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Research

Oklahoma's perceptions, attitudes, and beliefs related to water resources and their management: A decade long look

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Abstract

Water resources are a critical issue across the United States. Addressing water issues requires public understanding, acceptance, support, and participation. This study compared the public's perceptions and knowledge of Oklahoma water over time. A 53-item paper questionnaire was administered to a randomly sampled mailing list of Oklahoma residents in 2008 and 2018. There were no statistically significant differences between the public's perception in 2008 and 2018. Participants were mostly unaware of what watersheds are, and their perceptions and behaviors were seemingly unaffected by changes in weather patterns and water education efforts. When questioned about their knowledge of water issues, the most frequent response was '*don't know*'. Results suggest improved education and outreach is needed to advance the public's water knowledge. Furthermore, this study found that long term evaluations of public perceptions, behaviors, and knowledge are extremely important in determining education program effectiveness. In this case, findings indicate status quo will not yield needed changes.

1 | INTRODUCTION

Water resources are a critical and growing issue across the United States (US) and globally. According to the National Water Quality Inventory, 70.9% of lakes, reservoirs, and ponds; 79.5% of bays and estuaries; and 52.9% of rivers and streams assessed in the US are impaired and do not meet established water quality standards (EPA, 2020). Oklahoma is no different, with almost 700 surface waterbodies having impaired water quality (DEQ, 2018).

Water quantity is a growing concern as well, particularly in the western US where growing populations, over-allocation or over-use of water, increasing drought frequency and severity, and declining precipitation and snowpack are threatening already stressed water supplies. Addressing these issues and achieving sustainable water resource management will require public understanding, acceptance, support (Flack & Greenberg, 1987), and participation. Unfortunately, these are lacking in many cases.

To improve the public's understanding of water issues and actions to address them, effective education and outreach programs are needed. However, developing and targeting such programs to maximize their reach, effectiveness, and impact requires an understanding of the public's perceptions, knowledge, and communication preferences (Chapagain et al., 2020; Eck et al., 2019). Prior studies reveal that consumers' reactions to water conditions and conservation campaigns depend on a multitude of intervening psychological, situational, and physical factors (DeLorme et al., 2003). When crafting messages, past research recommends keeping messages simple, focusing messages on the economic benefits of water conservation, and showing measurable results

of efforts (DeLorme et al., 2003). Educating consumers and communicating about water management is quite complex and challenging (DeLorme et al., 2003).

Most studies seeking to understand the public and support development of targeted education and outreach programs are point in time studies, with few evaluating longer-term changes in water perceptions (Chapagain et al., 2020; DeLorme et al., 2003; Eck et al., 2019; Flack & Greenberg, 1987). Understanding point in time public perceptions is essential for designing effective education through targeted outreach; however, understanding long-term trends in perceptions provides greater insight into not only program design, but also effectiveness of outreach programs. Likewise, it helps to know how major events such as droughts, floods, high profile drinking water issues (Flint, MI, USA), policy changes, technological changes, and others are impacting public perceptions over time (Mahler et al., 2019). Several states and regions have examined their residents' perceptions and behaviors associated with water over time (Castro et al., 2011; Gholson et al., 2019; Mahler et al., 2019; Mahler et al., 2013; Trumbo et al., 1999). Drought and weather fluctuations seem to have the biggest effect on the public's perceptions and behaviors related to water (Gholson et al., 2019; Trumbo et al., 1999).

The last decade has been a period of significant change in Oklahoma in regard to water resource issues and management. Similar to Texas, Oklahoma endured its hottest and third driest summer on record in 2011 (National Weather Service, 2011). This served as the impetus for passage of House Bill 3055 (*The Water for 2060 Act*) in 2012 (OWRB, 2011), whereby Oklahoma established a statewide goal of consuming no more fresh water in 2060 than was consumed in 2010. Concurrently, in 2012, the state finalized its most extensive water planning effort completing its *Update of the Oklahoma Comprehensive Water Plan* (OWRB, 2011) which consequently had been initiated in response to a devastating drought in 2006. This, in conjunction with a number of bills and court cases addressing out-of-state use of water and tribal water ownership during the late 2000s and early 2010s, (OWRB, 2011) set the stage for how the state views and manages water in Oklahoma.

