The complex interplay between climate change belief, political identity, and potable water reuse willingness: Insights from the arid region of the United States

Minh-Hoang Nguyen [1], Dan Li [2,*], Geng Li [3], Thi Mai Anh Tran [4], Quan-Hoang Vuong [1,5]

[1] Centre for Interdisciplinary Social Research, Phenikaa University, Hanoi 100803, Vietnam

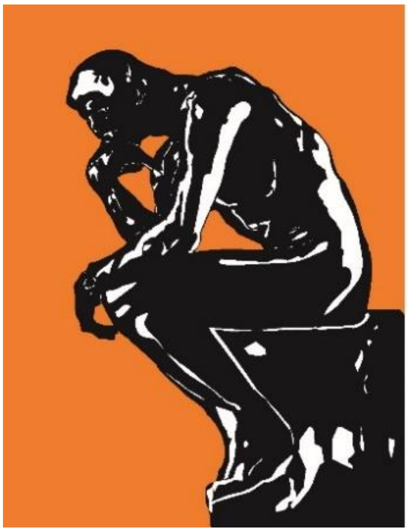
[2] Yan'an University, Yan'an, China

[3] China Institute of Coal Science, Beijing 100013, China

[4] College of Forest Resources and Environmental Science, Michigan Technological University, Houghton, MI 49931 USA

[5] A.I. for Social Data Lab (AISDL), Hanoi, Vietnam

*Corresponding Email: dellelee103@gmail.com (Dan Li)



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"Lately, it had been raining a lot, the plants were lush, and the ponds were full of fish and shrimp. Birds from everywhere flocked to live here. The population of the Bird Village increased sharply."

In "The Kindness Policy"; *The Kingfisher Story Collection* (2022)

Abstract

Public sentiment regarding climate change in the United States is starkly divided, with the Republicans and Democrats holding markedly different views. Given the inherent connection between the water crisis and climate change, this research aimed to investigate the interplay between the residents' beliefs about the impact of climate change on water supply unpredictability, their political identity, and their willingness to adopt direct and indirect potable water reuse. The Bayesian Mindsponge Framework (BMF) analytics was conducted on a dataset of 1,831 water users in the arid region of Albuquerque, New Mexico. The findings reveal a complicated interplay among examined factors. Specifically, we discovered a positive association between the belief in the impacts of climate change and the willingness to adopt potable water reuse among non-Republican water users. In contrast, Republican water users exhibit a negative association between climate change belief and willingness to adopt potable water reuse. Interestingly, despite this, Republicans generally show a higher overall willingness to adopt potable water reuse compared to non-Republicans. These findings suggest that contextual factors in Albuquerque, New Mexico, in which challenges of aridity and economic dependence on water resources are pronounced, might be important aspects contributing to the Republican's high willingness to adopt potable water reuse. Also, the current climate change communication strategy with the Republicans might not be appropriate, and it should be tailored to align with the Republicans' beliefs and persuade them better.

Keywords: climate change belief, political identity, potable water reuse willingness, eco-surplus culture

1. Introduction

Water scarcity, exacerbated by climate change, is a critical global issue with profound implications for both humanity and ecosystems (Gude, 2017; He et al., 2021; Koebele et al., 2022). As of 2019, nearly two-thirds of the world's population experiences severe water shortages for at least one month annually. Projections indicate that by 2030, water-related crises could displace up to 700 million people (GCEW, 2023).

In the United States, this issue has garnered significant attention. It is estimated that within the next five decades, nearly half of the country's freshwater basins will fail to meet public water demand. These looming shortages are expected to affect not only the Southwest but also the central and southern Great Plains, the Rocky Mountain region, parts of California, the South, and the Midwest (Andiroglu et al., 2024). Such widespread water stress threatens not only public health and community development but also exacerbates the disruption of biodiversity and the environment (Koebele et al., 2022). As prolonged droughts, rapid urbanization, and population growth intensify the situation, sustainable water conservation and management have become paramount concerns for the country (Tortajada & Nambiar, 2019).

One of the most promising solutions is potable water reuse, which offers a viable means of providing clean water supplies and mitigating local water shortages (U.S. Environmental Protection Agency, 2018). Potable reuse encompasses two primary strategies: direct potable reuse, where highly treated wastewater is introduced directly into drinking water distribution systems, and indirect potable reuse, which involves an environmental buffer, such as groundwater aquifers or surface water reservoirs, before the treated water enters the drinking water system (National Research Council, 2012). By intentionally repurposing treated wastewater for drinking water, potable reuse aligns with the principles of a circular water economy, promoting sustainable production and consumption (Chen et al., 2021). This approach could reduce freshwater withdrawals by up to eight percent, decreasing reliance on locally available water resources (Warziniack et al., 2022).

Previous research has demonstrated that potable reuse technologies can effectively treat wastewater to meet or even exceed drinking water standards (Lau et al., 2023). Additionally, potable reuse water has been found to be less cytotoxic and less contaminated with microbes than conventional drinking water, which helps mitigate factors that have contributed to waterborne outbreaks in traditional systems (Onyango et al., 2015). Despite the advancements in wastewater treatment technologies and their potential, the implementation of potable reuse in the United States remains limited, with less than one percent of reused wastewater designated for potable purposes (National Research Council, 2012).

Several studies have identified key factors influencing public acceptance. The "yuck factor," an instinctive aversion to using recycled sewage water, stands out as a significant psychological barrier (Schmidt, 2008). Additionally, public perceptions of health risks associated with potable water reuse hinder acceptance, even when scientific evidence supports the safety of treated wastewater (Dolnicar et al., 2011; Ormerod et al., 2019; Ross et al., 2014). Trust in water authorities and the perceived competence of water managers also significantly impact acceptance rates (Hartley, 2006; Nkhoma et al., 2021). Higher levels of trust are strongly correlated with greater willingness to use reused water (Ding & Liu, 2024; Thaker et al., 2019; U.S. Environmental Protection Agency, 2018). Moreover, public understanding of water treatment processes and the water cycle influences acceptance, with increased knowledge generally linked to higher acceptance levels (Fielding et al., 2020; Scruggs et al., 2020). Environmental attitudes also play a crucial role, with individuals who hold stronger pro-environmental views tending to be more receptive to potable reuse (Liu et al., 2018; Poortvliet et al., 2018).

Despite extensive research on potable reuse acceptance, little attention has been paid to the interaction roles of climate change perceptions and political ideology in influencing willingness to adopt potable water reuse (Callison & Holland, 2017; Dunlap & McCright, 2008; Garcia-Cuerva et al., 2016). To address this gap, this study examines how these factors are associated with the willingness to use direct and indirect potable water reuse among 4,000 water-utility account holders in Albuquerque, New Mexico, USA. The specific objectives of the study are:"

- Examine whether the residents' belief in the impact of climate change on water supply is associated with their willingness to adopt direct and indirect potable water reuse in Albuquerque, New Mexico.

- Examine whether being a member of the Republican party moderates the relationship between the belief in the impact of climate change on water supply and the willingness to adopt potable water reuse.

By focusing on both direct and indirect potable reuse strategies, this study offers a comprehensive understanding of public acceptance of reused water. Given the lack of prior research on the impacts of climate change belief on potable reuse acceptance in politically diverse contexts within an arid, inland region of the United States, this study serves as a pioneering inquiry into these dynamics. The findings are expected to inform the development of more effective strategies for implementing potable water reuse and addressing water scarcity in the face of climate change, particularly in politically diverse communities.

