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Understanding drivers of local water quality perception in the Lake Erie Basin

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ABSTRACT

In recent years, Lake Erie has seen a surge in harmful algal blooms, largely attributed to climatic changes and agricultural runoff in the Maumee River Watershed. These trends are shared in other watersheds across the Great Lakes and throughout the world. The actions of local citizens can improve local water quality, but action is unlikely to occur if the local community does not perceive problems with local water quality. While much of the literature focuses on how organoleptic properties (e.g., water quality is considered good if it smells and looks good) and demographic factors explain public perceptions, this study assesses more proximate indicators–including trust in those communicating about and managing water quality and pro-environmental values. We assess relationships among these variables among urban and rural residents in the Maumee River Watershed. Our results indicate that greater trust in agricultural organizations and local government was consistently associated with better perceived water quality. Future research should focus on how influential sources of information about water quality are presenting local water quality issues, as exploratory analyses support the idea that individuals with connections to agriculture, and affiliating as Republican, may be using a trust heuristic to assess local water quality. In other words, in the absence of actual metrics of water quality, beliefs about water quality may be formed based on who is most trusted. The results also indicate that assumptions about how a local community perceives local water quality can be based on particular identifying characteristics, such as political affiliation.

1. Introduction

In the past decade there has been an increase in soluble phosphorous in Lake Erie coming from the Western Lake Erie Basin. This increase is likely due to several factors, including agricultural practices like surface application of fertilizer through broadcast methods (Smith et al., 2015). Additionally, the Western Lake Erie Basin is expected to see higher temperatures, and more variable and extreme levels of precipitation in the future (USGCRP, 2018). These changes are expected to increase nutrient runoff, exacerbating harmful algal blooms. At the same time, demand for agricultural products is projected to increase due to a growing global population (D'Odorico et al., 2018), creating a perceived conflict between food production and other ecosystem services provided by the agricultural landscape (e.g., clean water).

Increasing public support for individual and governmental action across the rural to urban gradient could help communities adapt to these changing conditions and mitigate future harm to water quality. For communities in rural areas with a high percentage of agricultural operations, the introduction of conservation practices such as controlled drainage and buffer systems can help to protect local water quality by trapping soil and nutrients otherwise lost through erosion and run-off (McLellan et al., 2018). At a household level, proper disposal of toxic substances (e.g., motor oil, paint) and septic system management also diminish the likelihood of water contamination (US EPA, 2023). Individuals across the rural to urban gradient can also make their voices heard through political action, to ensure that elected representatives are working to support positive change (Maddock, 2004). However, the first step to engaging people in individual and political actions to improve their local water quality is understanding how individuals perceive water quality. Many behavioral theories contend that it is *perceptions* of reality, not objective factual information, that drive decision-making (Ajzen, 1985, 2001; Rogers and Prentice-Dunn, 1997; Witte, 1992; Lindell and Perry, 2012).

Water quality for the purposes of the research presented here refers

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to surface water quality. In this study, we ask individuals to reflect on the quality of the water in the lakes, streams, and rivers near one's home. However, the literature on water quality perception focuses largely on drinking water, leaving a relative gap in our knowledge of how individuals perceive the quality of surface and groundwater sources of that drinkable water. The water quality perception literature demonstrates that perceptions are partly based on organoleptic properties (Carlson et al., 2014; Cockerill, 2016; de França Doria, 2010), using how the water looks and smells as a proxy for quality. However, such properties do not always give a complete or accurate picture of water quality perceptions (Brooks et al., 2017; Dobbie and Brown, 2014). Thus, another focus of the existing literature is the role of demographic factors in understanding perception (e.g., Withanachchi et al., 2018). These factors have practical appeal, since demographic factors are largely knowable through public records and could be a low-cost starting point for estimating public perceptions. Despite their intuitive appeal, demographic factors alone are unreliable predictors of water quality perceptions (Mobley, 2016). As a result, we propose that water quality perceptions would be better understood by largely under-explored, non-observable factors (e.g., trust, values) that are prevalent in social-psychological theories explaining the formation of perceptions and attitudes.