Other changes occurred over this time as well, influencing Oklahoma's water use patterns and perceptions. According to the US Census Bureau (2019), the state population grew by over 190,000 residents (> 5%) and increased in cultural diversity with most of this increase occurring in the Hispanic community, which almost doubled between 2000 and 2010. Economically, state revenues declined resulting in far reaching impacts on water resources monitoring, management, and education/outreach programs. During this timeframe, the state's Cooperative Extension Service (CES) appropriations alone declined by over 30% impacting education program delivery and effectiveness. Despite these funding reductions, the Extension Service, state agencies, municipalities, and others continued to provide education and outreach to the public on water resource issues, although at a reduced level.

Core Ideas

- The most frequent response to water knowledge related questions was '*don't know*'.
- Although weather has changed significantly, the Oklahomans' opinions have not changed.
- Participants were unfamiliar with watersheds and pollutants that cause water quality issues.

To better understand the public's perceptions, attitudes, and learning preferences regarding water, CES administered a statewide survey in 2008, just prior to the events described above, as part of a larger national effort. Unfortunately, state level results from this survey were not analyzed prior to this study. In our current study, we seek to utilize this 2008 data and new data collected via a follow-up survey to evaluate decadal changes in Oklahoma's perceptions, knowledge, and behavior between the period of 2008 and 2018 and possible implications on future environmental education campaigns.

1.1 | Purpose and objectives

Three research objectives guided the study. We sought to assess the cumulative impacts of changes in population, climatic events, and educational programs on Oklahoma's:

1. perceptions of water,
2. knowledge of water and water related problems, and
3. behavior related to water.

2 | MATERIALS AND METHODS

In 2008, the Water Issues in Oklahoma survey was issued as part of the National Water Needs Assessment Program (Mahler et al., 2013). The survey was replicated in 2018 as a follow-up to the initial study. The 53-items survey included four sections assessing environmental perceptions, drinking water issues, preserving and protecting water resources, and respondents' demographics. To reach our population of interest (i.e. the Oklahoma public), a random sampling method was implemented in both 2008 and 2018 through the purchase of a resident mailing list for Oklahoma from a commercial. provider. The 2008 list included 512 Oklahoma residents, while the 2018 study utilized a randomized mailing list of 2000 residents. Mailings followed the tailored design method (Dillman et al., 2014) through four rounds of communication

to increase participant response rate. The initial survey was sent out via postal mail to the entire mailing list with a personalized cover letter, a survey questionnaire, and a postage paid, return addressed survey reply envelope. A reminder postcard was distributed to all potential participants two weeks after the initial mailer. All non-respondents were contacted a third time with an additional complete survey packet four weeks after the initial survey was sent. A final postcard reminder was distributed to all non-respondents six weeks after initial contact. The research team removed individuals from the list between follow-ups who returned a completed survey or indicated they did not want to participate in the study. Out of the 512 initial surveys sent out in 2008, 264 (52%) were returned as completed surveys. In 2018, 192 survey packets were returned postmarked undeliverable, while 414 surveys were returned by respondents, providing an adjusted response rate of 22.9%. Of the 414 surveys returned, 401 surveys were completed and available for analysis. The demographics of both participant groups are presented in Table 1.

This study evaluated descriptive comparisons between the two survey years to answer the three research objectives. The first research objective aimed to identify the perceptions of the Oklahoma public regarding important water issues. To accomplish this, we analyzed responses from question 1 of the survey which asked respondents to rate the importance of 27 water issues on a five-point Likert-Type scale of agreement (i.e., 1 = Not Important, 2 = Somewhat Important, 3 = No Opinion, 4 = Very Important, 5 = Extremely Important) . The analysis included mean scores and standard deviations to rank the 27 water issues, performing an analysis of variance (ANOVA) to assess differences between issues, and using t-tests to determine differences between years.

