Center for Climate Communication
University of California, Merced

Survey of California Water Resource Managers and Climate Change

Carol A. Hart, Professor LeRoy Westerling, and Professor Teenie Matlock, UC Merced

Summary

I have completed a survey of California water resource managers with guidance from Professor LeRoy Westerling, Director of the Center for Climate Communication and Professor Teenie Matlock, McClatchy Chair of Communications and Professor of Cognitive Science, both at the University of California Merced. This survey result summary will be used to help educate the public about how climate change may affect water resource management decisions in California. Complete survey responses were received from 47 California water resource managers from February 1, 2018 through May 25, 2018.

The eight survey questions are: What is your work place zip code; Which natural resources are you managing; Where do you find information on climate change used in making your management decisions; How has climate change affected your resource management; What time scales are you considering in your resource decision making; What do you consider as the biggest problem(s) if climate change is not addressed; How do you define climate; How do you define climate change.

Special Recognition: Our survey outreach was assisted by Armando Quintero, Executive Director of the Sierra Nevada Research Institute at UC Merced; David Boland, Director of State Regulatory Relations at the Association of California Water Agencies (ACWA); Carole Combs of the Tulare Basin Watershed Connections Collaborative; Jennifer Morales, SR Environmental Scientist at California Department of Water Resources' Climate Change Program; and Michelle Selmon, former Climate Change Specialist/Senior Environmental Scientist at the California Department of Water Resources and currently Environmental Program Manager at California Department of Fish and Wildlife.

Objective

Our objective is to use the results of this study to help educate the public about how climate change may affect water resource management decisions in California. The

summary report will be made available to the public by University website publication and distribution to all agencies involved in the survey outreach.

Methods

We utilized a Qualtrics survey platform and reached approximately 500 individuals either by ACWA email recipient lists or by survey link shared on multiple water resource websites. We received 130 recorded responses (26% response rate) of which 47 were complete, resulting in a 9.4% completed response rate. Respondents were asked to provide their names to assure that there was no duplication, but remain anonymous.

We utilized Wordle.net software to create word cloud figures that visually demonstrate survey responses. In word cloud figures, the relative font size of each word is proportional to the frequency with which it is used in any given data set.

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
UNIVERSITY OF CALIFORNIA, MERCED
Study Title: Quick Survey Purpose and Background: Carol Hart, Dr. Leroy Westerling, and Dr. Teenie Matlock from the University of California, Merced Center for Climate Communication are conducting a water resource manager study. **Procedures:** If you agree to be in this study, the following will happen: You will complete a short survey on the computer. Participation in this study will take less than 1/2 hour. All study procedures will be done at a location chosen to the participant. **Risks:** There are no physical risks associated with this study. **Benefits:** There will be no direct benefit to you by participating in this study. **Payments:** You will not be paid for participating in this research study. **Confidentiality:** All records from information gathering activities associated with this study will be confidential and not linked to you by name. Some information may be published in reports or presented at meetings, but will not identify you or any participating individuals. **Right to Withdraw from the Study:** You may refuse to participate in this study. You may change your mind about being in the study and quit after the study has started. **Questions:** If you have any other questions about the study, you may contact Carol Hart by e-mail at chart5@ucmerced.edu. If you have any complaints or concerns about this study, you may address them to Linda-Anne Rebhun, IRB Chair of the IRB, who can be reached at (209) 383-8655, UC Merced, 5200 N. Lake Rd., Merced, CA 95343; rci@ucmerced.edu. **Consent:** Participation in this research is voluntary. You have the right to decline to participate or to withdraw at any point in this study without penalty.
By clicking to continue you are acknowledging: I have read this consent and understand that I am free to ask questions via email or phone. I understand that I may request a copy of this consent form.

1. What is your work place zipcode:

2. Which natural resources are you managing?

3. Where do you find information on climate change used in making your management decisions?
Please list up to five of your resources, (state, federal, county, civic, social media, scientific journals, newsprint, websites, and other media) and then rate each one on a scale of 0 (occasionally untrustworthy not very useful) to 100 (extremely trustworthy and useful.)

4. How has climate change affected your resource management, using a scale of 1 (not at all) to 10 (greatly)?

5. What time scales are you considering in your resource decision making? Check all that apply. (options to choose: days, weeks, months, seasons, years, other:)

6. What do you consider as the biggest problem(s) if climate change is not addressed?

7. How do you define climate?

8. How do you define climate change?

Thank you for your participation in this survey. The results will be available to resource managers and to a community of climate scientists engaged with ClimateFeedback.org, gauging trust in various information sources.

Figure 1. Survey Text

Results

Question 1: What is your work place zip code?

