Relationship between climate change belief and water conservation behaviors: Is there a role for political identity?

Vuong-Quan Hoang [1], Dan Li [2,*], Viet-Phuong La [1,4], Minh-Phuong Thi Duong [3], Minh-Hoang Nguyen [1,4]

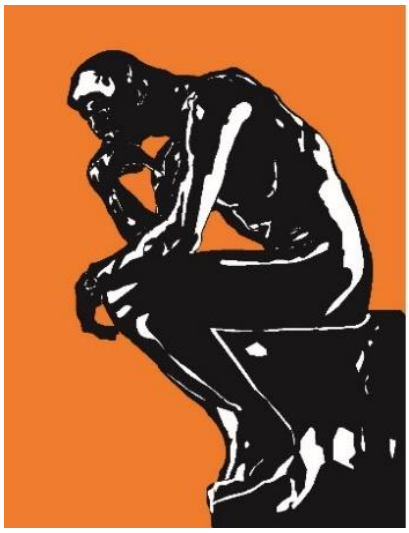
[1] Centre for Interdisciplinary Social Research, Phenikaa University, Yen Nghia Ward, Ha Dong District, Hanoi 100803, Vietnam

[2] Yan'an University, Yan'an, China

[3] Faculty of Social Sciences and Humanities, Ton Duc Thang University, Ho Chi Minh, Vietnam

[4] A.I. for Social Data Lab(AISDL), Vuong & Associates, Hanoi 100000, Vietnam

* Corresponding: Dan Li; Email: dellelee103@gmail.com



November 10, 2023

Preprint v.1.1

*****

> "With his utmost wisdom and the lobbying power resulting from delicious fish, Kingfisher and his task force have received a consensus from all birds residing in the village over his GHG emission reduction plan."
>
> In "GHG Emissions"; *The Kingfisher Story Collection* [1]

Abstract

In the United States, public opinions about climate change have become polarized, with a stark difference in the belief in climate change. Climate change denialism is pervasive among Republicans, especially conservatives, contrasting the high recognition of human-induced climate change issues among Democrats. As the water crisis is closely linked to climate change, the current study aims to examine how the belief in climate change's impacts on future water supply uncertainty affects water conservation behaviors and whether the effect is conditional on being a Republican. The Bayesian Mindsponge Framework (BMF) analytics was performed on a dataset of 1831 water users in an arid region (Albuquerque, New Mexico). The analysis shows that water users' belief in climate change's impacts on future water supply uncertainty positively affects the number of water conservation behaviors they adopt, regardless of whether they are Republicans. Although being a Republican does not significantly negatively moderate the association between climate change belief and water conservation behaviors, the result still underscores the importance of fighting climate change denialism. Otherwise, it will not only hinder the climate change alleviation efforts but also exacerbate the water crisis. Several strategies to reduce climate change denialism are also recommended.

Keywords: social identity; political identity; eco-surplus culture; communication strategies; progressive culture

1. Introduction

Like climate change, water security is also a crucial issue relevant to all countries. Among a long list of global threats to humanity's existence and the natural world, water has been ranked as the top at present and in the future. The water crisis does not only affect humans but also other species on the planet: 12 million hectares of global land are lost yearly to drought [2], and desertification and 1/3 of the world's freshwater species are threatened with extinction partly due to the rapid decline of wetlands [3]. According to Lynch [4], drought could affect up to 75% of the world's population by 2050. A report by UNESCO on behalf of UN-Water approximated that around 2 billion people, including 26% of the worldwide population, do not have adequate access to potable water. Furthermore, the report emphasized that around 3.6 billion individuals, accounting for 46% of the global population, lack access to sanitation facilities that are adequately managed [5]. Growing water demand and declining supplies could create a "perfect storm" that threatens the future of human civilization [6].

Ensuring a sustainable water supply is imminent to avoid the "perfect storm" caused by water insecurity. A multifaceted approach, especially behavioral-based approaches that promote water conservation, can be integral to demand reduction strategies [7]. Therefore, water-saving behaviors, as the most crucial water resource planning and management strategy, are becoming increasingly important globally in the coming decades [6]. However, much less attention has been paid to water-related interventions than other interventions around energy and recycling. This study will concentrate on examining how climate change belief and political affiliation can affect water-related conservation behaviors.

As one of the biggest challenges facing human survival today, climate change has caused many direct or indirect impacts on humans [8], and water resources are among the most vulnerable to the impacts of climate change [9]. With population growth and economic development, climate change is driving demand and increasing pressure on water supplies [10]. The most critical impacts of climate change include global temperature rises, precipitation declines in water-scarce areas, and decreases in water quantity and quality [11-13]. Climate change is also expected to exacerbate droughts, making the drought set in quicker, become more intense, and last longer [14]. Rising temperatures can also cause ocean levels to rise and salt water to enter coastal aquifers [15], as well as facilitate the growth of fatal bacteria in freshwater sources, making the water unsafe to drink [16].

Studies have indicated that awareness, knowledge, and risk perception of climate change are significantly associated with people's pro-environmental attitude and can promote their pro-environment behaviors in a direct and indirect way [17-20]. Public perception of climate change and other environmental issues mainly includes concern about the impacts of these issues and an understanding of their causes and damages [21]. For instance, Han*, et al.* [22] show that as mediated by environmental concerns, youths' climate change causes and risk perceptions enable them to adopt energy-saving behaviors.

Since water security is inextricably linked to the climate crisis and its consequences, climate change risk perceptions might be crucial in influencing water conservation behavior. People's perceived risk of water scarcity due to climate change has a significant impact on their daily behavioral decisions and how they adjust their behavior accordingly, including those related to water conservation [23,24]. Previous research has examined how experiences with water shortage and quality influence attitudes and behaviors [25]. For example, Hannibal*, et al.* [26] reported that individuals living in drought-affected areas are more likely to change behaviors to conserve water and make small financial investments to save water. However, there are scenarios in which people are unwilling to change their behaviors toward water use despite perceiving the adverse impacts of climate change. Water conservation behavior does not depend solely on climate change perceptions but also on multiple other factors simultaneously, including personal experience, education level, worldview, considerations of economic, political, and technological factors, and awareness [6,25].

Environmental issues, especially climate change, have become a politically polarizing issue globally. The climate change communication literature has extensively examined how conservatism and liberalism predict attitudes and behavior [21]. People who identify as liberals (or Democrats) are more likely to support measures to curb climate change than those who identify as conservatives (or Republicans) [27-29]. Besides climate change, other studies also found connections between political ideology and water conservation attitudes and behaviors. Callison and Holland [25] found that liberals are more likely to engage in behaviors that support water conservation than conservatives when responding to water scarcity and water quality news stories. Political identity is also found to affect the perceived message credibility of news related to water scarcity, but not the concern or intent to conserve water [30]. Thus, we suspect that political identity can be a potential factor influencing the relationship between climate change belief and water conservation behavior, as these factors have been found to be associated with each other. Nevertheless, to our knowledge, no study has been conducted to explore the moderation effect of political identity.

To address the abovementioned gap, this research aims to enhance our understanding of how the possessed political identity can influence the association between climate change belief and water conservation behaviors.

The current study has two primary objectives:

- Examine whether the residents' belief in climate change's impact on future water supply uncertainty affects their water conservation behaviors.
- Examine whether being a member of the Republican party moderates the relationship between the perceived impact of climate change on water supply and water conservation behaviors.

2. Methodology

2.1. Theoretical foundation

This Subsection presents the Mindsponge Theory, which was used for building models [31,32]. The theory was developed from the mindsponge mechanism, which is an inclusive model of cognition-shifting processes that demonstrates how new information, deemed valuable, is absorbed from the environment while information deemed unimportant or with waning values is ejected from the individual's mind [33]. The original mindsponge mechanism is formed through the observation of psychological and social phenomena, which is also true for many other theories and frameworks, like those produced by Abraham Maslow [34], Geert Hofstede [35], Inoue Nonaka [36], Henry Mintzberg [37], and Michael Porter [38], etc. Although this method has been found effective for explaining the complexity of human behavior and social systems, it still does not account for the essential components that make a human a human: the cells and molecules and the processes that give life to organic materials. As a result, the mindsponge mechanism was developed into Mindsponge Theory, integrating the newest

data from brain and life sciences [32]. Many psychological and behavioral studies have employed the theory as the theoretical foundation.