The second research objective utilized responses from two questions to determine knowledge of water and water related problems. The first question asked if the participant knew if any of 12 potential pollutants (i.e., pathogens, fertilizer/nitrates, fertilizer/phosphates, heavy metals, minerals, pesticides, salinity, pharmaceuticals, petroleum, algae, sediment, or turbidity) affect the surface or groundwater in their area. Answer choices ranged from '*Know it is a problem'* to '*Know it is not a problem'* on a five-point scale. The second question for research objective 2 was a '*Yes/No'* question asking if the participant knew what a watershed was. Data were reported as response percentages after being analyzed.

The final research objective aimed to evaluate participants' behavior related to water. Two survey questions were used to determine behavioral changes, the first question asked participants if they tested their home drinking water, with a '*Yes'* or '*No'* response. The second question addressed participants actions toward water conservation efforts on an individual or community level, where they could select all potential answers that applied to them (i.e., changed the way your yard is landscaped, changed how often you water your yard, changed your use of pesticides, fertilizers, or other chemicals, pumped your septic system, and adopted new technologies such as low flow showerheads, high-efficiency washing machines or dishwashers, etc.). After data analysis, frequencies and percentages were used to compare the changes over the 10-year period.

TABLE 1 Relevant Demographics Comparisons

Demographics		2008% (*n*) (*n = 264*)	2018% (*n*) (*n = 401*)
Gender	Male	69.7 (184)	45.8 (184)
	Female	30.3 (80)	42.5 (171)
	No response		11.7 (46)
Years lived in Oklahoma	All my life	47.5 (126)	40.5 (162)
	More than 10 years	37.7 (100)	44.3 (177)
	5 to 9 years	7.5 (20)	3.0 (12)
	Less than 5 years	3.8 (10)	1.5 (6)
	No response	3.5 (8)	10.7 (43)
Size of residence community	> 100,000	29.4 (78)	31.3 (125)
	25,000 to 100,000	26.8 (71)	20.3 (81)
	7,000 to 25,000	15.1 (40)	14.5 (58)
	3,500 to 7,000	7.2 (19)	9.5 (38)
	< 3,500	12.5 (33)	17.0 (68)
	No response	8.0 (23)	7.4 (30)
Education	Less than or some high school	5.3 (14)	3.8 (15)
	High school graduate	16.6 (44)	19.0 (76)
	Some college	33.6 (89)	34.8 (139)
	College graduate	23.8 (63)	24.0 (96)
	Advanced college degree	15.8 (42)	16.8 (67)
	No response	4.9 (12)	1.8 (7)
Age	18 to 34	6.0 (16)	5.0 (20)
	35 to 49	19.7 (52)	15.0 (60)
	50 to 64	35.5 (94)	29.5 (118)
	65 years or older	34.3 (91)	38.8 (155)
	No response	4.5 (11)	11.7 (47)
Residence Location	Inside city limits	75.1 (199)	63.3 (254)
	Outside city limits, not farming	14.0 (37)	24.9 (100)
	Outside city limits, farming	7.5 (20)	10.3 (41)
	No response	3.4 (8)	1.6 (6)

TABLE 2 Comparison of water priorities for the general public in Oklahoma between 2008 and 2018