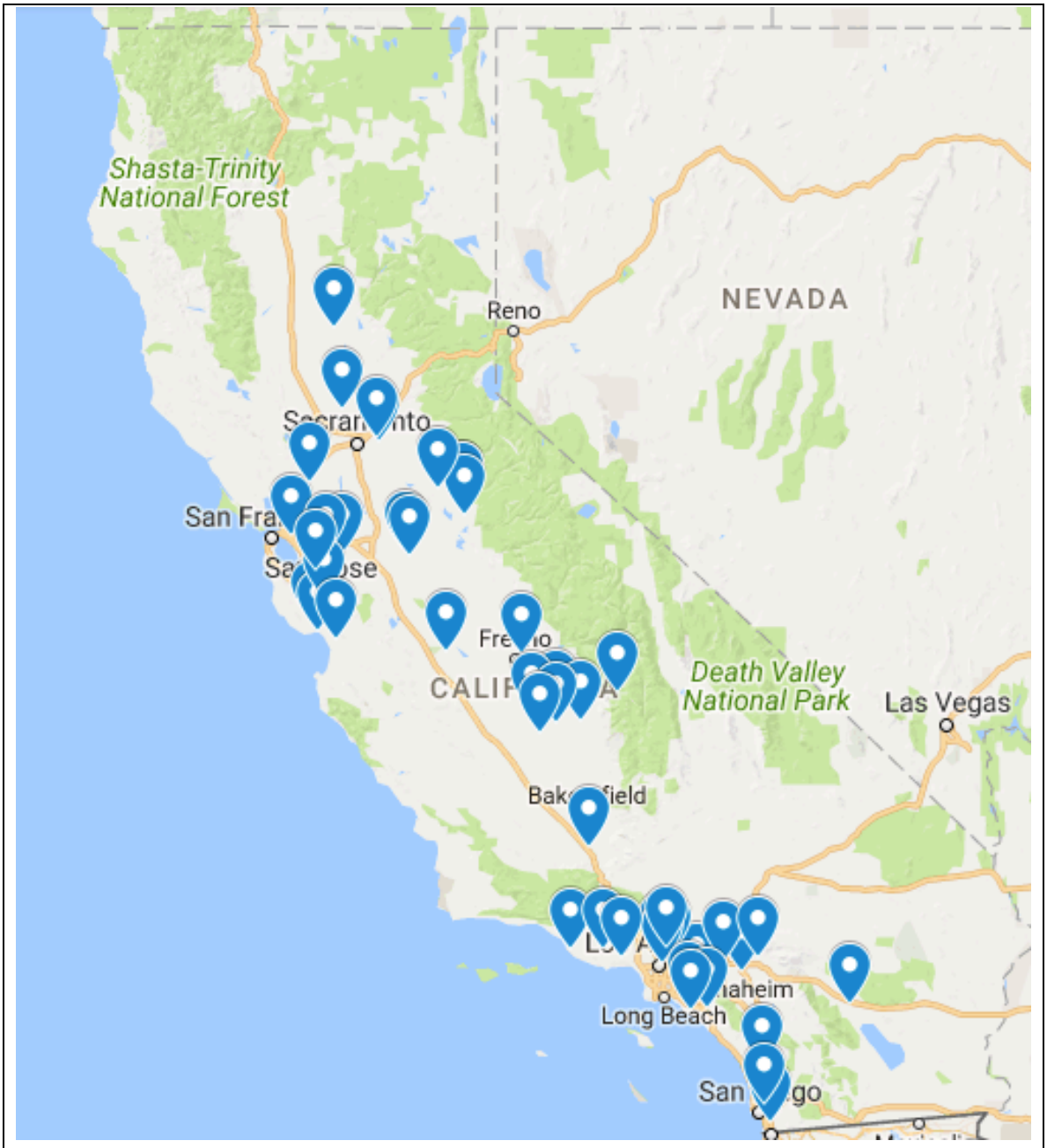

Figure 2. Respondent zip codes: 90012, 91011, 91101, 91203, 91302, 91360, 91730, 91910, 92069, 92123, 92201, 92346, 92501, 92618, 92627, 92708, 92870, 93035, 93212, 93230, 93247, 93271, 93274, 93277, 9331, 93622, 93726, 94533, 94538, 94550, 94566, 94610, 95010, 95066, 95076, 95118, 95249, 95310, 95350, 95354, 95370, 95608, 95670, 95676, 95958

All zip codes were listed by one respondent with the exception of two zip codes that had two respondents each.

Question 2: Which natural resources are you managing?