The theory contends that the human mind is an information collection-cum-processor. For cognitive processes to occur, the presence of physical structures is necessary to provide a foundation for processing activities, as demonstrated by the human brain. The collection of all accepted knowledge in the system (or beliefs or highly-trusted information) can be deemed as the mindset that takes memory to retain. Using the content of the existing mindset as the benchmark, the filtering mechanism determines what information can enter or be ejected from the mindset, which updates the mind and its subsequent information processing system [32]. The process is dynamically balanced and incorporates cost–benefit evaluation for maximizing the perceived benefits and minimizing the perceived costs of the system. When the information is deemed beneficial, it will be integrated into the mindset. If the information is deemed costly, it will be ejected from the mind [39]. From an information processing perspective, either a thought or a behavior is an outcome of an information process based on the available information and estimated consequences. As a result, for a behavior to be conducted, the ideation (or information) associated with such behavior must exist within the mind and be deemed the most beneficial alternative among other information in a specific context [40]. The evaluation is mainly driven by the value system induced by the mindset and the information observed from the environment at the time the behavior needs to be carried out.

Following this logic, it can be thought that for people to conduct water conservation behaviors, the ideation associated with water conservation needs to exist within the mind and be deemed beneficial by the mind. For such ideation to emerge, beliefs (or highly-trusted information) in the mindset significantly shape people's value systems. If a belief implying climate change's threats or negative impacts on people's survival and well-being exists in the mindset, the mind will be more likely to seek and absorb information that aims to minimize the consequences of climate change or alleviate climate change. Subsequently, it gives ground for the emergence of conservation-related thinking and behaviors [41,42]. Empirically, people who believe or perceive the negative impacts of climate change are more willing to change their thinking and behaviors [22,23,41]. In addition, previous studies also indicated that experiencing water shortage is a strong predictor of water conservation behaviors, even including financial payment [25,26]. Based on this reasoning and evidence, we came up with the first Hypothesis:

> **H1:** Belief in climate change's impact on future water supply uncertainty is positively associated with water conservation behaviors.

Human social life is group-based, so their mindset can also be shaped by the collective identities of their groups, as suggested by the Social Identity Approach [21]. In other words, there exists beliefs or highly-trusted information identifying people as a part of the group they belong to in the mindsets, which influence people's values, thinking, emotions, and behaviors according to the groups' norms, values, and ideologies. Among

types of collective identities, political identity is prominent, especially in the US [21]. When the new information is absorbed into the mind, it will be easily integrated into the mindset if it aligns with the political values stored in the people's mindsets. In contrast, the information can be more likely rejected if it contradicts the peoples' political values [43]. For example, Bouman*, et al.* [44] discovered that perceiving a national or political ingroup as prioritizing environmental values predicted pro-environmental behavior of individuals who highly identify with the group. Therefore, it is plausible to think that people in a political party not supporting climate change tend to attribute less value to information-related to climate change, subsequently hindering the absorption of information pertaining to water conservation.

In the US's political atmosphere, the divide between the Republican and Democratic parties over governmental environmental protection programs, especially issues pertaining to climate change, has widened significantly since the early 1980s. Most Republicans thought that the seriousness of global warming is generally exaggerated in the news, whereas only a few percent of Democrats thought so [45]. Most recently, the Politics & Global Warming report indicates that most of Democrats prefer to vote for a candidate supporting action on global warming (i.e., 95% of liberal Democrats and 76% of moderate/conservative Democrats), while much fewer Republicans prefer so (i.e., 23% of conservative Republicans and 44% of liberal/moderate Republicans). Almost half of conservative Republicans even prefer candidates opposing actions on global warming (46%) [46]. Given that most Republicans in the US are likely not to support or even oppose climate change, we hypothesized that:

> **H2:** Being a Republican negatively moderates the association between belief in climate change's impact on future water supply uncertainty and water conservation behaviors.

2.2. Model construction

2.2.1. Variable selection

The dataset generated by Distler and Scruggs [47] was employed in the current study for the data analysis. The dataset was an outcome of a large-scale community survey conducted by the Distler and Scruggs [47] and the Albuquerque Bernalillo County Water Utility Authority (ABCWUA), the sole provider of water and wastewater services to the greater Albuquerque metropolitan area. The community survey concentrates on collecting water knowledge, water habits, opinions on two potable reuse scenarios, level of trust in institutions, a variety of water- and climate change-related topics, and demographic information of ABCWUA account holders. During the survey collection, Distler and Scruggs concurrently distributed four versions of the survey, of which one version contained no additional material while the other three versions different types of educational materials (i.e., "Water Sources and Reliable Supplies," "Environmental Benefits of Water Reuse," and "The Urban Water Cycle"). This separation was to reduce the perceptual biases derived from educational materials.

The questionnaire was designed through multiple focus group interviews and debriefing sessions. A total of eight focus groups, each lasting 90 minutes, were conducted to facilitate the evaluation of sample questionnaire questions and the identification and development of additional content to be incorporated into the survey. The focus groups consisted of 7-10 individuals each. Participants had to be at least 18 years old and ABCWUA clients. While conducting the focus group interview, the draft survey was administered to a sample population of 12 individuals, and the survey debriefing sessions were conducted one-on-one. These debriefing sessions facilitated researchers in verifying the accurate interpretation and comprehension of survey questions and materials, as well as ascertaining the duration required for survey completion. Eight focus group interviews were held in July, October, and November, and 12 debriefing sessions were conducted in August, October, and November of 2016.

Four thousand accounts were randomly chosen from over 180,000 residential accounts in the ABCWUA customer accounts log for initiating the survey collection. The log contained many data, such as Census tract, ZIP code, and postal address for each client. The names of customers were instantly removed from the sample file, and the addresses were subsequently eradicated after the completion of data analysis. Every prospective participant was allocated a distinct random code as a means of identification, ensuring anonymity while facilitating response tracking. The survey was distributed to the prospective participants through mailing to their physical addresses. The invitation that was sent by mail includes a link to participate in the survey online via the internet platform Survey Monkey. A pretest was also conducted on 200 account holders to ensure the collection method worked properly. Finally, the survey distribution to a random sample of 4,000 ABCWUA account holders from April to September 5, 2017, resulted in 1831 valid responses, with a response rate of 46%. Several studies have employed this dataset to study water-related issues in Albuquerque [48-50].

For the purpose of this study, three variables were retrieved from the dataset: *WATER_CONSERVATION*, *CLIMATE*, and *REPUBLICAN*. *WATER_CONSERVATION* is the outcome variable representing the number of water conservation behaviors the water users were doing at home. The variable was generated by summing six variables: *CONSERVE_XERI* (i.e., xeriscaped land/yard), *CONSERVE_YARD* (i.e., do not water land/yard), *CONSERVE_FIXTURES* (i.e., use water saving fixtures, like faucets, toilets, etc.), *CONSERVE_APPLIANCES* (i.e., use water-efficient appliances, like dishwasher, washing machine, etc.), *CONSERVE_RAINWATER* (i.e., practice rainwater harvesting), and *CONSERVE_SIMPLE* (i.e., use simple conservation measures, like turning off water when brushing teeth, etc.). The higher the number, the more water conservation behaviors the water user conducted.

CLIMATE variable was retrieved directly from the original dataset without any modification. The variable was generated from the question asking whether the respondent "believes that the impact of climate change on the water cycle will make it more difficult for ABCWUA to meet our community's water needs in the next 10 to 40 years." Meanwhile, the *REPUBLICAN* was generated from the *POLITICAL* variable,

indicating the water users' political parties that they primarily identify as. If the respondent chose Republican, they would be referred to as '1.' For other political parties, they would be referred to as '0.' All variable description is presented in Table 1.