2. Methodology

2.1. Theoretical foundation and proposed hypotheses

The theoretical foundation for developing models in this research is based on the Mindsponge Theory, which synthesizes empirical findings from a wide range of ecological and physiological systems, from the cellular to the molecular scale, to explain the functioning of the mind (Vuong, 2023). Recently, this theory has been further developed by incorporating granular worldviews and insights from quantum mechanics (Vuong & Nguyen, 2024a, 2024c). The concept of the 'mindsponge' draws an analogy between the mind and a sponge, which expels incompatible values and absorbs new ones that align with core values (Vuong & Napier, 2015). Viewed through the lens of information processing, the Mindsponge Theory offers a dynamic perspective on the cognitive processes of the human mind (Vuong, 2023).

The Mindsponge Theory posits that the mind and its surrounding environment are reciprocally interconnected and interdependent (Vuong & Nguyen, 2024a). The mindset consists of deeply rooted beliefs and values, which form the foundation of an individual's value system. The buffer zone acts as a temporary holding area for new information, while the multi-filtering mechanism consolidates or segregates this information based on core values, determining whether to accept, reject, or retain it for further evaluation.

The dynamic interplay between the human mind and its environment is fundamental to cognitive functions and behavioral tendencies, enabling continuous adaptation and progress in response to external stimuli and changing circumstances. This evolving relationship underscores the idea that the mind is not a static entity but a flexible system capable of learning, adjusting, and assimilating new information through experiences and interactions with the world (Davidson & McEwen, 2012; Galván, 2010; Vuong et al., 2022). As such, the Mindsponge Theory suggests that an individual's mental framework—including beliefs, attitudes, and cognitive processes—can change and adapt. When confronted with new information or shifts in contextual factors, the mind can reassess and recalibrate its perspectives accordingly (Vuong et al., 2022).

According to the Mindsponge Theory, for individuals to be more likely to adopt potable water reuse, either directly or indirectly, the ideation of water reuse must be present in their minds and perceived as beneficial. The emergence of this concept is strongly influenced by the core beliefs and values that shape individuals' value systems. For example, if someone believes that climate change poses a threat to human existence and well-being, they will be more likely to seek out and absorb information aimed at mitigating its impacts. This belief lays the groundwork for developing environmentally conscious mindsets and behaviors. Empirical evidence suggests that individuals who acknowledge or believe in the adverse effects of climate change are more inclined to change their mindsets and behaviors accordingly (Han et al., 2022; Nguyen et al., 2023; Nguyen, Duong, et al., 2024; Pandey et al., 2018). Prior research also indicates that perceived water scarcity is a significant determinant of water conservation practices (Hannibal et al., 2019; Liu et al., 2022). Based on this rationale and evidence, we formulated the following hypothesis (H):

> H1: Belief in the impact of climate change on the unpredictability of the water supply is positively associated with residents' willingness to drink directly reused potable water.
>
> H2: Belief in the impact of climate change on the unpredictability of the water supply is positively associated with residents' willingness to drink indirectly reused potable water.

The Social Identity Approach posits that human social existence is fundamentally group-oriented, meaning that an individual's cognition is significantly influenced or shaped by the collective identities associated with their social groups. In the U.S., political identity is a particularly prominent form of collective identity (Mackay et al., 2021). When new information is introduced into a person's mind, it will be more easily integrated into the mindset if it aligns with their established political values and beliefs. Conversely, information that contradicts these political values and beliefs is more likely to be rejected (Santirocchi et al., 2023).

The political landscape in the U.S. has become increasingly polarized, particularly regarding governmental environmental protection programs, including those addressing climate change (Gilligan et al., 2018). According to a 2019 report by the Pew Research Center, 90% of Democrats support increased federal efforts to mitigate climate change, while only 24% of conservative Republicans agree, with over 70% holding opposing views. Additionally, nearly half of conservative Republicans favor candidates who oppose climate change measures (Leiserowitz et al., 2022).

It is reasonable to assume that conservative Republicans who do not support climate change mitigation efforts are less likely to prioritize information related to climate change, thereby hindering their acceptance of information pertaining to water conservation, such as potable water reuse. Evidence suggests that a significant portion of Republican voters in the U.S. are skeptical of or dismissive of the scientific consensus on climate change. When political identity interacts with beliefs about climate change, it can create complex scenarios where political values either negate or reinforce the impact of climate change beliefs on information processing (Vuong & Nguyen, 2024c). Consequently, we hypothesize that:

H3: Being a Republican negatively moderates the relationship between the belief in climate change's impact on water supply unpredictability and the willingness to drink directly reused potable water.

H4: Being a Republican negatively moderates the relationship between the belief in climate change's impact on water supply unpredictability and the willingness to drink indirectly reused potable water.

2.2. Model construction

2.2.1. Variable selection and rationale

To investigate our hypotheses, we utilized a dataset compiled by Distler and Scruggs (2020b). The dataset as been employed in previous studies on water consumption behaviors in Albuquerque, New Mexico (Distler, 2018; Distler & Scruggs, 2020a; Nguyen, Doan, et al., 2024). The dataset includes information from 4,000 water-utility account holders in Albuquerque, New Mexico, USA. The study was conducted in collaboration with the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) to explore water-related knowledge, usage habits, attitudes toward water reuse, and topics related to water and climate change, as well as demographic information.

The survey design process involved eight focus group interviews, each of which lasted 90 minutes, and 12 debriefing sessions with 7 to 10 participants each. The focus groups were conducted in July, October, and November 2016, and the debriefing sessions took place in August, October, and November of the same year. All participants were ABCWUA clients aged 18 or older who actively engaged in testing prototype survey questions during the focus group interviews and provided valuable feedback for accurate interpretation during the debriefing sessions.

A random sample of 4,000 accounts was selected from over 180,000 residential accounts to ensure that the proportions closely resembled those in the overall customer database. The survey was conducted from April to September 2017 by sending mail invitations with a hyperlink to participate in an online survey via Survey Monkey. It garnered 1,831 valid responses, achieving a response rate of 46%.

For this study, we utilized four variables from the dataset to construct our model: two outcome variables and two predictor variables. The outcome variables, *DPR_WILL_3* and *IPR_WILL_3*, represent whether the respondents are willing or unwilling to drink directly and indirectly reuse potable water. The predictor variables include *CLIMATE* and *REPUBLICAN*. The *CLIMATE* variable was directly retrieved from the original dataset and is based on a 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." The *REPUBLICAN* variable was derived from the dataset's *POLITICAL* variable, indicating the political affiliation of water users. Respondents who primarily identified as Republicans were assigned a value of '1,' while those identifying with other political parties were assigned a value of '0.' Detailed descriptions of these variables are provided in Table 1.

Table 1. Variable description

Variable	Description	Type of variable	Value
DPR_WILL_3	The extent of willingness to reuse direct potable water	Binary	Willing = 1 Unwilling = 0
IPR_WILL_3	The extent of willingness to reuse indirect potable water	Binary	Willing = 1 Unwilling = 0
CLIMATE	Whether the respondent believed that the impact of climate change on the water cycle would have a negative effect on the water supply in a few decades	Binary	Yes = 1 No = 0
REPUBLICAN	Whether the respondent primarily identified himself/herself as Republican	Binary	Yes = 1 No = 0

2.2.2. Statistical models

To test the connection between residents' climate change belief and their willingness to drink direct reuse potable water, as well as the moderating effect of being a Republican on this relationship, we constructed Model 1 with the following structure:

$$DPR\_WILL\_3 \sim normal\left(\log\left(\frac{\mu_i}{1-\mu_i}\right), \sigma\right) \quad (1.1)$$

$$\log\left(\frac{\mu_i}{1-\mu_i}\right) = \beta_0 + \beta_1 * CLIMATE_i + \beta_2 * CLIMATE_i * REPUBLICAN_i \quad (1.2)$$

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

The probability around the mean $\log\left(\frac{\mu_i}{1-\mu_i}\right)$ is determined by the shape of the normal distribution, where the width of the distribution is specified by the standard deviation σ. μi represents the probability that the residential account holder i willing to accept drinking directly recycled water; $CLIMATE_i$ 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 *DPR_WILL_3*. If the coefficient is significant, the water user's political party is deemed to affect (or moderate) the relationship between climate change belief and the willingness to reuse drinkable water directly. 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.