One hundred percent of respondents indicated that they manage water. Some respondents listed additional resources managed including land (4); sewer (1); endangered species (1); wetlands (1); soil (1); habitat (2) and trash (1). Of the respondents who listed water as their managed resource, 30 specified water only, 8 indicated ground water, 5 for recycled or waste water, 2 for agricultural water, 5 for surface water, 2 for wetlands, 1 for potable water, and 12 listed water in combination with land, soils, vegetation, endangered species, recreation, and/or energy.

Question 3: Where do you find information on climate change used in making your management decisions?
Please list up to five of your resources, (state, federal, county, civic, social media, scientific journals, newsprint, websites, and other media) and then rate each one on a scale of 0 (occasionally untrustworthy not very useful) to 100 (extremely trustworthy and useful.)

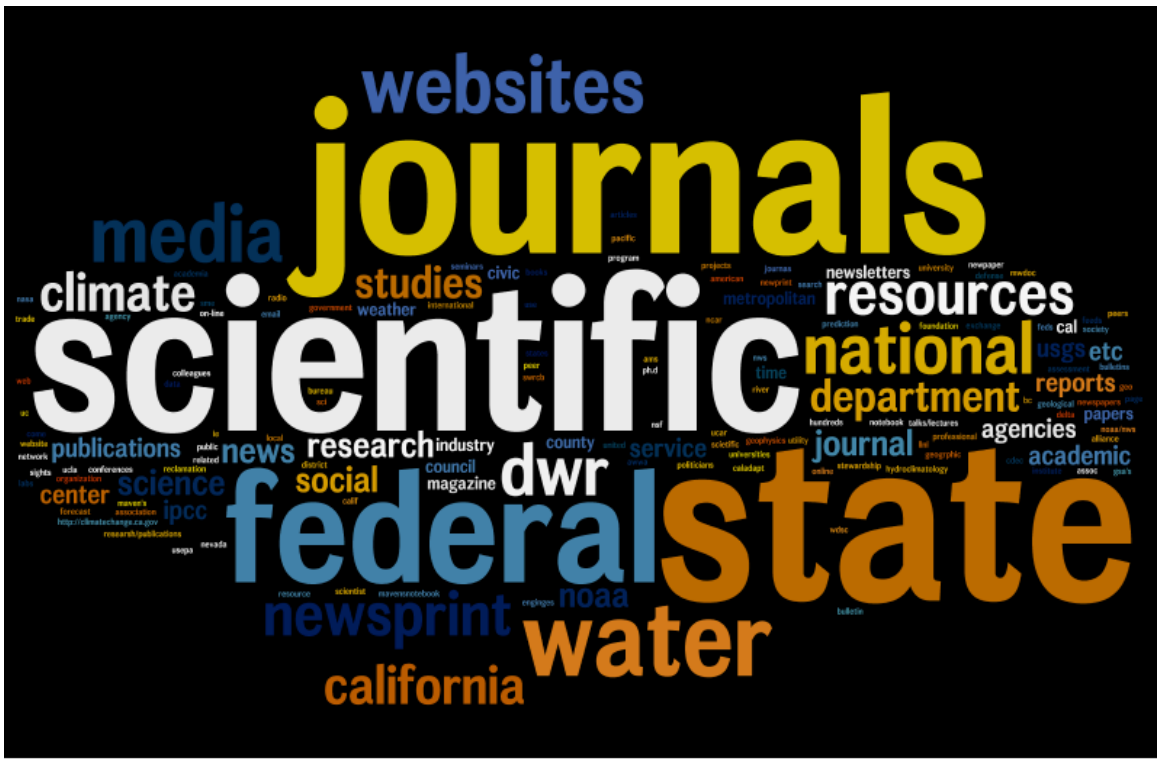

Figure 3. Word cloud representation of all respondent words to Question 3: Where do you find information on climate change used in making your management decisions? The more often a word was used by respondents, the larger the font size. All responses in the data set were used for this word cloud.

Question 3: Where do you find information on climate change used in making your management decisions? Responses:

ating	Resource 1	Rating	Resource 2	Rating	Resource 3	Rating	Resource 4	Rating	Resource 5
90	NWS	90	DWR	95	Our own studies	70	Journals	40	Other
57	GSA's	70	climate newsletters	70	Time	83	National Geogrphic	83	seminars
100	state		federal - 100		newsprint - 75	100	scientific journals	50	other media
100	State	80	Federal	90	scientific journals	70	websites		
100	Scientific journals	100	State	100	Federal	100	County	95	Social media
90	State	64	Federal	50	University	50	Scientist	10	Politicians
80	Association of California Water Agencies	61	Social Media	71	Colleagues				
90	Scientific American	80	Newpaper Articles	100	Journal Studies				
74	State websites	53	Social media	87	Professional journals	87	Industry peers	80	Email news fee
85	Federal	61	academic	85	scientific				
90	I use my Ph.D. in Hydroclimatology research	85	I have hundreds of research studies and papers						
30	websites	96	scientific Journals	65	federal	88	state -	25	newsprint
40	Federal	45	scientific publications	60	academia	2	State	1	Newsprint
20	News	25	Government						
85	CalAdapt	80	Cal Climate page: http://climatechange.ca.gov/	80	USEPA	79	National Climate Assessment	90	IPCC
80	DWR bulletins	50	on-line	60	reports that come out over time				
80	State	50	Federal	70	Scientific Journals	10	Websites	5	Newsprint
100	Department of Water Resources (DWR) (Bulletin 120)	100	National Weather Service	100	DWR California Data Exchange Center	90	Climate Prediction Center	90	California Neva

					(CDEC)				
91	State Department of Water Resources	92	National Weather Service, NOAA	72	scientific journals				
90	dwr	90	usgs	90	noaa	50	science magazine	70	geophysics jou
90	State: DWR, SWRCB	80	Conferences	75	Scientific Journals	70	Pacific Institute	60	NCAR, UCAR
80	IPCC reports	24	federal researsh/publicat ions	51	state publications such as by DWR	55	scietific journas	52	peer agencies
62	National Labs ie) LLNL	16	UC scientific papers	6	Science Journals	6	State of Cal Web sights	10	SME Talks/Lect
90	Metropolitan Water District	90	MWDOC	70	State of California	90	Scientific Journals	90	AWWA
90	BC Water News	89	Maven's Notebook	83	other online search enginges				
70	industry journals	80	newsletters	90	National Public Radio	70	newspapers	50	Federal resour
80	NOAA	80	USGS	75	NASA	70	NSF	75	National Geo S
23	State	24	Feds	4	Civic	19	Science Journal	3	Trade Journals
90	state	90	scientific journals	75	websites	70	federal	60	civic
70	NOAA/NWS	70	California Department of Water Resources	70	US Bureau of Reclamation	50	AMS Studies	50	UCLA academic
90	scientific journals	80	Organization Reports	80	state	50	websites	25	newsprint
0									
80	Assoc of Calif Water Agencies	70	Science News magazine						
94	state	94	federal	94	scientific journal	91	county	80	other media
70	California Department of Water Resources	75	United States Geological Service	25	National Resource Defense Council Publications	80	Delta Stewardship Council Scientific Program		
91	State	60	Newprint	90	scientific journals	50	websites		
100	State	80	Federal	100	Universities	100	Scientific journals	50	other media

80	State Department of Water Resources	50	Newsprint	30	Websites				
31	scientific journals	14	state	9	federal	38	website	59	social media
	sci. journals		state		federal				
90	International (IPCC)	90	State	90	Water Utility Climate Alliance	70	Scientific Journals	70	Research Proje
90	Metropolitan WDSC	91	State DWR	91	Federal NOAA	70	Mavensnote book	60	Scientific Journ
84	State	83	federal	95	Local	93	scientific journals	80	newsprint
90	usgs	90	scientific journals		other media	70			
80	scientific research	75	climate related books	75	academic studies	60	water agency network		
70	state								
61	websites	70	journals	50	media				

Figure 4. Rated responses to Question 3: Please list up to five of your resources, (state, federal, county, civic, social media, scientific journals, newsprint, websites, and other media) and then rate each one on a scale of 0 (occasionally untrustworthy not very useful) to 100 (extremely trustworthy and useful.) Each row of answers is from a single respondent. Responses are in their original form; they have not been edited.

Question 4: How has climate change affected your resource management, using a scale of 1 (not at all) to 10 (greatly)?

The mean response is 6.04 with a range of 0 (4 responses) to 10 (5 responses.) The mean response is 6.60 if the four "0" responses are removed from the calculation as they fall outside the data range requested.

Question 5: What time scales are you considering in your resource decision making? Check all that apply.