Table 1: Description of variables

Variable	Description	Type of variable	Value
WATER_CONSERVATION	The number of water conservation behaviors that the respondent was doing at home at the time of being surveyed.	Numerical	Min = 1 Max = 6
CLIMATE	Whether the respondent believed the impact of climate change on the water cycle would negatively affect the water supply in the region in the next 10-40 years	Binary	Yes = 1 No = 0
REPUBLICAN	Whether the respondent primarily identified himself/herself as Republican	Binary	Yes = 1 No = 0

2.2.2. Statistical model

For testing the association between climate change belief and wate conservation behaviors and the moderation effect of being a Republic on the relationship, we constructed Model 1 as follows:

$$WATER\_CONSERVATION \sim normal(\mu, \sigma) \quad (1.1)$$

$$\mu_i = \beta_0 + \beta_1 * CLIMATE_i + \beta_2 * CLIMATE_i * REPUBLICAN_i \quad (1.2)$$

$$\beta \sim normal(M, S) \quad (1.3)$$

The probability around μ is determined by the form of the normal distribution, whose width is specified by the standard deviation σ. μ_i indicates the number of water conservation behaviors of water user i; $CLIMATE_i$ indicates whether water user i' believes in the impact of climate change on future water supply's uncertainty; $REPUBLICAN_i$ indicates whether water user i primarily identified himself/herself as a Republican. β_2 indicates the coefficient of the non-additive effect of $CLIMATE_i * REPUBLICAN_i$ on $WATER\_CONSERVATION$. If the coefficient is significant, the water user's political party is deemed to affect (or moderate) the relationship between climate change belief and water conservation behaviors. Model 1 has two coefficients, β_1 and β_2, the intercept, β_0, and the standard deviation of the "noise", σ. The coefficients of the predictor variables are distributed as a normal distribution around the mean denoted M and with the standard deviation denoted S. The logical network of Model 1 is shown in Figure 1.

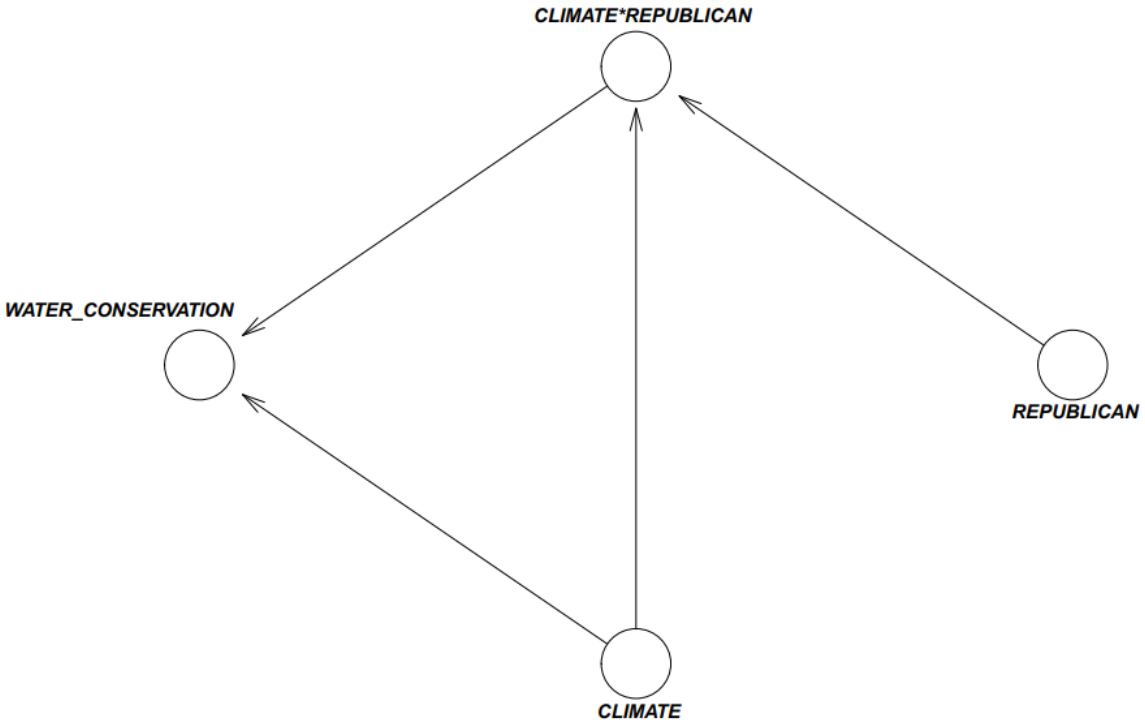


Figure 1. Model 1's logical network

2.3. Analysis and validation

The current study utilized the Bayesian Mindsponge Framework (BMF) analytics as the methodological approach [39,51]. The BMF is an analytical structure that integrates the strengths of the Mindsponge Theory with Bayesian inference in order to examine various psychological and behavioral concepts and phenomena in humans. The utilization of the Mindsponge Theory within the framework enables the construction of theoretical models that effectively capture the intricate and dynamic nature of the human mind.

Simultaneously, Bayesian inference, known for its substantial flexibility, facilitates the fitting of these models for statistical analysis. The two components exhibit a high degree of compatibility and mutually enhance one another over the course of performing a study. In general, the match between mindsponge and Bayesian inference can be characterized by the following key aspects [51]: (1) both approaches, at a philosophical and theoretical level, embrace subjectivity, making them particularly suitable for social and psychological research; (2) they offer researchers considerable flexibility in constructing and fitting models; and (3) both methods embrace information updating mechanism in a dynamic manner.

Due to the intricate nature of the human psychological process, our objective is to develop parsimonious models to enhance the capacity to make accurate predictions. The Bayesian inference technique is advantageous in estimating parsimonious models due to its probabilistic treatment of all properties, including the unknown parameters [52,53]. Moreover, Bayesian analysis aided by the Markov Chain Monte Carlo (MCMC) algorithm offers the capability to estimate models with high complexity, such as those in the current study with non-linear relationships [54]. The inclusion of non-linear relationships in the estimating process increases the complexity of the model and necessitates a higher sample size in order to obtain accurate estimations [55]. The utilization of a large number of iterative samples produced by stochastic processes, specifically Markov chains, can significantly enhance the efficacy of fitting such intricate models.

It is crucial to acknowledge that the scientific community is now facing a reproducibility crisis. Numerous research conducted in various disciplines, particularly psychology [56] and social sciences [57], have encountered challenges in replicating their findings. These challenges mostly stem from technical difficulties associated with the analytical methods utilized in these studies. One important factor believed to contribute to the crisis is the wide sample-to-sample variability observed in the *p*-value [58]. Therefore, the decision to utilize Bayesian analysis was motivated by the need to circumvent the utilization of *p*-values. This is because Bayesian analysis requires researchers to observe the posterior distributions and credible intervals to interpret the results [59].

Finally, the inclusion of prior distributions is a notable benefit of employing Bayesian analysis. Despite the utilization of "uninformative" priors to mitigate subjective impacts on simulated outcomes, it is still possible to capitalize the prior function on assessing the robustness of simulated results through the implementation of the "prior-tweaking" approach [60]. In this study, we employed two informative priors to check the robustness of the simulated results. The first prior distribution represents our disbelief in the existence of the effect of *CLIMATE* and non-additive effect of *CLIMATE*REPUBLICAN* on *WATER_CONSERVATION*; their priors were set as a normal distribution with mean value at 0 and standard deviation being 0.5. The second prior distribution represents our belief in the existence of those effects; the prior of *CLIMATE* was set as a normal distribution with a mean value of 0.5 and standard deviation being 0.5, while that of *CLIMATE*REPUBLICAN* was set as a normal distribution with a mean value at -0.5 and standard deviation being 0.5.

To validate the simulated posterior outcomes, a three-pronged validation technique is employed. We employed Pareto-smoothed importance sampling leave-one-out cross-validation (PSIS-LOO) diagnostic plots to assess the goodness of fit with the dataset for each simulated model [61,62]. The model's suitability with the data may be assessed by examining the plot and evaluating whether all k values are below the 0.5 threshold. Subsequently, we proceeded with the convergence assessment by employing diagnostic statistics and visualizations. The diagnostic statistics encompass two key measures: the effective sample size (*n_eff*) and the Gelman-Rubin shrink factor (*Rhat*). Additionally, the diagnostic plots consist of the trace plot, Gelman-Rubin-Brook plot, and autocorrelation plot. Ultimately, the prior-tweaking procedure was executed. The Results section provides a comprehensive presentation of diagnostic statistics and plots, accompanied by thorough explanations and interpretations.