Similarly, we constructed Model 2 to examine the connection between residents' climate change belief and their willingness to reuse drinkable water indirectly, as well as the moderating effect of being a Republican on this relationship:

$$IPR\_WILL\_3 \sim normal\left(\log\left(\frac{\mu_i}{1-\mu_i}\right), \sigma\right) \quad (2.1)$$

$$\log\left(\frac{\mu_i}{1-\mu_i}\right) = \beta_0 + \beta_1 * CLIMATE_i + \beta_2 * CLIMATE_i * REPUBLICAN_i \quad (2.2)$$

$$\beta \sim normal(M, S) \quad (2.3)$$

μ_i represents the probability that the respondent i is willing to reuse drinkable water indirectly. Model 2 has four parameters: the coefficients, β_1 – β_2, the intercept, β_0, and the standard deviation of the "noise," σ.

2.3. Analysis and validation

The study utilizes the Mindsponge Framework (BMF) analytics because it integrates the inferential strengths of Bayesian analysis with the logical reasoning capabilities of Mindsponge Theory (Nguyen et al., 2022; Vuong et al., 2022). Both approaches are highly suitable, which complement each other in examining the socio-psychological issues (Nguyen et al., 2022). Moreover, Bayesian inference probabilistically handles all properties, including those that are known and unknown, enabling the prediction of parsimonious models (Csilléry et al., 2010; Gill, 2015). Additionally, Bayesian analysis can handle complex models such as multilevel and nonlinear regression frameworks, thanks to the Markov chain Monte Carlo (MCMC) method (Dunson, 2001). Compared to the frequentist method, Bayesian inference offers several advantages, including the use of credible intervals for result interpretation instead of confidence intervals and *p*-values (Halsey et al., 2015; Wagenmakers et al., 2018).

It is crucial to carefully choose the appropriate prior when developing a Bayesian model. In this investigation, we opted for uninformative priors or a flat prior distribution to reduce the amount of prior information available for model estimation due to the exploratory nature of the study (Diaconis & Ylvisaker, 1985). Following successful model fitting, we utilized Pareto-smoothed importance sampling leave-one-out (PSIS-LOO) diagnostics to evaluate the goodness of fit of the models (Vehtari & Gabry, 2024; Vehtari et al., 2017):

$$LOO = -2LPPD_{LOO} = -2\sum_{i=1}^{n} log \int p(y_i|\theta)p_{post(-i)}(\theta)d\theta$$

The posterior distribution, represented as $p_{post(-i)}(\theta)$, is calculated using the data minus data point i. The *k*-Pareto values are used in the PSIS method for computing leave-one-out cross-validation, which aids in identifying observations with a significant impact on the PSIS estimate. Observations with *k*-Pareto values greater than 0.7 are considered influential and may present challenges in accurately estimating leave-one-out cross-validation. It is common to consider a model as fitting well with the data when the k values are below 0.5.

If the data align well with the model, we will then proceed to the convergence diagnostics and interpretation of the results. Statistical and visual methods can be used to verify the convergence of Markov chains. Statistically, the effective sample size (*n_eff*) and the Gelman–Rubin shrink factor (*Rhat*) are employed to assess convergence. The *n_eff* value indicates the number of independent samples during stochastic simulation. Convergence is generally validated if *n_eff* exceeds 1000, ensuring sufficient samples for reliable inference (McElreath, 2018). On the other hand, the *Rhat* value is the potential scale reduction factor. If *Rhat* exceeds 1.1, the model does not converge, while the *Rhat* value of 1 indicates convergence. Additionally, visual validation of Markov chains' convergence utilizes trace plots, Gelman–Rubin–Brooks plots, and autocorrelation plots.

The researchers utilized the bayesvl R package to conduct Bayesian analysis in the current study (La & Vuong, 2019). The dataset, data description, and code snippets related to the Bayesian analysis were uploaded to Zenodo to enhance transparency and assist in later replication and validation (Vuong, 2018): https://zenodo.org/records/13363770

3. Results

3.1. Model 1

To interpret the results, it is essential to evaluate the goodness of fit of Model 1 with the data. As depicted in Figure 1, all the estimated *k*-values are below the 0.5 threshold, signifying a good fit between the model and the data.

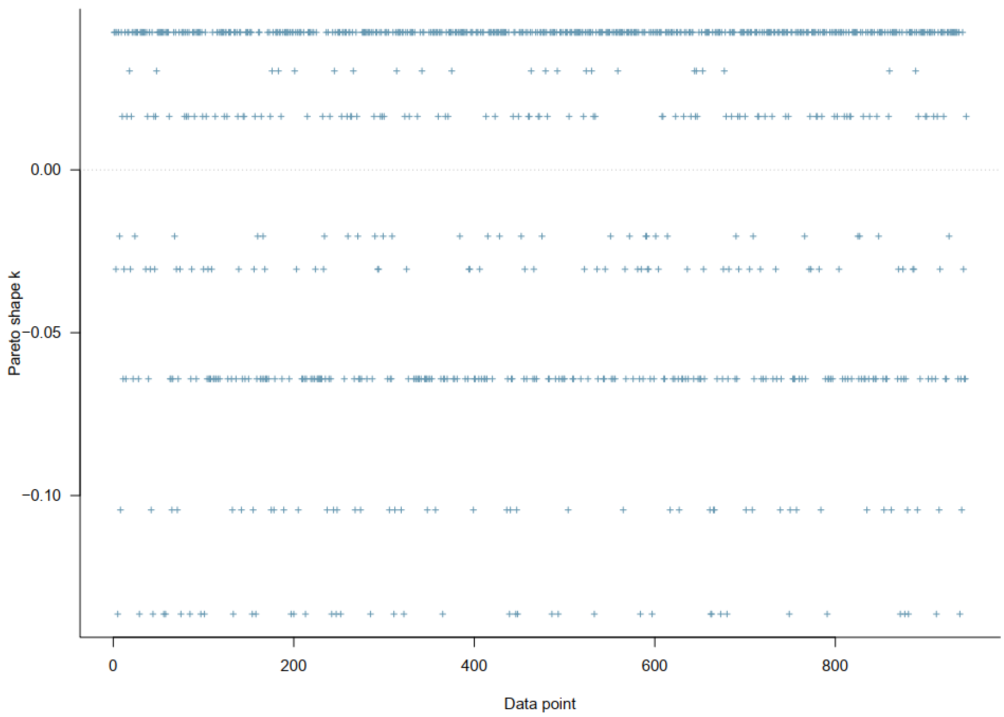

Figure 1: Model 1's PSIS-LOO diagnosis

The estimated posterior distributions of Model 1 are presented in Table 1. All *n_eff* values exceed 1,000, and *Rhat* values are equal to 1, confirming the convergence of the Markov chains in Model 1. This convergence is further supported by the trace plots in Figure 2, where all chain values stabilize around a central equilibrium after the 2,000th iteration.