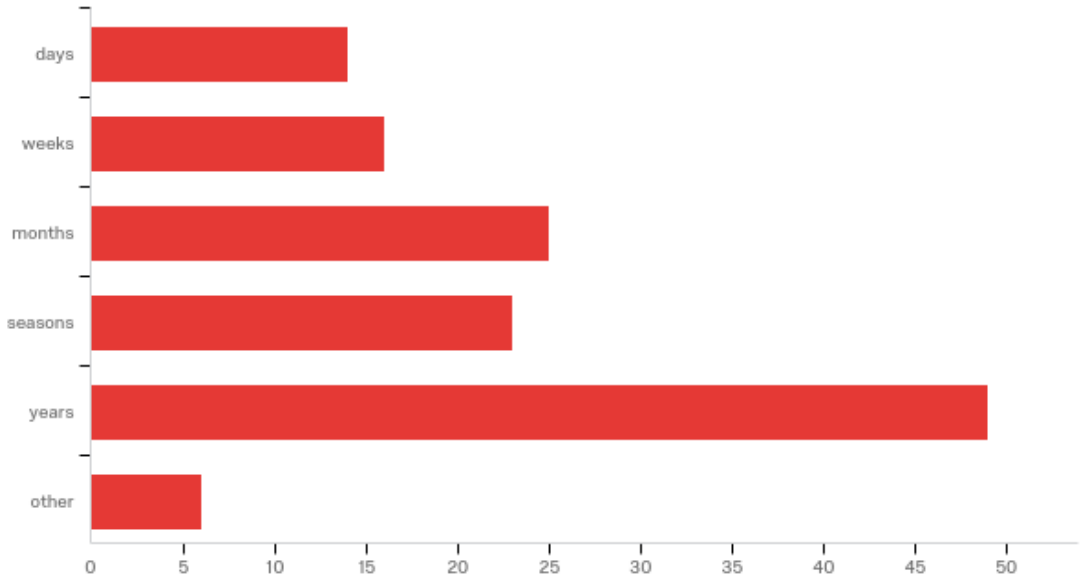

Figure 5. The number of respondents (X-axis) who indicated each time frame for decision making, or time horizon in days, weeks, months, seasons, years, and/or "other" (Y-axis.) "Other" responses include: "decades" (3 respondents); "long term variability"(1); "50-100 yr"(1); and "long term planning horizons (2040, 2100)" (1).

Question 6: What do you consider as the biggest problem(s) if climate change is not addressed?

Individual responses are listed in plain text in Figure 6 and in a word cloud format in Figure 7.

water supply and snow melt season

Extreme climate events

ecosystem collapse world-wide (e.g. Bladerunner 2049)

changes to hydrology

Question 6, continued: What do you consider as the biggest problem(s) if climate change is not addressed?

That our systems will be vulnerable to large climatic extremes they weren't designed for, unable to serve a flood protection or water delivery service.

Shift in farm production

Water supply scarcity

That our weather in turn will become so erratic it will prevent me and my family to continue in the business of farming with the dependability that the California Mediterranean climate provides.

Sea level rise, shifting snowpack melt season

Decline of California economy which is water-dependent. The unraveling of the of the Sierra Nevada due to THE EFFECTS of catastrophic fire.

For us it is saltwater intrusion rendering our water supply unusable
sea level rise, acidification of oceans

The variability in the models and lack of degree of confidence combined with the infusion of politics essentially make climate change less of a management challenge and more of separating the dogma from the data

Lack of water to use for agriculture

Environmental stress (native species and humans); water supply/quality reduced reliability; increased magnitude of storms and flood risk

water content of snow pack and changing of precip and snow seasons

Inadequate supply during irrigation season; Increased flooding; Ocean level rise

Lack of water storage

Loss of Supply, increase flooding, impacts to ag economy and enviornment
increased pressure from State and Federal government to conform

Difficulty in applying existing management practices.

cannot reliable achieve our mission of resource stewardship, water supply and bay protection

Question 6, continued: What do you consider as the biggest problem(s) if climate change is not addressed?

Future Competive Funding

Retail water service needs to be billed to customers as "service" rather than as a sale of water quantity; otherwise revenues will not cover expenses. Water Quality problems also need to be addressed as water conservation in response to climate change poses public health and safety problems; and also strands assets that becove "over-sized" as demand decreases.

Not enough water for the future due to reductions of rainfall and snowfall

Change to historic hydrology

War, Famine, Poverty, Collapse of Civilization and Pandemic Ecosystem Collapse

More surveys like this. We have info and cannot implement because policy makers (elected) must be short term oriented.

Irreversible damage to water resources

impacts to water supplies and infrastructure capacity due to extreme weather conditions

water supply

sea level rise

impacts on food production (temperature, water supply, pests) to supply increasing human needs

Long-term resource reliability

The timing of storage in reservoirs and flood control issues

lack of water resources to support businesses, communities

For our agency, sea-level rise will have the most unarguable impacts, many of the other identified impacts remain conjecture

Ecosystems collapse

water and food insecurity

Question 6, continued: What do you consider as the biggest problem(s) if climate change is not addressed?