The researchers employed the bayesvl R package to perform Bayesian analysis in the present study [39,63]. The dataset, data description, and code snippets pertaining to the Bayesian analysis were posted to The Open Science Framework to improve transparency and aid later replication and validation [64]: https://osf.io/tb9ps/

3. Results

The model was fitted on R version 4.2.0 ("Vigorous Calisthenics") using four Markov chains, each consisting of 5000 iterations, with 2000 used for the warmup period. The simulation took 322.5 s to be completed, and the simulated results are displayed in Table 2. In this Section, we focus on evaluating the results simulated using uninformative priors, while the results simulated using informative priors are only used to check the simulated results' robustness.

Before interpreting the results, it is necessary to assess Model 1's goodness of fit with the data. As seen in Figure 2, all the estimated *k*-values are below the 0.5 threshold, indicating a good signal of fit between the model and the data.

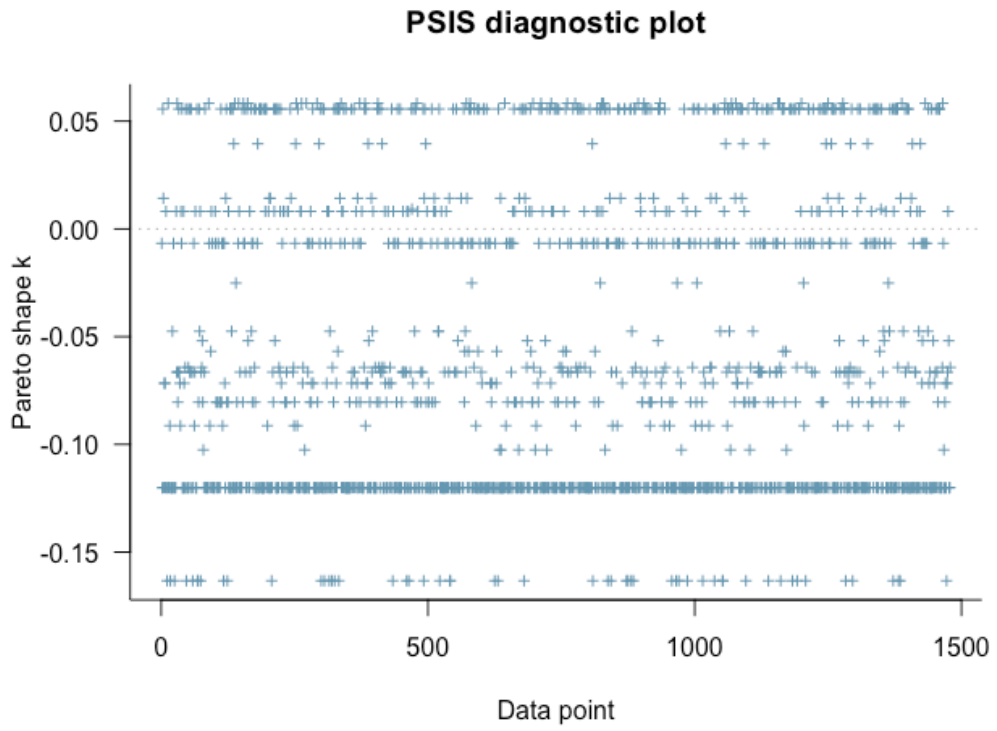


Figure 2. Model 1's PSIS-LOO diagnosis

The statistics of Model 1's posterior distributions are shown in Table 2. All the *n_eff* values are larger than 1000, and *Rhat* values are equal to 1, so it can be deemed that Model 1's Markov chains are well-convergent. The convergence of Markov chains is also reflected through the trace plots in Figure 3. Specifically, all the chains' values fluctuate around a central equilibrium after the 2000th iteration.

Table 2: Estimated results of Model 1

	Uninformative priors				Informative priors (belive in the effects)				Informative priors (disbelive in the effects)			
Parameters	**M**	**S**	**n_ff**	**Rhat**	**M**	**S**	**n_ff**	**Rhat**	**M**	**S**	**n_ff**	**Rhat**
Constant	2.80	0.08	7089	1	2.81	0.08	7052	1	2.79	0.08	6437	1
CLIMATE	0.11	0.09	6840	1	0.11	0.09	6915	1	0.13	0.09	6281	1

*CLIMATE*REPUBLICAN*	-0.02	0.10	9913	1	-0.02	0.10	9252	1	-0.04	0.10	9248	1
** Note: M is the abbreviation of Mean, while SD is the abbreviation of Standard Deviation*												

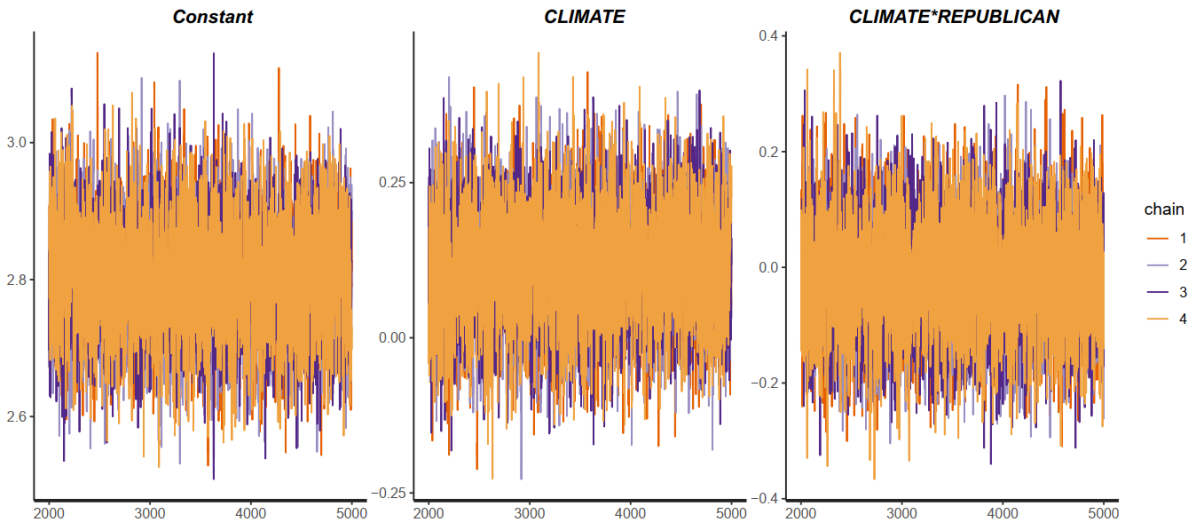


Figure 3. Model 1's trace plots

The Gelman-Rubin-Brooks plots and autocorrelation plots also signify the good convergence of Markov chains. The Gelman-Rubin-Brooks plots are used to assess the ratio between the

variance between Markov chains and the variance within chains. The *y*-axis illustrates the shrink factor (or Gelman-Rubin factor), while the *x*-axis demonstrates the iteration order of the simulation. In Figure 4, the shrink factors of all parameters drop rapidly to 1 before the 2000th iteration (within the warmup period). This manifestation suggests that there is no divergence among Markov chains.