	2008		2018	
Water Issue	***M (SD)***	**Rank**	***M (SD)***	**Rank**
Clean drinking water	5.0 (0.38)	1	5.0 (0.16)	1
Clean rivers and lakes	4.7 (0.63)	2	4.8 (0.49)	2
Clean groundwater	4.7 (0.63)	3	4.7 (0.59)	3
Improving water quality monitoring to detect pollution	4.6 (1.42)	4	4.5 (0.78)	5
Water for agriculture	4.5 (0.85)	5	4.5 (0.69)	4
Educating municipal officials	4.5 (1.54)	6	4.3 (0.85)	10
Improving wastewater treatment	4.4 (1.01)	7	4.4 (0.78)	7
Water for aquatic habitat	4.3 (1.03)	8	4.4 (0.79)	6
Making water quality & quantity data available to public	4.3 (1.56)	9	4.3 (0.87)	9
Improving agricultural practices	4.3 (1.23)	10	4.2 (0.82)	13
Water for commerce/ industry/power	4.3 (0.90)	11	4.1 (0.88)	14
Residential water conservation	4.3 (1.17)	12	4.3 (0.87)	12
Water for municipal use	4.2 (1.04)	13	4.3 (0.79)	11
Preserving agricultural land & open spaces	4.2 (1.42)	14	4.3 (0.78)	8
Building new water storage structures (dams, reservoirs)	4.1 (1.28)	15	4.1 (1.02)	15
Better management of shoreline access to prevent erosion	4.0 (1.54)	16	4.0 (1.01)	17
Preserving & restoring buffer zones & wetlands	3.9 (1.42)	17	4.0 (1.00)	16
Improving home & garden practices	3.9 (1.35)	18	3.8 (1.01)	22
Treating stormwater runoff	3.9 (1.30)	19	3.9 (0.96)	18
Better management of recreationalactivities (boating, fishing, ATVs)	3.8 (1.55)	20	3.8 (1.03)	20
Water for recreation	3.8 (1.23)	21	3.8 (1.01)	21
Within state transfer/ sale of water rights	3.8 (1.19)	22	3.9 (1.12)	19
Interstate transfer/ sale of water rights	3.6 (1.50)	23	3.8 (1.26)	23
Water for household landscapes	3.5 (1.29)	24	3.5 (1.29)	24

Note. Scale of agreement was based on the following, 1 = Not Important, 2 = Somewhat Important, 3 = No Opinion, 4 = Very Important, 5 = Extremely Important.

3 | RESULTS

3.1 | Research Objective 1: What impact have changes in population, climatic events and educational programs had on public perceptions of water in Oklahoma?

Participants were asked how important each of 27 identified water issues were to them on a five-point Likert-type scale of agreement. In both 2008 and 2018, mean scores from the respondent groups resulted in scores of 3.46 or higher on all items. Despite meaningful gap in respondent gender between surveys, there were no statistically significant differences between the public's perceptions in 2008 and 2018 and the top five priorities in both years remained essentially the same with only the fourth and fifth priorities flipping in 2018 (Table 2). In 2018, less variability was observed in public opinion than in 2008 as indicated by standard deviations (SD). Although differences in mean scores exist between each of the items, when clean drinking water (ranked 1 for 2018) and water for household landscapes (ranked 24 for 2018) are compared to other water issues, the ANOVA resulted in a non-statistically significant difference $f(1, 516) = 0.062$, $p > .05$, indicating the perceived importance of all water issues to respondents.

3.2 | Research Objective 2: What impact have changes in population, climatic events and educational programs had on knowledge related to water and water related problems in the Oklahoma public?

Oklahomas' knowledge of water issues was determined by their responses to two questions, the first of which asked whether they know if any of 12 potential pollutants (i.e., pathogens, fertilizer/nitrates, fertilizer/phosphates, heavy metals, minerals, pesticides, salinity, pharmaceuticals, petroleum, algae, sediment, or turbidity) affect the surface or groundwater in their area. For all 12 potential pollutants,

TABLE 3 Comparison of percentage of participants identifying pollutants impacting water quality