Loss of snow pack and diminished ability to manage river flows for water storage/use

Water supply reliability

Failure to perform of infrastructure designed for historical hydrolgy, inability for environmental and water quality regulation to adapt

Irregular weather patterns with less precipitation, less snow more rain.
rising sea level, changes in groundwater recharge

An inadequate water supply to meet human and environmental needs

Water storage

The slow change of climate will not affect us nearly as much as population growth, demands for ever increasing water quality, continued state regulation, technological advances, etc. The slow change of climate will be most likeley addressed within the context of the other larger management drivers in the water industry.

Figure 6. Individual responses to Question 6: "What do you consider as the biggest problem(s) if climate change is not addressed?" Responses are in their original form; they have not been edited.

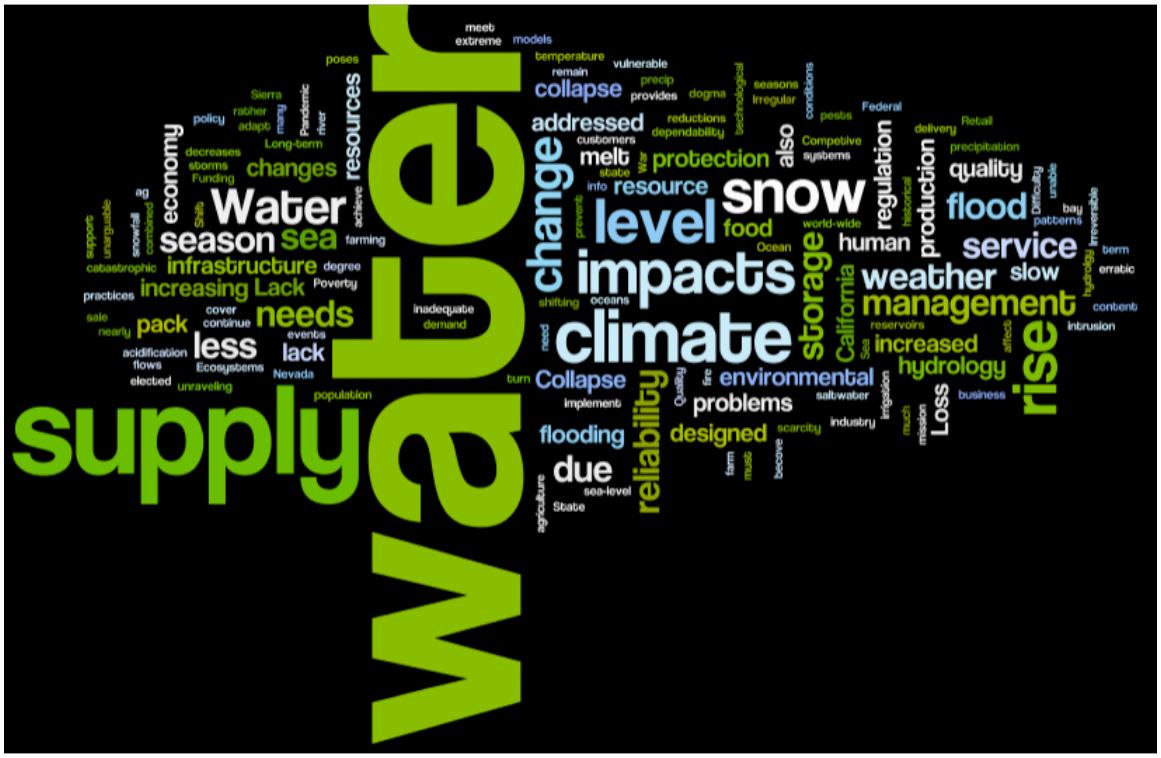

Figure 7. Word cloud representation of all respondent words to Question 6: “What do you consider as the biggest problem(s) if climate change is not addressed?” The more often a word was used by respondents, the larger the font size. All responses in the data set were used for this word cloud.

Question 7: How do you define climate?

Precipitation, Temperature and ET
natural conditions that affect life on our planet
overall seasonal temperature and precipitation
a long term average of weather
Long-term average of weather conditions
The environment that provides weather

Question 7, continued: How do you define climate?

Natural condition of environment

The weather conditions prevailing in an area over a long period. Either locally or the world over.

Predicable weather patterns over many years

An endless system of causes and effects influenced by fire, ice, currents, elements, earth and cycles within cycles.

Long-term averages, extremes, and timings of precip, temp, radiation, etc.

long term average weather 30+years

The weather patterns, temperature and precipitation levels and patterns over a long-term time frame.

How the weather effects other resources

long term weather conditions/patterns

weather conditions in a certain area

The expected weather pattern, measured over a period of years or decades

Timing and amount of snow in watershed

long term trend in climate conditions

pattern of meteorlogical characteristics over a period of time

long term weather patterns

typical weather pattern expected over a period of decades

Climate is the statistics of weather over long periods of time. It is measured by assessing the patterns of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods of time.