Table 1: Estimated results of Model 1

Parameters	Mean	SD	*n_eff*	*Rhat*
Constant	0.45	0.24	3087	1
CLIMATE	0.47	0.26	3021	1
REPUBLICAN	0.45	0.35	3333	1
*CLIMATE*REPUBLICAN*	-0.54	0.41	3262	1

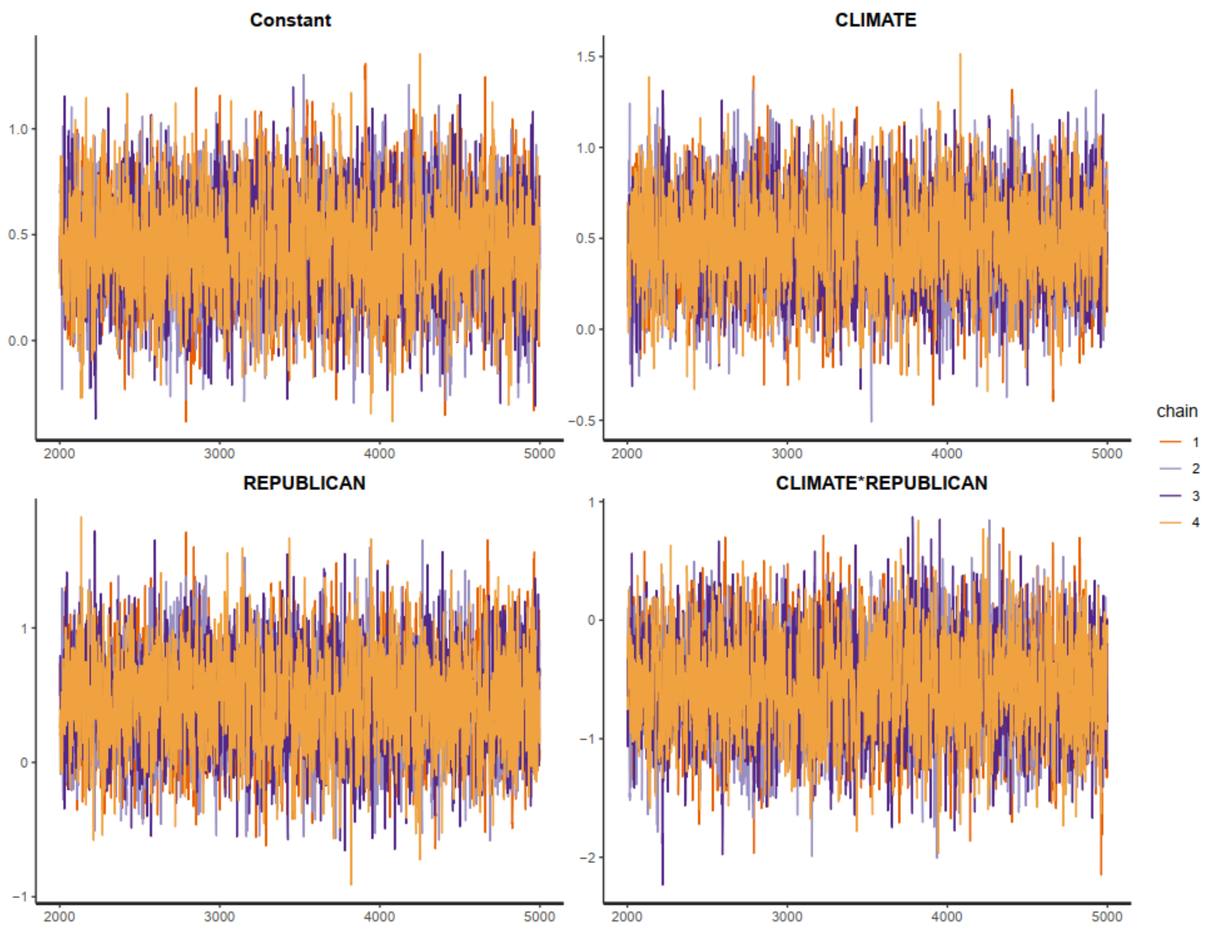

Figure 2: Model 1's trace plots

The Gelman-Rubin-Brooks plots and autocorrelation plots further confirm the convergence of the Markov chains. The Gelman-Rubin-Brooks plots are used to evaluate the ratio of variance between and within Markov chains. In these plots, the *y*-axis represents the shrink factor (or Gelman-Rubin factor), while the *x*-axis shows the iteration order of the simulation. As depicted in Figure 3, the shrink factors of all parameters rapidly drop to 1 before the 2,000th iteration (during the warmup period), indicating no divergence among the Markov chains.

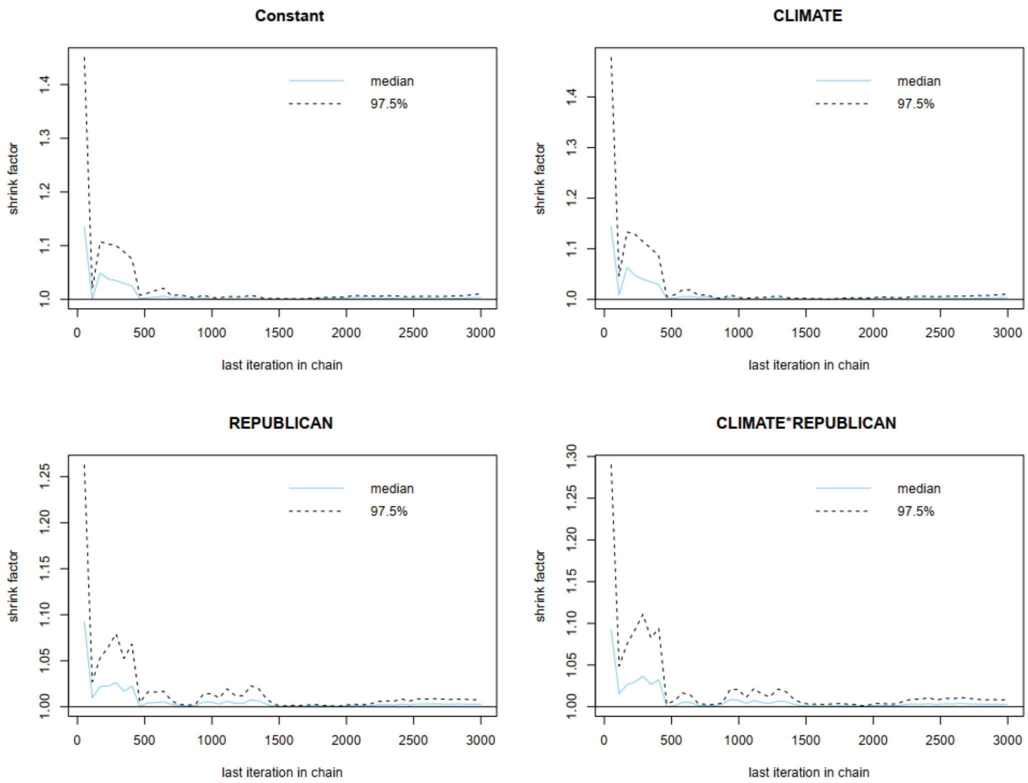

Figure 3: Model 1's Gelman-Rubin-Brooks plots

For Markov chains to converge, the simulation needs to obtain the Markov property, which denotes the memoryless characteristic of a stochastic process. It means that the successive values are not correlated with the preceding ones. Autocorrelation plots are used to assess these levels of autocorrelation among the values. Figure 4 illustrates the average autocorrelation level of each Markov chain on the *y*-axis and the lag of the iteration on the *x*-axis. Visually, the autocorrelation levels of all Markov chains decrease rapidly to 0 after a small number of lags (before 5), indicating that the Markov property is satisfied and the Markov chains are well-convergent.