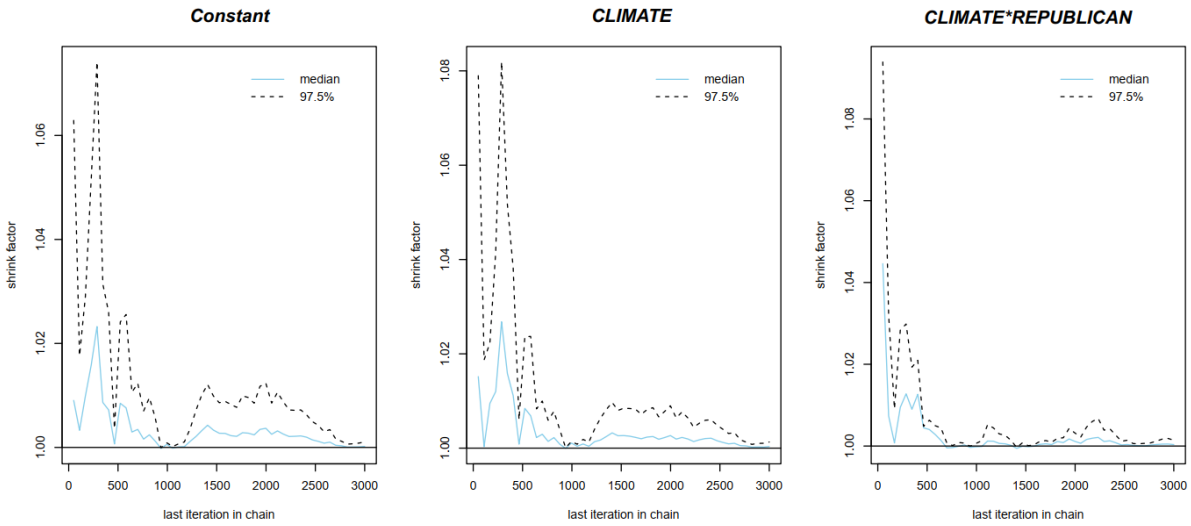


Figure 4. Model 1's Gelman-Rubin-Brooks plots

The Markov property refers to the memoryless property of a stochastic process. In other words, the iteration values are not autocorrelated with the past iteration values. The autocorrelation plots are employed to evaluate the autocorrelation levels among iteration values. The charts in Figure 5 show the average autocorrelation of each Markov chain along the *y*-axis and the lag of the chains along the *x*-axis. Visually, all the Markov chains' autocorrelation levels decline swiftly to 0 after a few number lags (before 5), suggesting that the Markov property is held and the Markov chains are well-convergent.

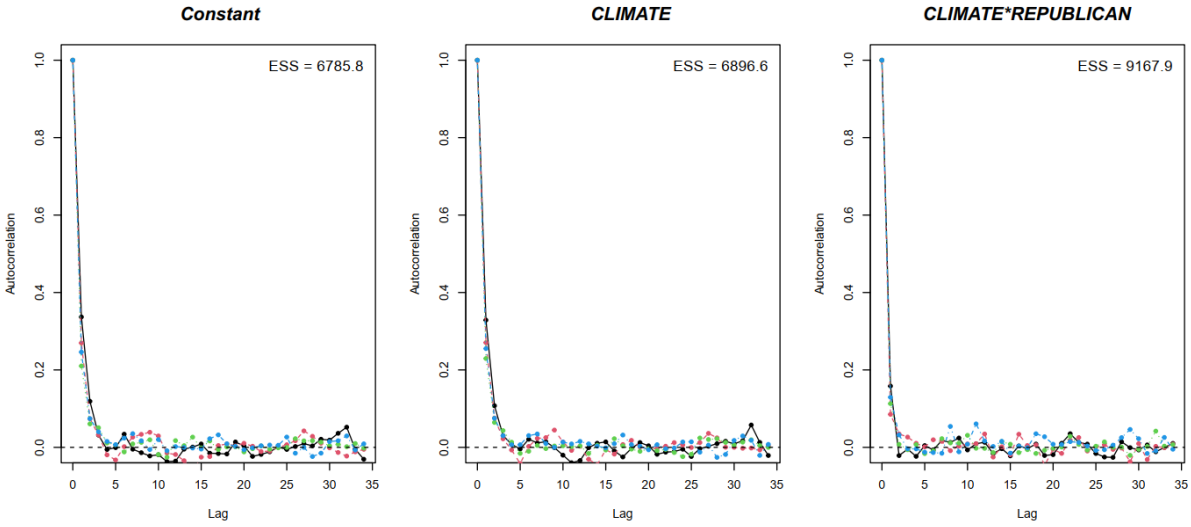


Figure 5. Model 1's autocorrelation plots

Since all the diagnostics confirm the convergence of Markov chains, the simulated results are

eligible for interpretation. The estimated results of Model 1 show that the belief in the impact of climate change on the uncertainty of water supply in the future has a positive effect on water conservation behaviors ($M_{CLIMATE} = 0.11$ and $S_{CLIMATE} = 0.09$). The positive effect of climate change belief can be deemed reliable because a majority of its posterior distribution is located on the positive side of the *x*-axis (see Figure 6).

Meanwhile, being a Republican negatively moderates the impact between climate change belief and water conservation behavior, but the moderation effect is not reliable. As can be observed from Figure 6, the posterior distribution of $CLIMATE * REPUBLICAN$ neither lies entirely on the positive nor negative side of the x-axis, implying an ambiguous effect.

The simulated results using two different prior distributions also confirm the results generated using the uninformative prior. Specifically, although the magnitude of the effect changes slightly, their main patterns are unchanged, suggesting that the estimated results are robust.

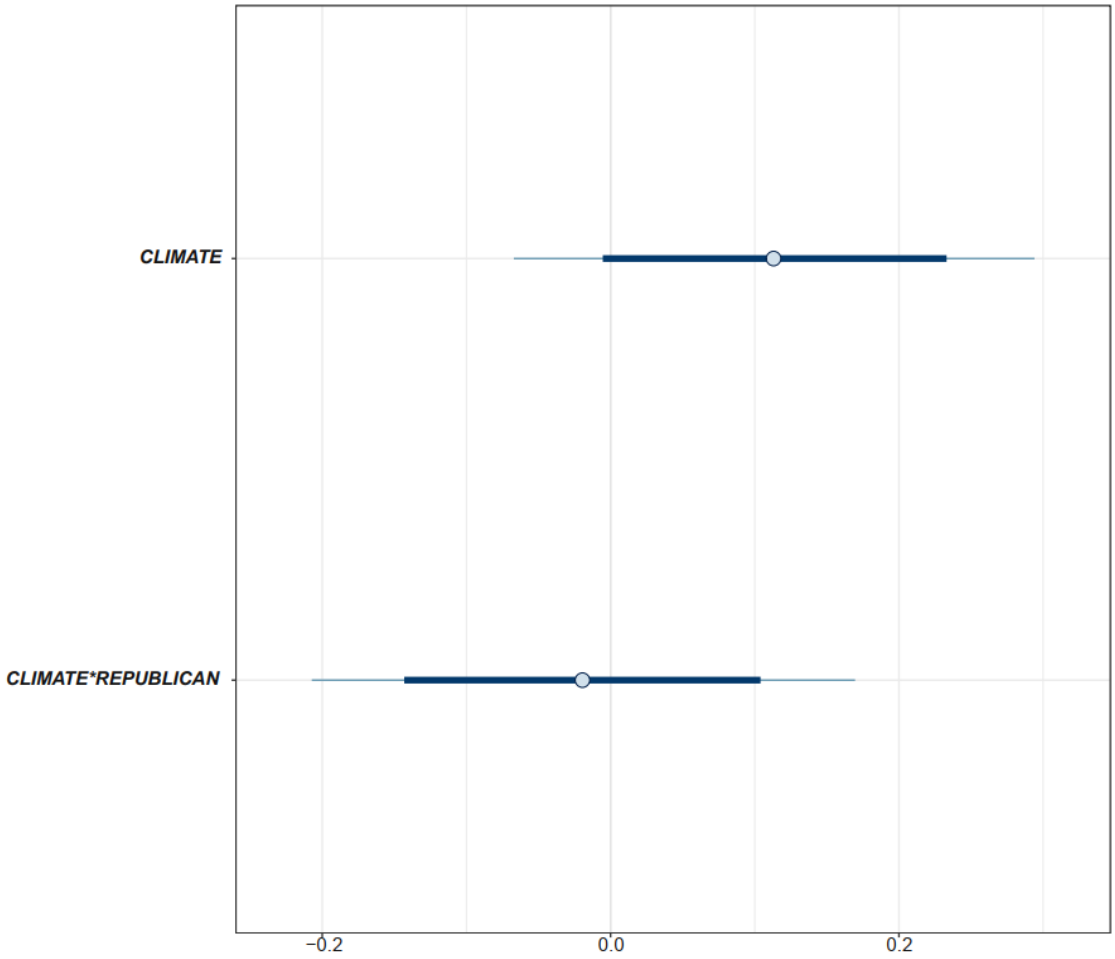


Figure 6. Model 1's posterior distributions

4. Discussion

Using the Bayesian Mindsponge Framework (BMF) analytics on a dataset of 1831 water users in Albuquerque, New Mexico, the current study found a positive association between the user's belief in the climate change's impacts on water supply uncertainty in the future and their water conservation behaviors. Although we also found the negative moderation effect of being a Republican on the association between climate change belief and water conservation behaviors, the effect is negligible and unreliable.