The condition of the earth's atmosphere with respect to temperature, moisture/precipitation, pressure, UV index, wind currents, oxygen and carbon dioxide.

Question 7, continued: How do you define climate?

The weather conditions in our environment, including temperature, rainfall, etc...

weather

The range of prevailing wind, precip, temperature, tidal factor that define normative atmosphereic and oceanic conditions for a parti ular region

regional and global weather systems

weather and hydrology

longterm, expected weather patterns

the atmoshperic system that produces our outdoor temperatures, precipitation and to some extent oceanic conditions

weather conditions on a decade time scale

The environment in which we live.

A variety of weather trends and patterns over an extended period of time

temperature, hydrology

The prevailing weather conditions

Overall temperatures, rainfall, weather patterns, etc.

long-term weather

Long-term variability in weather patterns and attendant drought, wet cycles

Long-term weather over a given region

long term weather patterns - their average behavior and the range and frequency of variability

The yearly cycle of heat, wind, and water precipitation

long-term weather patterns

Average and seasonal temperatures, amount and type of precipitation, sunlight intensity (UV radiation), humidity, wind speed/duration

Question 7, continued: How do you define climate?
seasonal weather conditions

The natural irregular patterns of seasons, temperature, percipitation and timing.

Figure 8. Individual responses to "How do you define climate?" Responses are in their original form; they have not been edited.

Question 8: How do you define climate change?

impacts caused by precipitation, temperature and ET such as water supply reliability

change in the natural conditions due to human activity

extreme variations in climate

changes in historical weather patterns caused by anthropogenic increases of GHG concentrations in our atmosphere

A change in climate conditions leading to more extreme swings from observed average conditions

Noticeable shits in weather pattern caused by man or nature or a combination of the two.

Change in air temperature and precipitation

When weather becomes erratic either due to human causes or natural tendencies that make living on Earth more arduous for humans.

A shift in the predicable patterns (seasons don't start and end as they historically have, un-charicteristic precipitation, temperature intensity - hotter hots and colder colds)

A system destabilized (by an event or an aggregate of factors) into disequilibrium and then moving towards equilibrium.

Changes of those climate metrics.

overall global average temperature change with redistribution of climate patterns

The variability over time of changes in the components of climate.

Question 8, continued: How do you define climate change?

The change in our natural systems of weather. Weather changes over time I think we need to expect that.

Significant and 'permanent' shifts in historic climate patterns

evolution of weather conditions

A shift in the expected weather pattern

Snow amounts declining, snow melting earlier, less snow at lower elevations

Changes to the long term trends observed

change in pattern of meteorlogical characteristics over time

abnormality in long term prevailing weather patterns.

change in the above. we are especially concerned over potential for more severe droughts and floods, sea level rise, and temperature impacts for fishery management

Sea level rise, Snow Pack Decline/ Flow change, and the measurable changes in climate over time and projections, through modeling of future changes to come in all aspects of Climate.

Increasing or decreasing amounts of the elements of climate described above.
a rise in temperature and decrease in rainfall/snowfall as a result of the way we use resources in our daily lives, that has dramatically affected the environment. This includes pollutants discharged into the environment from factories and processes.

deviation from the typical weather pattern variability

Documented, sustained variation from the norm

long term change trends to regional and global weather systems

variability of weather and hydrology

deviations in the pattern of anticipated precipitation and temperature patterns

the current trend or change in our climate that is atributable to man kind's influence

a significant shift in minimums, means, and maximums in temperature, precipitation

Question 8, continued: How do you define climate change?

and other weather parameters versus historical averages

The cyclical and environmental changes as compared to historical trends, especially those induced by human behaviors.

Changes in the patterns and weather trends over time

increase and decrease in temperature and hydrology from historic norm

A departure from the statistically 'normal' range of weather including low recurrence events, such as hyper wet or dry events. Climate change, to me, will include either more extreme weather (i.e. drier or wetter than has been historically precedented) OR a change in the frequency of existing extremes, or both.

Global/regional changes in temperatures, rainfall, weather patterns, etc. that result in global changes in the distribution of fresh water availability and shifts in plant and animal populations/distribution

human made global warming

Transitions from one climate pattern to another

The shift in a region's average weather conditions that lasts for an extended period of time

departure from recent historical patterns (period of modern industrial development) of long-term weather patterns

Increased basic temperature, causing more energy in water vapor in the atmosphere, with the irregular resultant precipitation.

changes to long-term weather patterns

A significant departure from historic temperatures, precipitation or other climate characteristics

seasonal weather patterns that have shifted from the average 50 year patterns

a major long term change in the natural irregular patterns of climate

Figure 9. Individual responses to “How do you define climate change?” Responses are in their original form; they have not been edited.