	Not a Problem		Don't Know		Known/Suspected Problem	
Issue	**2008**	**2018**	**2008**	**2018**	**2008**	**2018**
Pathogens	19	20	51	**49**	26	27
Fertilizers/Nitrates	15	16	**42**	40	40	**42**
Fertilizer/Phosphates	14	15	**44**	**42**	39	40
Heavy Metals	18	19	**54**	**52**	25	28
Minerals (iron, manganese, calcium) Turbidity (muddy water)	16	18	51	**46**	30	35
Pesticides	15	17	**44**	**43**	38	38
Salinity (water too salty)	**41**	33	**45**	**43**	10	12
Pharmaceuticals (antibiotics, personal care products)	25	26	**53**	**51**	19	21
Petroleum products/ bi-products	19	21	**47**	**47**	31	30
Algae	17	19	**45**	**42**	27	38
Sediment	24	16	**45**	40	27	**43**
Turbidity	13	20	23	35	23	**43**

Note. Not a problem = Participants selecting know it is not a problem or suspect it is not a problem, Don't know = Participants who selected don't know, Known/Suspected problem = Participants who selected suspect it is a problem or Know it is a problem. Any missing percentage is accounted for by participants not responding.

'Don't know' was the most frequent response with an average of 42.7% of participants selecting this option over both years on a five-point scale of agreement (i.e., 1 = Know it is not a problem, 2 = Suspect it is not a problem, 3 = Don't know, 4 = Suspect it is a problem, and 5 = Know it is a problem). In fact, only turbidity exhibited a *'Don't know'* response rate of less than 40%. Salinity was generally considered the least problematic with 41% and 33% identifying it as not a problem in 2008 and 2018, respectively. Table 3 provides a comparison of percentages of respondents divided into 3 categories based on their selection from one of the five options related to pollutants impacting water quality (i.e., Category 1 knows or suspects it is *not* a problem, category 2 does not know, and category 3 suspects or knows it is a problem). Any item over 40% is bolded to emphasize the items with the largest percentages. Little change (< 5%) in respondents' perceptions of pollutants being known/suspected problems were observed between years for most (9) pollutants. However, substantial (10-20%) increases were observed between 2008 and 2018 in respondents' perceptions of algae, sediment, and turbidity being known or suspected problems. This resulted in turbidity and sediment being ranked 1 and 2 as the most identified pollutants impacting water quality in 2018 in comparison to 2008 when they were ranked 10th and 6th, respectively.

The second question regarding respondents' water related knowledge found that there was no change in the percentage of respondents who knew what a watershed was. In both years, 64% of respondents felt that they knew what a watershed was, with the remaining 36% not knowing or not responding.

3.3 | Research Objective 3: What impacts have changes in population, climatic events and educational programs had on the public's behavior related to water in Oklahoma?

When considering behavioral change amongst the Oklahoma public between 2008 and 2018, we considered two items from the survey to measure this change. The first measure was that of residents testing their home drinking water, of which an insignificant increase was identified as 12.1% tested their water in 2008, while 13.3% of the Oklahoma public surveyed participated in this behavior in 2018. The second measure addressed the public's efforts to conserve water. In 2008 80.7% of participants stated they had changed their yard watering habits, while 19.3% had physically changed their landscape to help conserve water. In 2018, only 58.0% of participants reported having changed their yard watering habits; however, 62.1% integrated a new water saving technology in their home, 35.7% changed their pesticide and/or fertilizer usage, 18.8% changed their yard landscape, and 13.1% had their septic tank pumped.

4 | DISCUSSION

Changes in Oklahoma's perceptions, knowledge, and behaviors related to water between 2008 and 2018 have been minimal, if at all, despite landmark water legislation and planning, catastrophic drought, and changing population in the state over the past decade. The top five water priorities for

the Oklahoma public in 2018 were clean drinking water, clean rivers and lakes, clean groundwater, water for agriculture, and improving water quality monitoring, with the only change from 2008 being water for agriculture moving into the fourth spot over improving water quality monitoring. The importance of clean water is unsurprising and similar to recent findings from a study of the perceptions of secondary students in the college of agriculture in Oklahoma, which identified clean drinking water to be of greatest concern (Eck et al., 2020). However, it is a bit surprising that water quality monitoring would be a top water issue. For several decades, the volunteer monitoring program, Blue Thumb, has been the most extensive water education program in the state and perhaps it is these efforts producing the high priority placed on water quality monitoring.