Given that water quality issues are an environmental risk management problem, we chose to consider two primary drivers from the literature on risk perception and environmental behavior. In the context of risk perception, a leading theory outlining how such perceptions are formed is the Trust, Confidence, and Cooperation model (Earle et al., 2010). Generally speaking, the argument in this model is that perception of risk (e.g., water quality perceptions), and ultimately acceptance of a hazard (e.g., nutrient loss), is driven by trust in the managing entities. For example, if an individual trusts the state government to manage local water quality (i.e., the individual perceives that the government shares their values and motivations, and has confidence in the government's ability to manage water quality hazards), then that individual perceives the risks associated with local water bodies to be low and believes that water quality is high.

Similarly, in the context of pro-environmental behavior, a leading theory outlining how perceptions are formed (ultimately leading to pro-enviornmental behavior) is the values-and-beliefs model (Stern et al., 1995a). The argument in this model is that a variety of different values give rise to sets of beliefs or perceptions that lead to particular beahviors. These values range from biospheric values (i.e., focused on impacts to non-human others), to altruistic values (i.e., focused on impacts to other humans), to egoistic values (i.e., focused on impacts to oneself). While all three values can lead to environmental concern depending on who or what is impacted, individuals who hold biospheric values are the most pro-environmentally oriented, and are often the most likely to be concerned about environmental risks and associated environmental quality. For example, if I hold strong biospheric values, then I am likely to be more concerned about threats to local water quality, and thus more likely to perceive the quality as low.

We sought to examine trust in local management entitites and biospheric values as predictors of water quality perceptions, to test which aspects of perception formation were most relevant for this distinct population of individuals. The present study adds to current understanding of public perceptions of water quality by controlling for demographic factors commonly used to explain variation in perception and by testing the predictive power of more direct influences of water quality perceptions among residents of the Maumee River Watershed in the western Lake Erie Basin. A set of exploratory analyses also test to what extent easily identifiable demographic factors might have an indirect effect on water quality perception through trust and biospheric values.

2. Literature review

While commonly studied, there is no clear trend when it comes to the correlation between water quality perception and many demographic variables. Some studies report that women perceive water quality to be worse, on average, than men (House, 1996; Stedman and Hammer, 2006; Strapko et al., 2016), while others find the opposite (Brody et al., 2004; Mobley, 2016). Similarly, some investigations have shown older people are, on average, more concerned about surface water quality than younger people (House, 1996), but others observed the opposite pattern (Adhikary et al., 2022). Socio-economic factors and their influence are also unclear across the literature. For example, higher levels of education and income sometimes predict more concern about water quality (Ahmed and Shafique, 2019; Okumah et al., 2020; Tarannum et al., 2018), but other studies have observed the reverse (Andrew et al., 2019; Brouwer et al., 2020; Flint et al., 2017). Similarly, residents living closer to a polluted water source may be more likely to view it as such (Brody et al., 2004); but in other cases, perceptions among those closest to the polluted water were more positive due to the desire to positively evaluate their community (Bonaiuto et al., 2003).

Other readily observable characteristics demonstrate a more consistent correlation with water quality perception, although the relationship may be indirect. For example, some studies found that persons from minoritized groups were, on average, more likely to perceive drinking water as poor, compared to white participants (Flint et al., 2017; Javidi and Pierce, 2018). This effect may be due to marginalized communities being more negatively impacted by issues of poor water quality and other environmental risks (Hicks et al., 2021; Bolin and Kurtz, 2018; Song et al., 2020). In another example, farmers may perceive water quality more positively, perhaps because they want to believe that agriculture does not contribute to water quality issues (Gachango et al., 2015; Withanachchi et al., 2018). Finally, it has been noted that some water quality issues have become politicized along partisan divides. This is especially true for environmental issues related to or exacerbated by climate change (Hanna and McDonald, 2021). For example, individuals in urban areas tend to be more concerned about local water quality than those living in rural areas (Brody et al., 2005; Hu and Morton, 2011), perhaps due to systematic differences in political ideology and climate change beliefs that drive environmental concern.