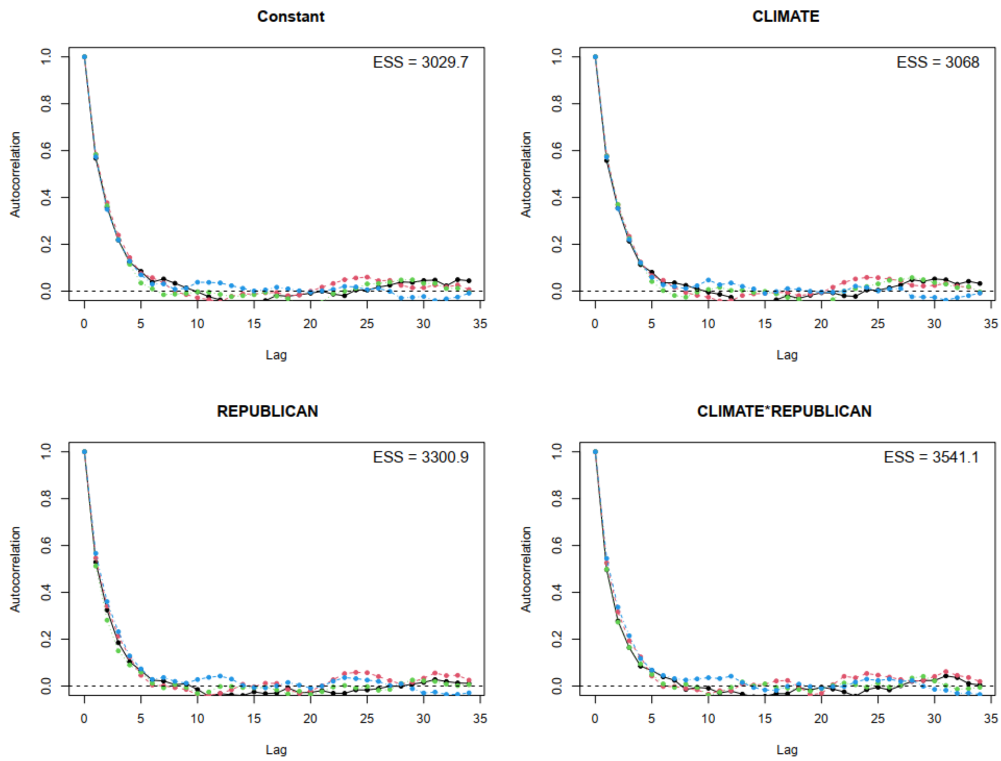

Figure 4: Model 1's autocorrelation plots

With all diagnostics confirming the convergence of the Markov chains, the simulated results are suitable for interpretation. The estimated results of Model 1 indicate that the belief in climate change's impact on future water supply unpredictability and being a Republican are positively associated with residents' willingness to adopt direct potable water reuse ($M_{CLIMATE}$ = 0.26 and $S_{CLIMATE}$ = 0.04; $M_{REPUBLICAN}$ = 0.45 and $S_{REPUBLICAN}$ = 0.35). Being a Republican also negatively moderates the relationship between climate change belief and willingness to directly reuse drinking water ($M_{CLIMATE*REPUBLICAN}$ = -0.54 and $S_{CLIMATE*REPUBLICAN}$ = 0.41).

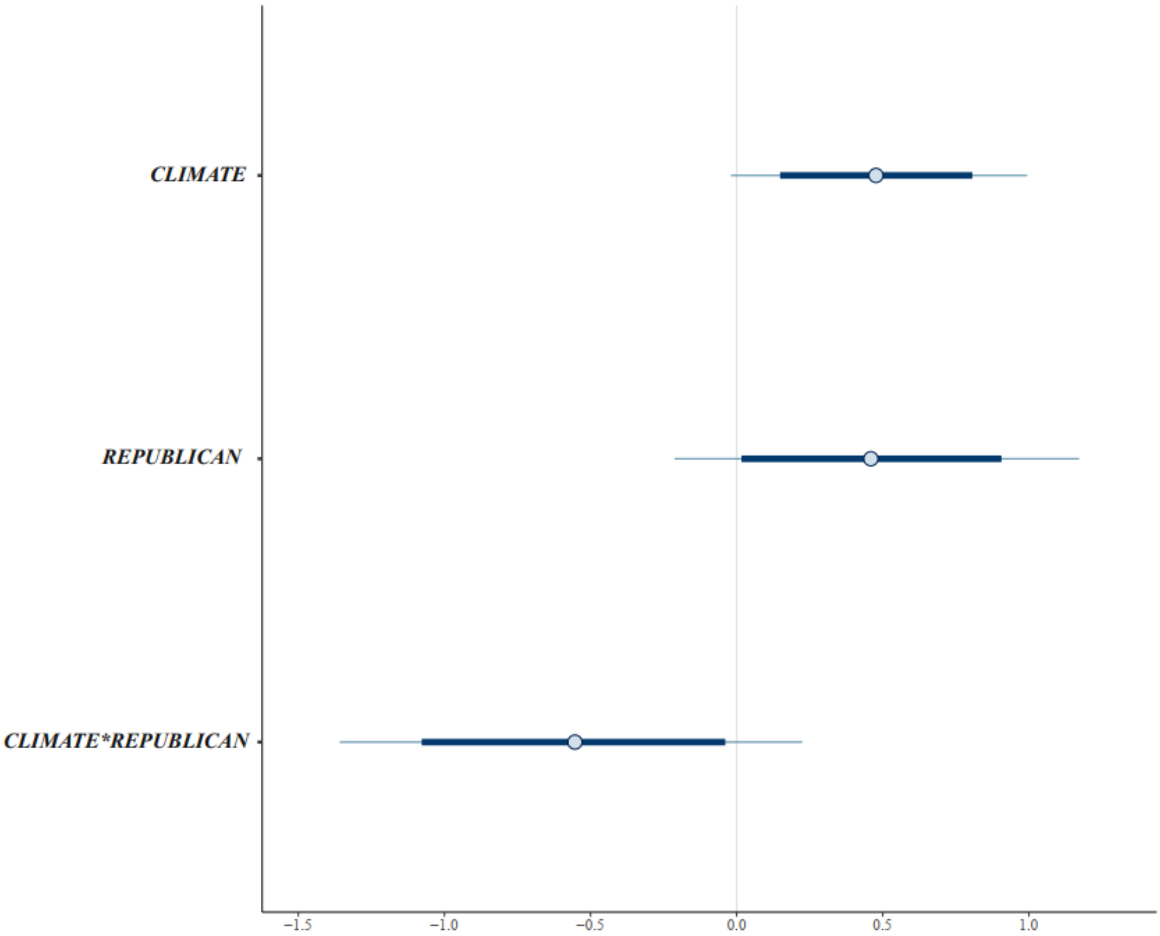

Figure 5: Model 1's posterior distributions

Figure 5 shows the posterior distributions of the coefficients, with their 89% Highest Posterior Density Intervals (HPDIs) represented by thick blue lines. The posterior distributions for $CLIMATE$ and $REPUBLICAN$ are entirely on the positive side of the *x*-axis, indicating the high reliability of positive associations. In contrast, the posterior distribution for $CLIMATE * REPUBLICAN$ is entirely on the negative side, suggesting a highly reliable negative moderation effect on the relationship between $CLIMATE$ and $REPUBLICAN$.

For clarity, we applied the estimated parameters' mean values in Equation 1 to calculate the probabilities of being willing to adopt direct potable water reuse. The probability shown in Figure 6 suggests that Republican water users tend to have a higher probability of being willing to adopt direct potable water reuse. However, if they believe in climate change's impacts, the probability will decline slightly. Non-Republicans with no belief in climate change's impact have the lowest probability, while those with the belief have the highest probability. In other words, the probability of non-Republicans adopting direct potable water reuse varies widely depending on whether they believe in climate change or not.