On the other end of the spectrum, we found it surprising that water rights and interstate water sales were a low priority, particularly in 2018, as significant and heated legal debate and actions occurred in Oklahoma in the intervening decade between the two surveys. In 2009, prompted by efforts by the growing Dallas-Fort Worth Metroplex to secure water supply sources from Oklahoma and ensuing lawsuits, the Oklahoma Legislature adopted House Bill 1483 requiring legislative approval of water apportionments to out-of-state water compacts. Further, in 2011, the Choctaw Nation and Chickasaw Nation filed a lawsuit against Oklahoma City, the city's water utility trust, the state water management agency and the Oklahoma Governor regarding the sale of water from their region to said city (OWRB, 2011).

In contrast to Oklahoma, Texans' water priorities changed substantially between 2008 and 2014 due to the severe drought experienced by the state in 2011 and increasing populations/water demands (Gholson et al., 2019; Mahler et al., 2013), current and future water quantity became a leading concern. Similarly, Nevada residents have been found to change their perceptions between wet years and dry years (Trumbo et al., 1999) and Castro et al. (2011) found Hawaiians to change some of their perceptions on water between 2004 and 2010 related to water quality and availability for industry and recreation. Perhaps we are observing the effects of the hydro-illogic cycle whereby Oklahomas memory of the *dry years* had dimmed during the intervening period between the two surveys. During and immediately preceding the 2008 survey (i.e. 2007–2009), statewide rainfall totals in Oklahoma exceeded the long-term average rainfall by 4–10 inches. Similarly, 2017–2018 were above average rainfall years with 4–7 inches above average rainfall statewide. However, from November 2, 2010 through May 26, 2015, the state experienced severe drought with statewide rainfall totals falling to > 8 inches below average in 2011–2012 (CS, 2018). During this drought, Oklahoma suffered $2 billion in losses. According to the National Weather Service, Oklahoma endured its hottest and third driest summer on record in 2011, destroying crops and grazinglands, creating favorable conditions for devastating wildfires, reducing lake and river levels to record lows and triggering widespread toxic blue-green algae blooms. Alternatively, the lack of change in water resource perceptions could be the result of more long-term rainfall trends experienced in the state. Despite precipitation being expected to decrease 6–10% by 2100 (SCIPP, 2014), Oklahoma has seen precipitation increases of 10–20% in the eastern two-thirds of the state and 2–10% in the southwestern region between 1901 and 2015, and little change in the Oklahoma Panhandle region (NOAA, 2016).

When we evaluated changes in water related knowledge between 2008 and 2018, no significant differences were found between the two survey years. However, there are notable differences between the public's perceptions of key water quality impairing pollutants and what the state's water management agencies have found. In 2018, the top pollutants perceived to be causing water quality issues were turbidity, sediment, and fertilizers, while in 2008 they were fertilizers, pesticides, and petroleum products. This compares to state reports (DEQ, 2008, 2018) indicating the predominant causes of lake impairment were low dissolved oxygen (DO), turbidity, color, and chlorophyll a in 2008 versus turbidity, mercury, DO, and chlorophyll a in 2018. The predominant causes of stream impairment were *enterococcus*, turbidity, *E. coli*, and fecal coliform in 2008 versus *enterococcus, E. coli*, turbidity, and dissolved oxygen in 2018. This demonstrates an improvement in the alignment of the public's perception of key pollutants in the state with those identified by state reports between 2008 and 2018. In 2008, only two causes of impairment identified by the state (lake DO and chlorophyll a) are aligned with a perceived pollutant (fertilizer). Whereas in 2018, five of the causes of impairment identified by the state (lake turbidity, DO, and chlorophyll a; stream turbidity and DO) are related to the public's top three perceived pollutants (turbidity, sediment, fertilizers). Turbidity and algal blooms, commonly associated low DO, sediment, fertilizer, and chlorophyll a, are visually observable. However, there is an obvious disconnect between the public's awareness of the 'unseen' water issues identified by monitoring efforts (mercury in lake water and bacteria in streams).