These findings partially validate the hypotheses proposed using the Mindsponge Theory and Social Identity Approach in the Subsection of the theoretical foundation. The negligible and unreliable moderation effect of being a Republican can be due to several reasons. First, in this scenario, the effect of political identity is not significant enough to alleviate the effect of climate change belief on water conservation behaviors. Second, the relationship between climate change beliefs and water conservation behaviors might be influenced by other factors more significant than political identity. Further studies are required to discover what those factors are.

Generally, the results suggest that people believing in the uncertainty of water supply caused by climate change are more likely to adopt more water conservation behaviors (e.g., having xeriscaped land/yard, using water-efficient appliances, using water saving fixtures, etc.), regardless of being a Republican or not. This finding can be explained by how the belief about climate change was asked. Specifically, the respondent was inquired whether they "believe that the impact of climate change on the water cycle will make it more difficult for ABCWUA to meet our community's water needs in the next 10 to 40 years" but not "human-caused climate change." In the circumstance that Republicans believe in climate change's impact, those people are likely to believe that humans do not cause climate change. Many prominent Republicans refuse that human activity is the major cause of climate change [65]. Recently, despite the strong consensus among the scientific community that climate change is caused by anthropogenic activities [66-68], Representative Mike Johnson of Louisiana, the newly elected House speaker of the US, still said that he did not believe fossil fuels were changing the climate [69]. From the viewpoint of Republicans with climate change beliefs, although they may not believe climate change is man-made, the information process within their minds will still be influenced by the consequences of climate change. In other words, regardless of the cause of climate change, those people tend to perceive conservation behaviors to be beneficial and more likely to adopt them due to the perceived uncertainty of water supply in the future.

Our study findings also hint at the risks of politicizing climate change in exacerbating other environmental crises, like the water crisis. People within the political groups that oppose climate change will be more likely to refuse climate change information, hindering the creation of climate change beliefs in their minds. If the belief in the non-existence of climate change persists, it might prevent the emergence of ideations and eventually the adoption of behaviors associated with climate change consequences, like water crisis. This tendency can further exacerbate the water crisis in arid regions like Albuquerque. Therefore, fighting climate change denialism and reducing the politicization of climate change is crucial for climate change alleviation and effective water conservation initiatives.

Researchers have proposed various strategies to reduce climate change denialism among Republicans. Climate change policies endorsed by members from the same party can be more effective in improving Republicans' support than those endorsed by members from the opposition party [70]. If the endorsing people are seen as prototypical of the ingroup,

their social influence effectiveness might be higher [21]. The persuasiveness of communications among Republicans and conservatives is enhanced when they are supported by messagers that align with the Republican or conservative ideology or when they employ language and reasoning that are consistent with conservative moral norms [71-74]. Goldberg*, et al.* [75] also found that advertising campaigns using videos designed to appeal to Republicans and targeted to this audience can enhance their understanding of climate change's existence, causes, and harms.

Besides these strategies, we recommend policymakers and climate change activists emphasize the eco-surplus cultural values and frame them as a part of the progressive values of a nation when conveying the climate change message [76,77]. Eco-surplus cultural value has been suggested by Vuong [78] as the 11th progressive cultural value besides the other ten values proposed by Harrison and Huntington [79]. Through this way, the message might promote "the identification with a superordinate category one that incorporates multiple groups under the same identity" [21]. It was evident that when the formation of US identity incorporated a broad range of values from across the political spectrum, liberals and conservatives demonstrated a shared commitment to environmental preservation and a strong sense of connectedness to the natural world [80]. When the eco-surplus cultural values are successfully built, they are expected to increase perceived benefits toward environmental-friendly policies and actions as well as the immunity to climate change denialism narratives.

The current study contains several limitations, which are reported here for transparency [81]. First, due to the cross-sectional nature of the dataset, the study could not confirm whether political identity does or does not affect the relationship between climate change belief and water conservation behaviors. Thus, longitudinal or experimental studies are required to check whether, in the long-term, being a Republican can moderate the effects of climate change belief on water conservation behaviors due to the information pressure induced by other ingroup members. Speaking differently, longitudinal or experimental studies can help validate if there are scenarios that, due to information exchange with other Republicans, belief in the impact of climate change on water supply might be weakened and eventually ejected, creating conditions for other information associated with water conservation to be ejected. In addition, it should be noted that the sample size is limited to the city of Albuquerque, which may not accurately reflect regions with varying geographical and climatic attributes across the United States. Further research is necessary to substantiate the impact of climate change beliefs on water conservation behaviors in regions exhibiting distinct geographical and climatic attributes.

References

1. Vuong, Q.-H. *The kingfisher story collection*; 2022.
2. UN News. World 'at a crossroads' as droughts increase nearly a third in a generation. Available online: https://news.un.org/en/story/2022/05/1118142 (accessed on November 9).

3. WWF. Freshwater biodiversity. Available online: https://wwf.panda.org/discover/our_focus/freshwater_practice/freshwater_biodiversity_222/ (accessed on November 9).

4. Lynch, R. Applying a circular economy mindset will help ensure a water-secure future. Available online: https://www.weforum.org/agenda/2023/09/water-security-saving-climate-change-positive-future/ (accessed on November 9).

5. UNESCO World Water Assessment Programme. *UN World Water Development Report 2023*; UNESCO: 2023.

6. Saurí, D. Water conservation: Theory and evidence in urban areas of the developed world. *Annual Review of Environment and Resources* **2013**, *38*, 227-248, doi:10.1146/annurev-environ-013113-142651.

7. Lede, E.; Meleady, R.; Seger, C.R. Optimizing the influence of social norms interventions: Applying social identity insights to motivate residential water conservation. *Journal of Environmental Psychology* **2019**, *62*, 105-114, doi:10.1016/j.jenvp.2019.02.011.

8. Sanson, A.V.; Wachs, T.D.; Koller, S.H.; Salmela-Aro, K. Young people and climate change: The role of developmental science. In *Developmental science sustainable development goals for children youth*, Verma, S., Petersen, A.C., Eds.; Springer: 2018; pp. 115-137.

9. Chang, H.; Bonnette, M.R. Climate change and water-related ecosystem services: impacts of drought in california, usa. *Ecosystem Health and Sustainability* **2016**, *2*, e01254, doi:10.1002/ehs2.1254.

10. Ayt Ougougdal, H.; Yacoubi Khebiza, M.; Messouli, M.; Lachir, A. Assessment of future water demand and supply under IPCC climate change and socio-economic scenarios, using a combination of models in Ourika Watershed, High Atlas, Morocco. *Water* **2020**, *12*, 1751, doi:10.3390/w12061751.

11. Javeline, D.; Dolšak, N.; Prakash, A. Adapting to water impacts of climate change: Introduction to special issue of Climatic Change. *Climatic Change* **2019**, *152*, 209-213, doi:10.1007/s10584-018-2349-1.

12. Trenberth, K.E.; Fasullo, J.T.; Shepherd, T.G. Attribution of climate extreme events. *Nature Climate Change* **2015**, *5*, 725-730, doi:10.1038/nclimate2657.

13. Bates, B.; Kundzewicz, Z.W.; Wu, S.; Palutikof, J. *Climate change and water*; IPCC Secretariat: Geneva, 2008; p. 210.

14. Trenberth, K.E.; Dai, A.; Van Der Schrier, G.; Jones, P.D.; Barichivich, J.; Briffa, K.R.; Sheffield, J. Global warming and changes in drought. *Nature Climate Change* **2014**, *4*, 17-22, doi:10.1038/nclimate2067.