Discussion

Summary:

The average respondent in our survey manages California water resources, makes resource management decisions on the scale of years most commonly, has a job that is affected by climate change, and is most concerned with water availability and quality if climate change is not addressed.

Understanding Climate and Climate Change:

Most respondents have an understanding of the definitions of climate and climate change. Thirty nine of forty seven respondents accurately identified climate as prevailing weather conditions and twenty six accurately defined climate change as significant changes in global temperature, precipitation, wind patterns and other measures of climate that occur over several decades or longer. Some respondents gave examples of the effects of climate change such as decreased precipitation, rather than state the definition, which contributes to a lower percentage of correct responses. In future surveys, one way to minimize this potential problem is to add a statement discouraging the respondent from giving examples, but rather focus on the definition.

Decision making time scales:

Water resource managers, when grouped into Northern California Coastal, San Joaquin Valley and Sierra Nevada Foothills, and Southern California Coastal and Desert regions, make management decisions on all time scales: days, weeks, months, seasons, and years with the predominant time frame for decision making being years (Figures 5, 10.) Water managers in Southern California Coastal and Desert regions focus primarily on season and year timeframes when compared with water managers in Northern California Coastal, San Joaquin Valley and Sierra Nevada Foothills whose regular decision making time frames also include days, weeks, and months.

Some regions of California that are not well represented in this survey include far Northern California and the Eastern Sierra Nevada and Desert regions. Future survey efforts can be improved with additional emphasis placed on those underrepresented regions as well as continuing with those already included. David Boland, Director of State Regulatory Relations at Association of California Water Agencies (ACWA) was instrumental in reaching out to California Water Resource Managers for this survey and we hope to establish as productive a collaboration in future efforts.

Manager Region	Days	Weeks	Months	Seasons	Years	Other	Sample size
Northern California Coastal	33% (3)	33% (3)	67% (6)	44% (4)	100% (9)	33% (3)	9
San Joaquin Valley & Sierra Nevada Foothills	37% (7)	37% (7)	63% (12)	47% (9)	79% (15)	0% (0)	19
Southern California Coastal and Desert	11% (2)	21% (4)	26% (5)	42% (8)	100% (19)	11% (2)	19

Figure 10. Decision calendar for water resource managers by region. Percentage of respondents indicating each time frame for making water resource management decisions, rounded to nearest percent. Raw number of respondents are in parentheses. Percentages from 0-25% are yellow, 26-50% are orange, 51-75% are red, and 76-100% are purple. "Other" responses include: "decades;" "long term variability;" "50-100 yr;" and "long term planning horizons."

Comparing climate change references:

This survey has resulted in a compilation of water management reference titles and their perceived reliability as indicated by the respondent (Figure 4.) This list may be useful to resource managers reading this report, to compare and contrast references that they may or may not have used before. This comparative reference list may also be useful to the layperson who is conducting their own climate change related research. Federal, State, and other scientific journals and other references were the most common references listed, far outnumbering news media listings. Future surveys can be expanded by making individual telephone follow up calls to respondents who have given consent. In these follow up interviews, the surveyor could ask for more detail regarding the reasons for choosing one reference over another, their perceived validity of references, and how reference choices have changed since the survey was distributed. These phone interviews could result in more detail to responses such "state," "scientific journals," "research," and "federal" becoming specific state reference URLs or publication details. One respondent did use a specific URL (Cal Climate page:

http://climatechange.ca.gov/), which is the type of data that would be useful in future survey efforts.

Conclusion

Climate change is affecting California water resource management decision making. Continued surveys of repeated and expanded populations will help document the rate of change of climate-related effects on water resources. Finally, these survey responses regarding climate change references may be useful to water resource managers in other states with fewer resource funds available. The Ca.gov climate change link listed above as well as ACWA.com and other specific resources provided by survey respondents help establish California as a leader in science-based climate-oriented management decisions that can be utilized across the country and globe.

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Acronyms and Abbreviations

ACWA	Association of California Water Agencies
AMS	American Meteorological Society
AWWA	American Waterworks Association
DWR	California Department of Water Resources
ET	evapotranspiration
GSA	Groundwater Sustainability Agency
IPCC	Intergovernmental Panel on Climate Change
NASA	National Aeronautics and Space Administration
NCAR	US National Center for Atmospheric Research
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NWS	National Weather Service
UCAR	University Corporation for Atmospheric Research
UCLA	University of California Los Angeles
USEPA	United States Environmental Protection Agency