Of greatest concern is the response of '*Don't know*' as the most frequent response to water knowledge related questions. Survey participants were unfamiliar with watersheds with 36% indicating they '*Don't know*' what a watershed was and over 40% indicating they '*Don't know*' what pollutants cause water quality issues in each data collection period. These findings are consistent with research studies in the Northwestern United States and Hawaii (Castro et al., 2011; Mahler et al., 2019). A recent study in Oklahoma which evaluated the perceptions of secondary students in the college of agriculture also found their knowledge related to water lacking (Eck et al., 2020). This gap suggests prior education programs

have either been ineffective and/or inadequately delivered. The latter is likely a significant contributor due to the significant reductions in funding for Extension and other state agencies. Although funding for the Oklahoma Cooperative Extension Service peaked in fiscal year 2009, it has declined by over 30% since then, impacting all educational programming including funding for water programs. Greater investments will likely be required to improve the public's water knowledge and ultimately meet future water needs. More effective delivery will be required as well. These efforts will require the use of printed materials and television (for those over 50), along with social media and informational videos (for those under 34) to reach the broader public (Eck et al., 2019).

Ultimately, these education programs seek to achieve behavioral changes which conserve and yield cleaner water. Behavioral changes in water usage for Oklahoma's were found to be minimal if at all. While overall conservation efforts remained similar, an increase was identified in 2018 related to technology implementation to conserve water, while there was a decrease in changes to yard watering habits. Again, perhaps additional education related to water conservation and technology is needed across the state to produce necessary behavioral changes.

5 | IMPLICATIONS

This study found that long term evaluations of public perceptions, behaviors, and knowledge are extremely important in determining education program effectiveness. In this case, findings from this study and other states' water surveys indicate the status quo will not yield needed changes. With Oklahoma's population expected to grow to over 4.4 million by 2040 (University of Virginia Weldon Cooper Center, 2018), it will be increasingly important to educate the public to ensure water needs are met. New, more effective water education programs must be developed and implemented throughout Oklahoma. Successful programs from other states such as Watershed Steward programs, Well Owner Networks, Riparian Education, and water conservation programs could easily be modified and implemented in Oklahoma. Water related education programs include city programs such as Oklahoma City's Squeeze Every Drop, the Oklahoma Conservation Commission's Blue Thumb statewide citizen science program, Extension programs on poultry waste management, pond management, septic systems, irrigation management (rural and urban), low impact development, stream processes (via stream trailer), as well as 4H Water Fairs. Local, state, national, and private funding for fully implementing these along with "Water for 2060" Education Programing and others (e.g., Rural Water Education) is needed, along with extensive coordination and collaboration among agencies, universities, municipalities, nonprofits, and others interested in and concerned with preserving water resources and improving their management. In addition to developing and implementing these programs, efforts are needed to evaluate the impact of the programs on participants' change in perceptions, knowledge, and ultimately their behavior related to water stewardship and conservation.

Future research should compare how local water quality and known impairments in the immediate area affect respondents' perceptions regarding water resource issues. Further, research on public perspectives on water issues should evaluate how audience ethnicity should be considered in program development, as Oklahoma has a growing Hispanic population who could benefit from purposeful and targeted water education programming. Further, the Native American population in the state may have different water perceptions, knowledge, and behaviors, that should be considered. Similar statewide surveys should be updated based on water trends and needs every five years to provide longitudinal data on the public's perceptions of water. It is recommended that the paper survey used in both 2008 and 2018 be continued to reach older demographics, while adding an electronic survey option for younger demographics to help increase participation and response rate. Lastly, questions such as those seeking to understand water priorities for the general public (such as those listed in Table 2) be updated so that respondents not only rate each according to their perceived importance, but they are also asked to rank issues in order to get a better understanding of their priorities.

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