15. Misra, A.K. Climate change and challenges of water and food security. *International Journal of Sustainable Built Environment* **2014**, *3*, 153-165, doi:10.1016/j.ijsbe.2014.04.006.

16. Nichols, G.; Lake, I.; Heaviside, C. Climate change and water-related infectious diseases. *Atmosphere* **2018**, *9*, 385, doi:10.3390/atmos9100385.

17. Heath, Y.; Gifford, R. Free-market ideology and environmental degradation: The case of belief in global climate change. *Environment and Behavior* **2006**, *38*, 48-71, doi:10.1177/0013916505277998.

18. Kim, S.; Jeong, S.-H.; Hwang, Y. Predictors of pro-environmental behaviors of American and Korean students: The application of the theory of reasoned action and protection motivation theory. *Science Communication* **2013**, *35*, 168-188, doi:10.1177/1075547012441692.

19. Masud, M.M.; Akhtar, R.; Afroz, R.; Al-Amin, A.Q.; Kari, F.B. Pro-environmental behavior and public understanding of climate change. *Mitigation and Adaptation Strategies for Global Change* **2015**, *20*, 591-600, doi:10.1007/s11027-013-9509-4.

20. Zhou, Q.; Tang, S. Media use and pro-environmental behavior of the Chinese public: An analysis on the multiple mediating effects of environmental knowledge and risk perception. *Journal of China University of Geosciences* **2017**, *17*, 80-94.

21. Mackay, C.M.; Schmitt, M.T.; Lutz, A.E.; Mendel, J. Recent developments in the social identity approach to the psychology of climate change. *Current Opinion in Psychology* **2021**, *42*, 95-101, doi:10.1016/j.copsyc.2021.04.009.

22. Han, P.; Tong, Z.; Sun, Y.; Chen, X. Impact of Climate Change Beliefs on Youths' Engagement in Energy-Conservation Behavior: The Mediating Mechanism of Environmental Concerns. *IJERPH* **2022**, *19*, 7222, doi:10.3390/ijerph19127222.

23. Pandey, R.; Kumar, P.; Archie, K.M.; Gupta, A.K.; Joshi, P.; Valente, D.; Petrosillo, I. Climate change adaptation in the western-Himalayas: Household level perspectives on impacts and barriers. *Ecological Indicators* **2018**, *84*, 27-37, doi:10.1016/j.ecolind.2017.08.021.

24. Pakmehr, S.; Yazdanpanah, M.; Baradaran, M. How collective efficacy makes a difference in responses to water shortage due to climate change in southwest Iran. *Land Use Policy* **2020**, *99*, 104798, doi:10.1016/j.landusepol.2020.104798.

25. Callison, C.; Holland, D. Impact of political identity and past crisis experience on water attitudes. *Journal of Contemporary Water Research and Education* **2017**, *161*, 19-32, doi:10.1111/j.1936-704X.2017.3249.x.

26. Hannibal, B.; Sansom, L.; E. Portney, K. The effect of local water scarcity and drought on water conservation behaviors. *Environmental Sociology* **2019**, *5*, 294-307, doi:10.1080/23251042.2018.1519882.

27. Dunlap, R.E.; Xiao, C.; McCright, A.M. Politics and environment in America: Partisan and ideological cleavages in public support for environmentalism. *Environmental Politics* **2001**, *10*, 23-48, doi:10.1080/714000580.

28. Hart, P.S.; Nisbet, E.C. Boomerang effects in science communication: How motivated reasoning and identity cues amplify opinion polarization about climate mitigation policies. *Communication Research* **2012**, *39*, 701-723, doi: 10.1177/0093650211416646.

29. Geiger, N.; Pasek, M.H.; Gruszczynski, M.; Ratcliff, N.J.; Weaver, K.S. Political ingroup conformity and pro-environmental behavior: Evaluating the evidence from a survey and mousetracking experiments. *Journal of Environmental Psychology* **2020**, *72*, 101524, doi:10.1016/j.jenvp.2020.101524.

30. Holland, D.; Janét, K.; Landrum, A. Experience is key: Examining the relative importance of factors influencing individuals' water conservation. *Water* **2019**, *11*, 1870, doi:10.3390/w11091870.

31. Vuong, Q.H.; Napier, N.K. Acculturation and global mindsponge: An emerging market perspective. *International Journal of Intercultural Relations* **2015**, *49*, 354-367, doi:10.1016/j.ijintrel.2015.06.003.

32. Vuong, Q.-H. *Mindsponge Theory*; De Gruyter: 2023.

33. Vuong, Q.-H. *A new theory of serendipity: Nature, emergence and mechanism*; De Gruyter: Berlin, 2022.

34. Maslow, A.H. *Motivation and personality*; Prabhat Prakashan: 1981.

35. Hofstede, G. *Culture's consequences: International differences in work-related values*; Sage: Newbury Park, 1984; Volume 5.

36. Nonaka, I.; Konno, N. The concept of "Ba": Building a foundation for knowledge creation. *California Management Review* **1998**, *40*, 40-54.

37. Mintzberg, H. *Nature of managerial work*; Harper & Row: New York, 1973.

38. Porter, M.E. Competitive strategy. *Measuring Business Excellence* **1997**, *1*, 12-17.

39. Vuong, Q.-H.; Nguyen, M.-H.; La, V.-P. *The mindsponge and BMF analytics for innovative thinking in social sciences and humanities*; De Gruyter: 2022.

40. Nguyen, M.-H.; Le, T.-T.; Vuong, Q.-H. Ecomindsponge: A novel perspective on human psychology and behavior in the ecosystem. *Urban Science* **2023**, *7*, 31, doi:10.3390/urbansci7010031.

41. Nguyen, M.-H.; Duong, M.-P.T.; Nguyen, M.-C.; Mutai, N.; Jin, R.; Nguyen, P.-T.; Le, T.-T.; Vuong, Q.-H. Promoting stakeholders' support for marine protection policies: Insights from a 42-country dataset. *Sustainability* **2023**, *15*, 12226, doi:10.3390/su151612226.

42. Nguyen, M.-H.; Jones, T.E. Predictors of support for biodiversity loss countermeasures and bushmeat consumption among Vietnamese urban residents. *Conservation Science and Practice* **2022**, *4*, e12822, doi:10.1111/csp2.12822.

43. Santirocchi, A.; Spataro, P.; Alessi, F.; Rossi-Arnaud, C.; Cestari, V. Trust in science and belief in misinformation mediate the effects of political orientation on vaccine hesitancy and intention to be vaccinated. *Acta Psychologica* **2023**, *237*, 103945, doi:10.1016/j.actpsy.2023.103945.

44. Bouman, T.; Steg, L.; Zawadzki, S.J. The value of what others value: When perceived biospheric group values influence individuals' pro-environmental engagement. *Journal of Environmental Psychology* **2020**, *71*, 101470, doi:10.1016/j.jenvp.2020.101470.

45. Dunlap, R.E.; McCright, A.M. A widening gap: Republican and Democratic views on climate change. *Environment: Science and Policy for Sustainable Development* **2008**, *50*, 26-35, doi:10.3200/ENVT.50.5.26-35.

46. Leiserowitz, A.; Maibach, E.; Rosenthal, S.; Kotcher, J. *Politics & Global Warming, April 2022*; Yale University and George Mason University, Yale Program on Climate Change Communication: New Haven, 2022.

47. Distler, L.N.; Scruggs, C.E. Survey data on perceptions of water scarcity and potable reuse from water utility customers in Albuquerque, New Mexico. *Data in Brief* **2020**, *29*, 105289, doi:10.1016/j.dib.2020.105289.

48. Distler, L.N. Potable water reuse in Albuquerque, NM: A large scale community survey to understand public perceptions and the impact of educational materials on acceptance. The University of New Mexico, 2018.

49. Distler, L.N.; Scruggs, C.E. Arid inland community survey on water knowledge, trust, and potable reuse. I: Description of findings. *Journal of Water Resources Planning and Management* **2020**, *146*, 04020045, doi:10.1061/(ASCE)WR.1943-5452.0001218.