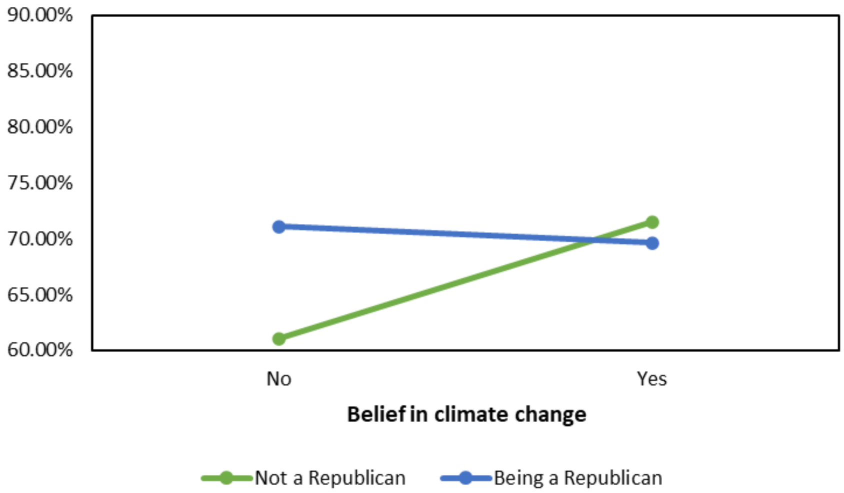

Figure 6: Calculated probabilities of being willing to adopt direct potable water reuse, according to the belief in climate change and Republican affiliation

3.2. Model 2

The PSIS-LOO test results for Model 2 are displayed in Figure A1. All the computed *k*-values are below the 0.5 threshold, indicating that the model demonstrates an acceptable goodness of fit with the data.

The statistical values of *n_eff* (greater than 1000) and *Rhat* (equal to 1) in Table 3 indicate the convergence of Model 2's Markov chains. Additionally, the trace plots, Gelman-Rubin-Brooks plots, and autocorrelation plots further validate the convergence (see Figures A2-A4). Consequently, the simulated results of Model 2 are suitable for interpretation.

Table 3: Estimated results of Model 2

Parameters	Mean	SD	n_ff	Rhat
Constant	0.81	0.25	2981	1
CLIMATE	0.35	0.26	3001	1
REPUBLICAN	0.88	0.41	3129	1
*CLIMATE*REPUBLICAN*	-0.65	0.47	3273	1

The simulated results in Table 3 indicate that belief in the impact of climate change on future water supply unpredictability and Republican affiliation are positively associated with residents' willingness to indirectly reuse potable water ($M_{CLIMATE}$= 0.35 and $S_{CLIMATE}$ = 0.25; $M_{REPUBLICAN}$ = 0.88 and $S_{REPUBLICAN}$ = 0.41). Moreover, Republican affiliation negatively moderates the relationship between belief in climate change and the willingness to indirectly reuse drinking water ($M_{CLIMATE*REPUBLICAN}$ = -0.65 and $S_{CLIMATE*REPUBLICAN}$ = 0.47).

Figure 7 displays the posterior distributions along with their 89% HPDIs. The HPDIs of $CLIMATE$ and $REPUBLICAN$ are entirely on the positive side of the *x*-axis, indicating high reliability in their positive effects. Meanwhile, the entire HPDI of $CLIMATE * REPUBLIC$AN is on the negative side of the *x*-axis, suggesting that the negative moderation effect is also highly reliable.

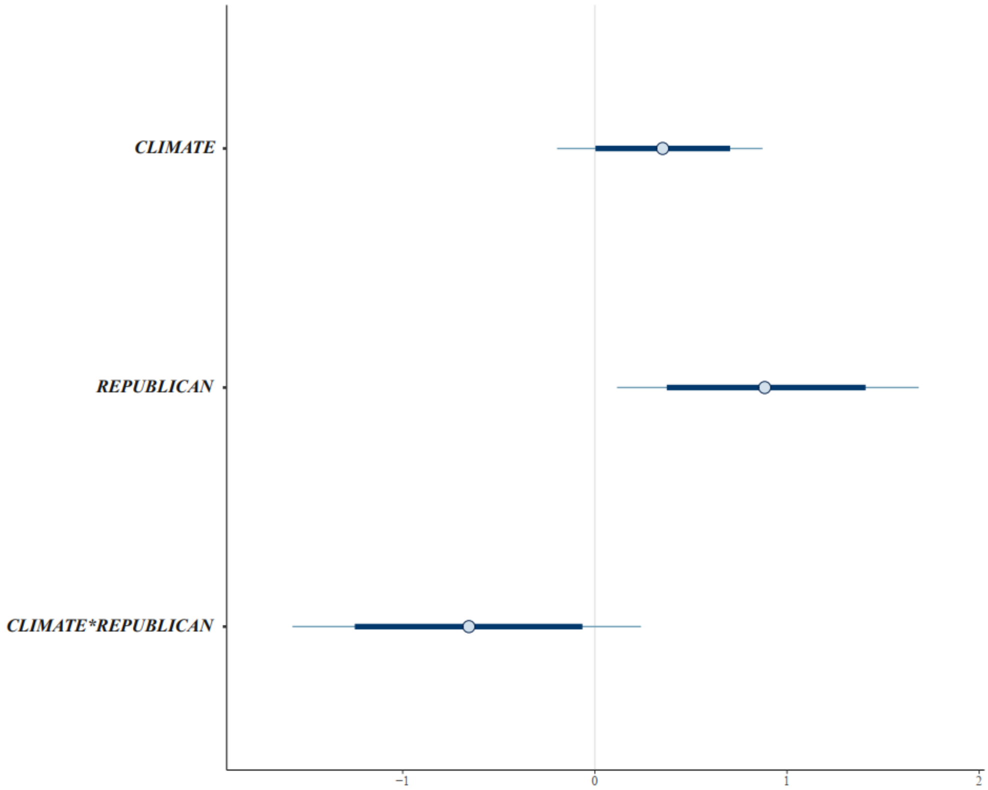

Figure 7: Model 2's posterior distributions

The estimated parameters' mean values were applied in Equation 2 to calculate the probabilities of being willing to adopt direct potable water reuse. The calculated probabilities are visualized in Figure 8. As can be observed, although Republican water users generally have a higher probability of being willing to adopt indirect potable water reuse than non-Republican water users, their probability declines as they believe in climate change's impacts. In contrast, non-Republican water users have a higher probability of being willing to adopt indirect potable water reuse when they believe in climate change's impacts.

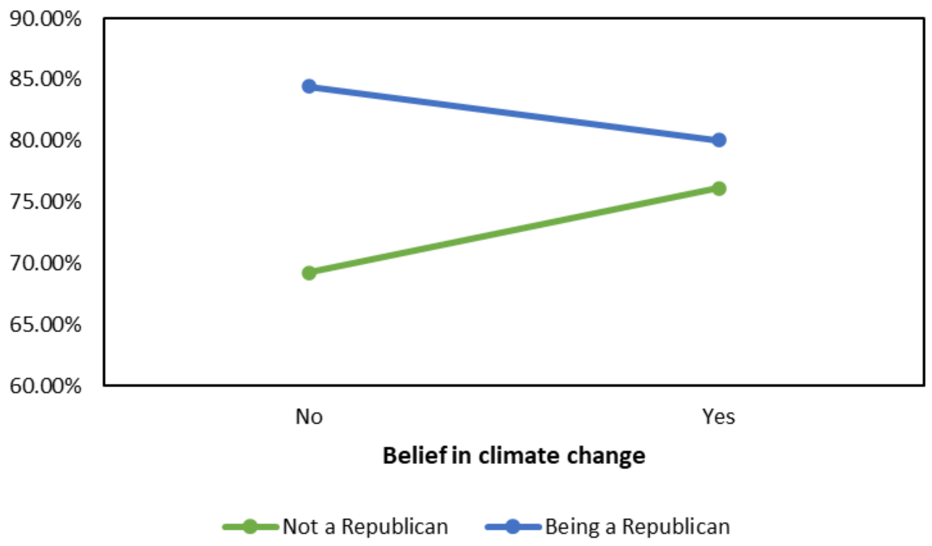

Figure 8: Calculated probabilities of being willing to adopt indirect potable water reuse, according to the belief in climate change and Republican affiliation

4. Discussion

The study utilized Bayesian Mindsponge Framework analytics to explore the complex interplay between climate change beliefs, political ideology, and willingness to adopt direct and indirect potable water reuse. The research focused on a sample of New Mexico residents, particularly in Albuquerque, where challenges of aridity and economic dependence on water resources are pronounced. Analysis of data from 1,831 water consumers in Albuquerque revealed complex results. Among non-Republican water users, we found a positive association between their beliefs in the impact of climate change on future water supply unpredictability and their willingness to engage in both direct and indirect potable water reuse. However, for Republican water users, there is a negative association between their beliefs in the impact of climate change and their willingness to adopt potable water reuse. Also, Republican users are generally found to have a higher willingness to adopt potable water reuse than non-Republican users.

