997; Wilhite et al. 2000). State drought plans should no longer be

regarded as only a reference guideline or checklist to be used for responding to current drought disasters, but should be established as a standing living document that is to be implemented at all times.

5 Research limitations and future studies

As is the case with all research, limitations exist. First, this study uses a content analysis method to assess the current US state drought plans' quality in risk management, which involves a subjective coding process taken and modified from the current hazards literature. Although a very specific coding category (mentioned or not mentioned) is applied and the three-step evaluation procedure is followed, it is impossible to entirely eliminate the scorer's personal bias from the coding process. However, the authors believe the redesigned evaluation method (employing a 0–1 coding scale and three-time evaluation procedure) increases the reliability and accuracy of the study to the greatest extent possible given only one scorer. Future studies could employ more scorers to evaluate the plans in order to further enhance the work.

Secondly, as the first study in empirically evaluating the drought plans on a national basis, this article develops a drought protocol utilizing 44 indicators to preliminarily examine these state plans' quality. As most existing drought plans in place today are still mainly centered on a crisis management approach (Fontaine et al. 2012; Wilhite 1997, 2011), we chose 44 general indicators in our protocol in order to assess a given plan's quality based on the assumption that most plans are still weak in integrating risk management components. In addition, we systematically evaluated these plans with one coding protocol, though developed from the leading literature in drought planning, which may somehow ignore the states' variations in jurisdictional characteristics (e.g., wealth, education, planning faculty, political will and drought experiences). Future studies will develop region-specific coding protocols with the inclusion of more specific indicators to examine states with similar jurisdictional characteristics so as to further explore why plans vary significantly from each other and what factors influence the plans' quality the most.

Lastly, the findings of the study are based on the designated state drought documents collected from the NDMC Web site. Other plans (e.g., state all-hazard mitigation and/or state water plan), which may also enhance our drought resilience to some extent, have not been considered. This study only focused on designated state drought plans and provides suggestions for improving these plans' quality in risk management so as to build communities' drought resilience in the long term. Future studies shall expand the scope to examine all the drought planning efforts at state levels.

6 Conclusions

Droughts have caused tremendous losses and severe impacts to communities all around the United States in the past and may occur more frequently, or intensely, in the near future. All levels of governments are starting to act in response to droughts, particularly at the state level. Nearly all states have developed drought plans which suggested that these plans are effective in reducing drought losses to some extent. However, most of these plans were developed to facilitate drought responses, and such a crisis management approach toward droughts is largely ineffective and untimely. This study examined 44 state drought plans by incorporating a drought risk coding protocol developed from the leading work and methods

found in hazard and drought planning. All state plans were systematically evaluated and inventoried to demonstrate these plans' content and characteristics. Their strengths and weaknesses are therefore revealed. The findings and recommendations in this study can be beneficial to professional planners, state officials and decision makers to develop, improve and revise their drought plans.

Acknowledgments The authors gratefully acknowledge the three anonymous reviewers for their helpful comments. This project was support by the SKLEC Research Grant (SKLEC-KF201203), EPA Urban Water Grant (UW-97735101) and University of Nebraska Rural Futures Institute grant. None of conclusions expressed here necessarily reflect views other than those of the authors.

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