50. Distler, L.N.; Scruggs, C.E.; Rumsey, K.N. Arid inland community survey on water knowledge, trust, and potable reuse. II: Predictive modeling. *Journal of Water Resources Planning and Management* **2020**, *146*, 04020046, doi:10.1061/(ASCE)WR.1943-5452.0001219.

51. Nguyen, M.-H.; La, V.-P.; Le, T.-T.; Vuong, Q.-H. Introduction to Bayesian Mindsponge Framework analytics: an innovative method for social and psychological research. *MethodsX* **2022**, *9*, 101808, doi:10.1016/j.mex.2022.101808.

52. Csilléry, K.; Blum, M.G.; Gaggiotti, O.E.; François, O. Approximate Bayesian computation (ABC) in practice. *Trends in Ecology and Evolution* **2010**, *25*, 410-418, doi:10.1016/j.tree.2010.04.001.

53. Gill, J. *Bayesian methods: A social and behavioral sciences approach*; CRC press: 2014; Volume 20.

54. Dunson, D.B. Commentary: practical advantages of Bayesian analysis of epidemiologic data. *American journal of Epidemiology* **2001**, *153*, 1222-1226, doi:10.1093/aje/153.12.1222.

55. Kerkhoff, D.; Nussbeck, F.W. The influence of sample size on parameter estimates in three-level random-effects models. *Frontiers in Psychology* **2019**, *10*, 1067, doi:10.3389/fpsyg.2019.01067.

56. Open Science Collaboration. Estimating the reproducibility of psychological science. *Science* **2015**, *349*, doi:10.1126/science.aac4716.

57. Camerer, C.F.; Dreber, A.; Holzmeister, F.; Ho, T.-H.; Huber, J.; Johannesson, M.; Kirchler, M.; Nave, G.; Nosek, B.A.; Pfeiffer, T. Evaluating the replicability of social science experiments in Nature and Science between 2010 and 2015. *Nature Human Behaviour* **2018**, *2*, 637-644, doi:10.1038/s41562-018-0399-z.

58. Halsey, L.G.; Curran-Everett, D.; Vowler, S.L.; Drummond, G.B. The fickle P value generates irreproducible results. *Nature Methods* **2015**, *12*, 179-185, doi:10.1038/nmeth.3288.

59. Wagenmakers, E.-J.; Marsman, M.; Jamil, T.; Ly, A.; Verhagen, J.; Love, J.; Selker, R.; Gronau, Q.F.; Šmíra, M.; Epskamp, S. Bayesian inference for psychology. Part I: Theoretical advantages and practical ramifications. *Psychonomic bulletin review* **2018**, *25*, 35-57, doi:10.3758/s13423-017-1343-3.

60. Vuong, Q.-H.; Ho, M.-T.; Nguyen, M.-H.; Thang Hang, P.; Vuong, T.-T.; Khuc, Q.; Ho, H.-A.; La, V.-P. On the environment-destructive probabilistic trends: a perceptual and behavioral study on video game players. *Technology in Society* **2021**, *65*, 101530, doi:10.1016/j.techsoc.2021.101530.

61. Vehtari, A.; Gabry, J. *Bayesian Stacking and Pseudo-BMA weights using the loo package*, loo 2.2.0; 2019.

62. Vehtari, A.; Gelman, A.; Gabry, J. Practical Bayesian model evaluation using leave-one-out cross-validation and WAIC. *Statistics and Computing* **2017**, *27*, 1413-1432, doi:10.1007/s11222-016-9696-4.

63. La, V.-P.; Vuong, Q.-H. bayesvl: Visually learning the graphical structure of Bayesian networks and performing MCMC with'Stan'. *The Comprehensive R Archive Network (CRAN)* **2019**.

64. Vuong, Q.-H. The (ir)rational consideration of the cost of science in transition economies. *Nature Human Behaviour* **2018**, *2*, 5, doi:10.1038/s41562-017-0281-4.

65. Palm, R.; Lewis, G.B.; Feng, B. What causes people to change their opinion about climate change? *Annals of the American Association of Geographers* **2017**, *107*, 883-896, doi:10.1080/24694452.2016.1270193.

66. Earth Science Communications Team. How do we know climate change is real? Available online: https://climate.nasa.gov/evidence/ (accessed on October 23).

67. Cook, J.; Oreskes, N.; Doran, P.T.; Anderegg, W.R.; Verheggen, B.; Maibach, E.W.; Carlton, J.S.; Lewandowsky, S.; Skuce, A.G.; Green, S.A. Consensus on consensus: a synthesis of consensus estimates on human-caused global warming. *Environmental Research Letters* **2016**, *11*, 048002, doi:10.1088/1748-9326/11/4/048002.

68. Cook, J.; Nuccitelli, D.; Green, S.A.; Richardson, M.; Winkler, B.; Painting, R.; Way, R.; Jacobs, P.; Skuce, A. Quantifying the consensus on anthropogenic global warming in the scientific literature. *Environmental Research Letters* **2013**, *8*, 024024, doi:10.1088/1748-9326/8/2/024024.

69. Friedman, L. New House Speaker champions fossil fuels and dismisses climate concerns. Available online: https://www.nytimes.com/2023/10/26/climate/mike-johnson-climate-policies.html (accessed on November 9).

70. Fielding, K.S.; Hornsey, M.J.; Thai, H.A.; Toh, L.L. Using ingroup messengers and ingroup values to promote climate change policy. *Climatic Change* **2020**, *158*, 181-199, doi:10.1007/s10584-019-02561-z.

71. Luong, K.T.; Garrett, R.K.; Slater, M.D. Promoting persuasion with ideologically tailored science messages: A novel approach to research on emphasis framing. *Science Communication* **2019**, *41*, 488-515, doi:10.1177/1075547019862559.

72. Wolsko, C.; Ariceaga, H.; Seiden, J. Red, white, and blue enough to be green: Effects of moral framing on climate change attitudes and conservation behaviors. *Journal of Experimental Social Psychology* **2016**, *65*, 7-19, doi:10.1016/j.jesp.2016.02.005.

73. Benegal, S.D.; Scruggs, L.A. Correcting misinformation about climate change: The impact of partisanship in an experimental setting. *Climatic Change* **2018**, *148*, 61-80, doi:10.1007/s10584-018-2192-4.

74. Hurst, K.; Stern, M.J. Messaging for environmental action: The role of moral framing and message source. *Journal of Environmental Psychology* **2020**, *68*, 101394, doi:10.1016/j.jenvp.2020.101394.

75. Goldberg, M.H.; Gustafson, A.; Rosenthal, S.A.; Leiserowitz, A. Shifting Republican views on climate change through targeted advertising. *Nature Climate Change* **2021**, *11*, 573-577, doi:10.1038/s41558-021-01070-1.

76. Nguyen, M.-H.; Jones, T.E. Building eco-surplus culture among urban residents as a novel strategy to improve finance for conservation in protected areas.

Humanities & Social Sciences Communications **2022**, *9*, 426, doi:10.1057/s41599-022-01441-9.

77. Hoàng, V.Q.; Hoàng, N.M.; Sơn, N.H. Không hy sinh rừng để phát triển kinh tế - xã hội: Việt Nam lựa chọn lối hài hòa, cân bằng sinh thái. Available online: https://dangcongsan.org.vn/hoidonglyluan/Lists/XayDungDang/View_Detail.aspx?ItemID=198 (accessed on

78. Vuong, Q.-H. The semiconducting principle of monetary and environmental values exchange. *Economics and Business Letters* **2021**, *10*, 284-290, doi:10.17811/ebl.10.3.2021.284-290.

79. Harrison, L.E.; Huntington, S.P. *Culture matters: how values shape human progress*; Huntington, S.P., Ed.; Basic Books: New York, 2000; p. 348.

80. Wolsko, C. Expanding the range of environmental values: Political orientation, moral foundations, and the common ingroup. *Journal of Environmental Psychology* **2017**, *51*, 284-294, doi:10.1016/j.jenvp.2017.04.005.

81. Vuong, Q.-H. Reform retractions to make them more transparent. *Nature* **2020**, *582*, 149, doi:10.1038/d41586-020-01694-x.