These findings only corroborate the first and second Hypotheses grounded on the Mindsponge Theory. Specifically, the positive associations between belief in the impact of climate change and residents' willingness to drink directly and indirectly reused water are only confirmed among non-Republican water users. These results highlight the significant influence of environmental factors on human responses to environmental challenges. This relationship aligns with the established link between awareness and risk perceptions of climate change, such as concerns about water scarcity and the adoption of water-saving practices—including water reclamation and recycling—particularly in arid regions (Pakmehr et al., 2020; Pandey et al., 2018; Qadir & Sato, 2015).

The third and fourth hypotheses regarding the negative moderation effects of being a Republican on the relationship between climate change belief and potable water reuse willingness are also confirmed. Nevertheless, what was unexpected was the positive association between being a Republican and the willingness to adopt potable water reuse.

This unexpected association, indeed, makes the relationships between climate change beliefs, political ideology, and willingness to adopt direct and indirect potable water reuse more complicated. Contrasting with previous studies predicting that Republicans are less concerned about environmental issues and less engaged in preparing to vote on a policy that affects water (Dunlap & McCright, 2008; Geiger et al., 2020; Gibson et al., 2021; Hart & Nisbet, 2012), Republican users with no belief in climate change's impacts on the water supply have the highest probability of being willing to adopt direct and indirect potable water reuse (see Figures 6 and 8). Even when we removed water users from parties other than Democratic and Republican parties (e.g., no political affiliation, Green party, and Libertarian party), the estimated results remained similar.

The contradicting results with previous findings in this study are intriguing and worth further investigation. Several potential directions can be investigated. The contextual factors in Albuquerque, New Mexico, where challenges of aridity and economic dependence on water resources are pronounced, might be one of them. Republican residents tend to prioritize the free market and economic growth (Hejny, 2018), so water recycling and reuse businesses would be supported as they reflect the properties of the free market, create more jobs, and promote economic growth. However, this explanation requires more thoroughly designed studies to be tested. Another potential research direction is investigating the socio-psychological aspects regarding the interplay between climate change perception, political identity, and water reuse willingness. Following normal logic, people believing the negative impact of climate change on future water uncertainty would be more likely to take action to minimize the perceived negative impact. Nevertheless, findings in this study indicate otherwise among Republican water users, possibly highlighting the inappropriate communication of climate change issues toward the Republicans.

Some implications can be drawn from these findings. Although the results contradict previous findings regarding the relationship between political affiliation (i.e., a proxy of political identity) and willingness to adopt direct and indirect potable water reuse, they still indicate political polarization in evaluating climate change-related information. Communicating information regarding climate change's impacts on future water uncertainty might be a good way to influence the adoption of water-saving intentions, but it is only effective among non-Republicans. Therefore, tailoring climate change messages and policies to align with the beliefs of Republican constituents might be essential (Fielding et al., 2020). Specifically, when designing advertising campaigns, Goldberg et al. (2021) proposed that utilizing videos tailored to resonate with Republicans and specifically aimed at this demographic could improve their comprehension of the reality, origins, and negative impacts of climate change. Given the already high probability of being willing to adopt direct and indirect potable water reuse among Republican water users, the right communication approach regarding climate change might further uphold and even increase their adoption of potable water reuse. In the long term, the eco-surplus cultural values might also be forged and reinforced by raising awareness about the impacts of climate change and their interconnection and interdependence with water scarcity (Nguyen & Jones, 2022; Vuong & Nguyen, 2023, 2024b; Vuong, 2021).

This research is not without limitations, which are outlined here for the sake of transparency (Vuong, 2020). Since the dataset is restricted to samples from Albuquerque, it may not adequately represent cities or states with different geographical and climatic conditions. Consequently, caution should be exercised when generalizing these findings to other regions across the U.S. Moreover, the evaluation of Albuquerque water consumers' perspectives on potable water reuse relies on self-reported data, which may be bounded by subjective biases. Additionally, the cross-sectional nature of the dataset limits the ability to establish causality between the predictor and outcome variables. Therefore, future experimental research is recommended to elaborate on and validate the interplay between climate change beliefs, political identity, and willingness to adopt potable water reuse.

Appendix

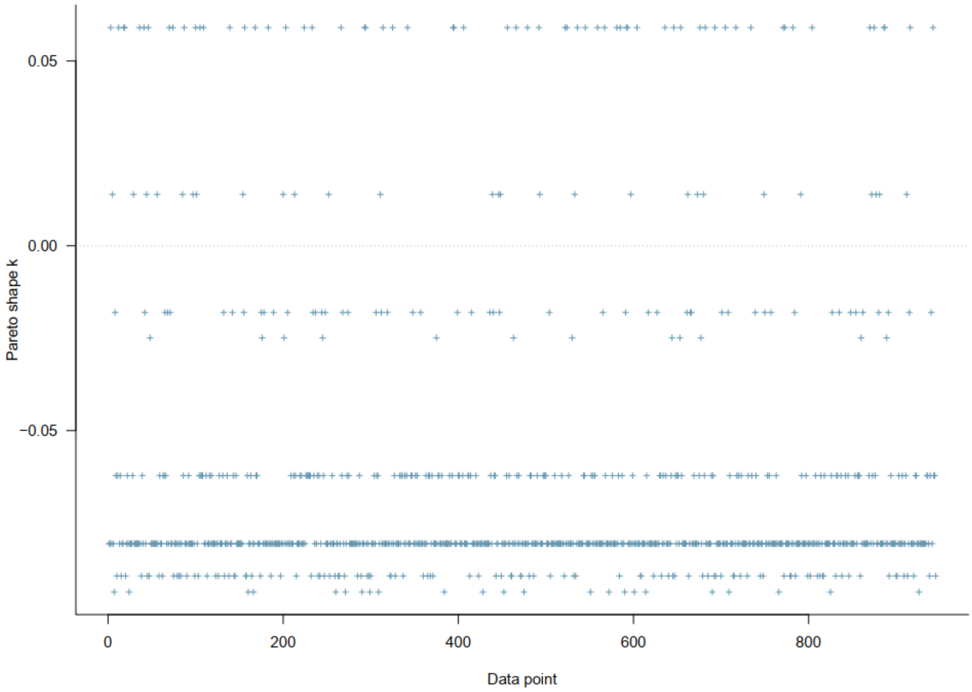

Figure A1: Model 2's PSIS-LOO diagnosis

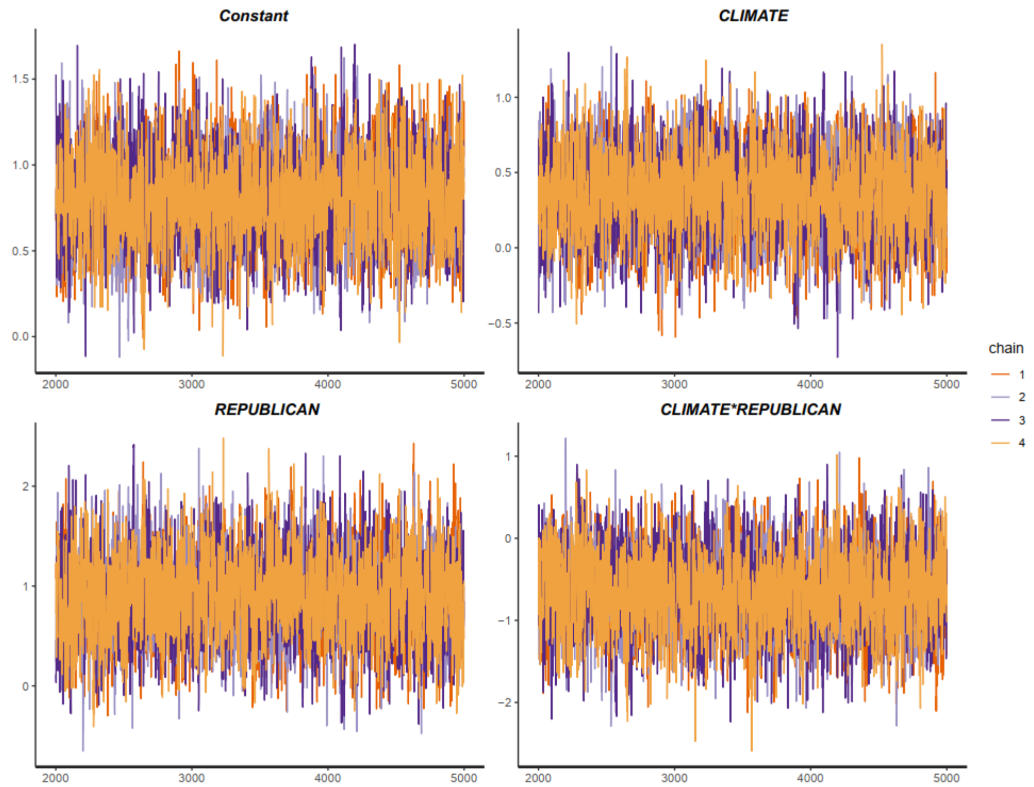

Figure A2: Model 2's traceplots

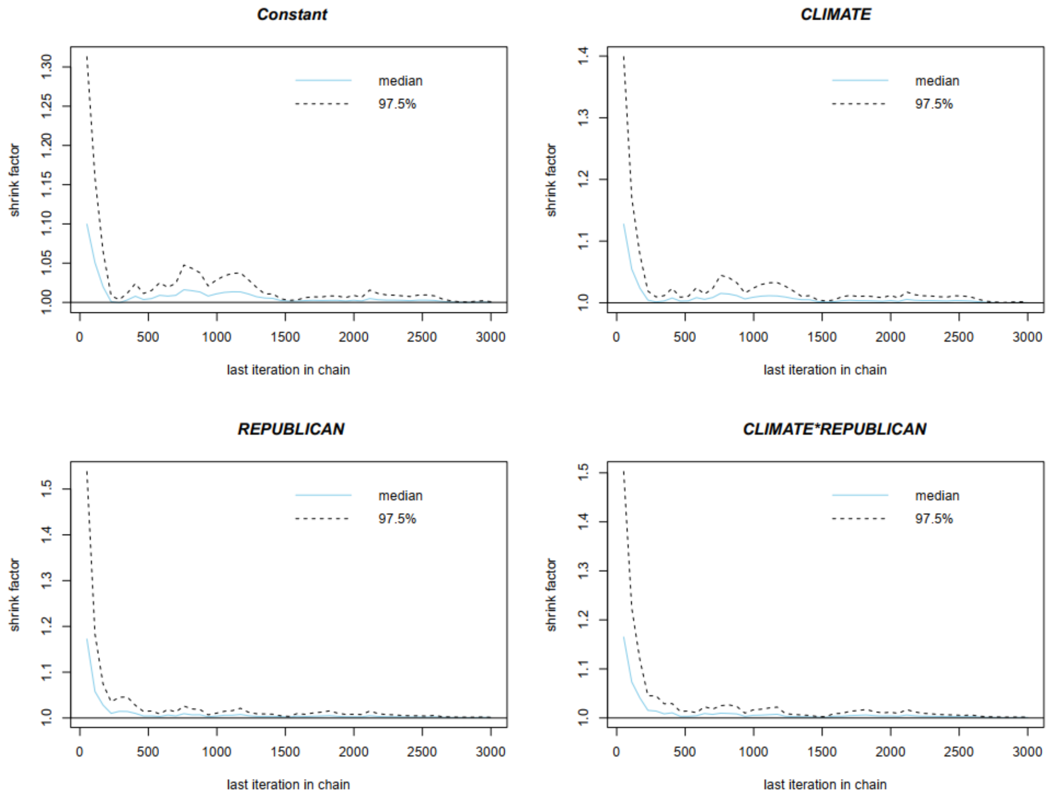

Figure A3: Model 2's Gelman-Rubin-Brooks plots

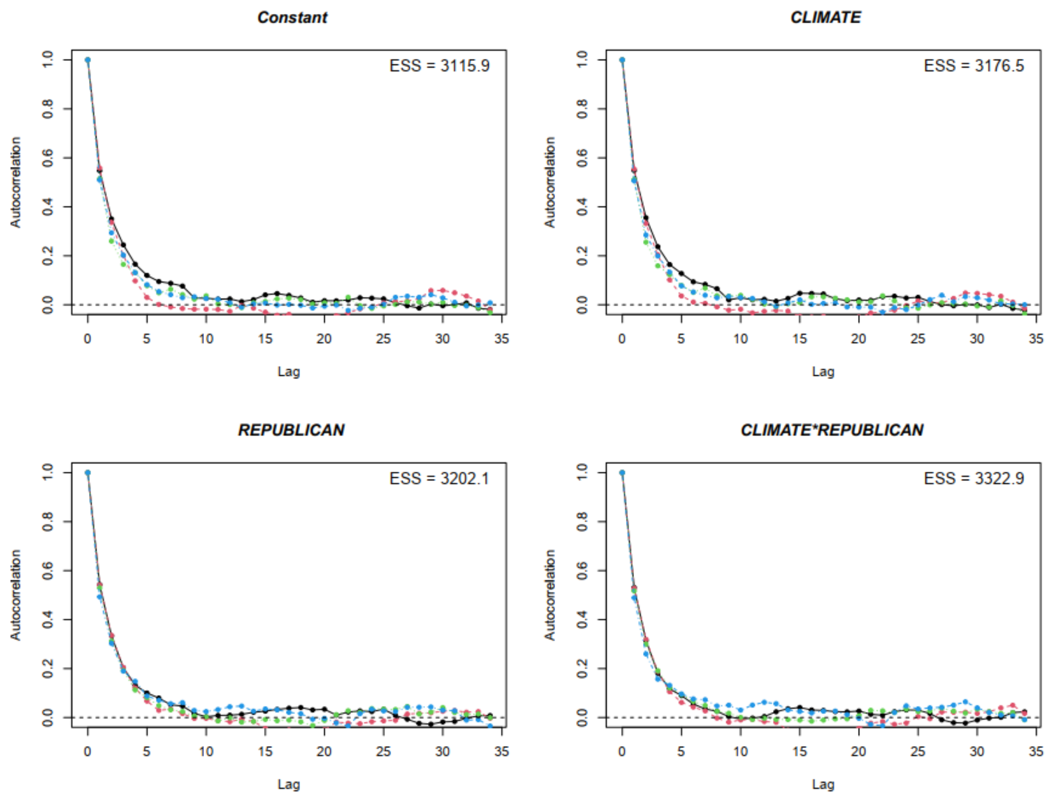

Figure A4: Model 2's autocorrelation plots

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