Because of these inconsistent, indirect, and often limited effects in the current literature, the present study sought to examine factors that may be more relevant to perception formation for environmental risks, namely social trust and biospheric values. It was hypothesized that these factors may be stronger indicators of water quality perception than demographic factors, as they are more direct mechanisms by which perception is developed and may mediate the relationship between demographic factors and perception of local water quality. Trust is widely accepted as critical to understanding perception, in particular, the relationship between social trust and risk perception (Slovic, 2000; Earle, 2010). Following the Trust, Confidence, and Cooperation model of risk management (Earle et al., 2010), trust in authorities, (e.g., water companies or local governments perceived as responsible for managing a hazard) is known to decrease risk perception (Siegrist and Cvetkovich, 2000; Brouwer et al., 2020; de França Doria et al., 2009; Grupper et al., 2021). Similarly, information that is used to form beliefs or perceptions is likely to come from trusted sources, who are sought out for information (Griffin et al., 1999), or whose information is most likely to be believed as true (Hovland, et al., 1953; McComas and Trumbo, 2001; Lee and Cho, 2022). In the context of water quality in the Great Lakes, prior evidence indicates that environmental organizations tend to speak out the least favorably about the role of agriculture in water quality challenges (Wickstrom and Specht, 2016), while agricultural organizations reduce the role of agriculture in communications about water quality, focusing more on the benefits that agriculture provides (Isaac and de Loë, 2022). These findings suggest that trust in agricultural organizations could lead to more favorable perceptions of agriculture, and a desire to believe that there is no issue with local water quality. On the other hand, trust in environmental organizations may lead to more blame placed on agriculture, and lower water quality perceptions, as these entities tend to emphasize water quality-related problems (US EPA, 2016). As a result, we hypothesized that local water quality will be perceived as better among those who trust agricultural organizations and worse among those who trust environmental organizations.

In addition, it is well-documented that value systems are important predictors of concern about environmental risks (Milfont et al., 2013). According to Stern et al.'s (1999) model of environment-related attitudes, individuals tend to draw on their pre-existing environmental values and beliefs when forming perceptions about novel environmental issues. For example, persons who value unity with nature, also called biospheric values, tend to believe that nature should be protected from harm (Schwartz, 1992). Biospheric values have been shown to predict higher pro-environmental awareness and intentions (De Groot and Steg, 2007; Drews and van den Bergh, 2016; Steg et al., 2005; Geiger et al., 2019; López-Mosquera and Sánchez, 2012; Menzel and Bögeholz, 2010; van der Werff et al., 2013) and greater concern about environmental quality in general (Hu and Morton, 2011). In the context of water quality, prior research has examined environmental concern and found that it negatively associates with perceived water quality (Levêque and Burns, 2017). Similarly, a study of midwestern US residents found that those with stronger environmental attitudes had the least confidence in local water quality (Hu and Morton, 2011).

3. Methods

3.1. Study area

The Maumee River Watershed was chosen for this study because it is a key source of phosphorus for the formation of harmful algal blooms in Lake Erie (Guo et al., 2019) (see Fig. 1), attributable to a combination of the prevalent local use of row agriculture and the poor natural drainage of the watershed (Muenich et al., 2016). Thus, water quality perceptions among the public in this area can affect overall water quality in Lake Erie and beyond. The watershed extends into three states; however, the study area here only draws on the population of individuals living in the portions in Indiana and Ohio.

3.2. Study sample

Data were collected through a survey administered in late 2013 through early 2014 by the Strategic Research Group. This was a stratified, random sample across 46 census tracts. That is, 23 tracts were randomly selected from each pool of rural and urban tracts across the watershed, and then the respondents within each census tract were randomly selected (see Fig. 1). Participants received an invitation letter that included instructions for completing the survey online, followed by a postcard reminder one week later. Non-respondents were then contacted via phone calls, and survey packages were mailed to those who had not yet completed the online survey.

3.3. Measures

Controlling for demographic factors that dominate the literature, it was hypothesized that water quality perceptions would be positively correlated with trust in agricultural organizations, and negatively correlated with trust in environmental organizations and biospheric values. To assess trust, seven items asked how much trust respondents have in different stakeholders to make decisions about local environmental issues, including: local government; various agricultural (i.e., state agricultural agencies, agricultural or farm organizations, local university Extension office) organizations; and environmental organizations (i.e., federal environmental agencies, state environmental agencies, and environmental advocacy groups and organizations). These items were measured on a scale from "1- None at all" to "7- A great deal." To measure biospheric values, three items from the validated scale were included in the survey: "respecting the earth"; having the goal to "exist in harmony" with other species; and "looking after the environment"

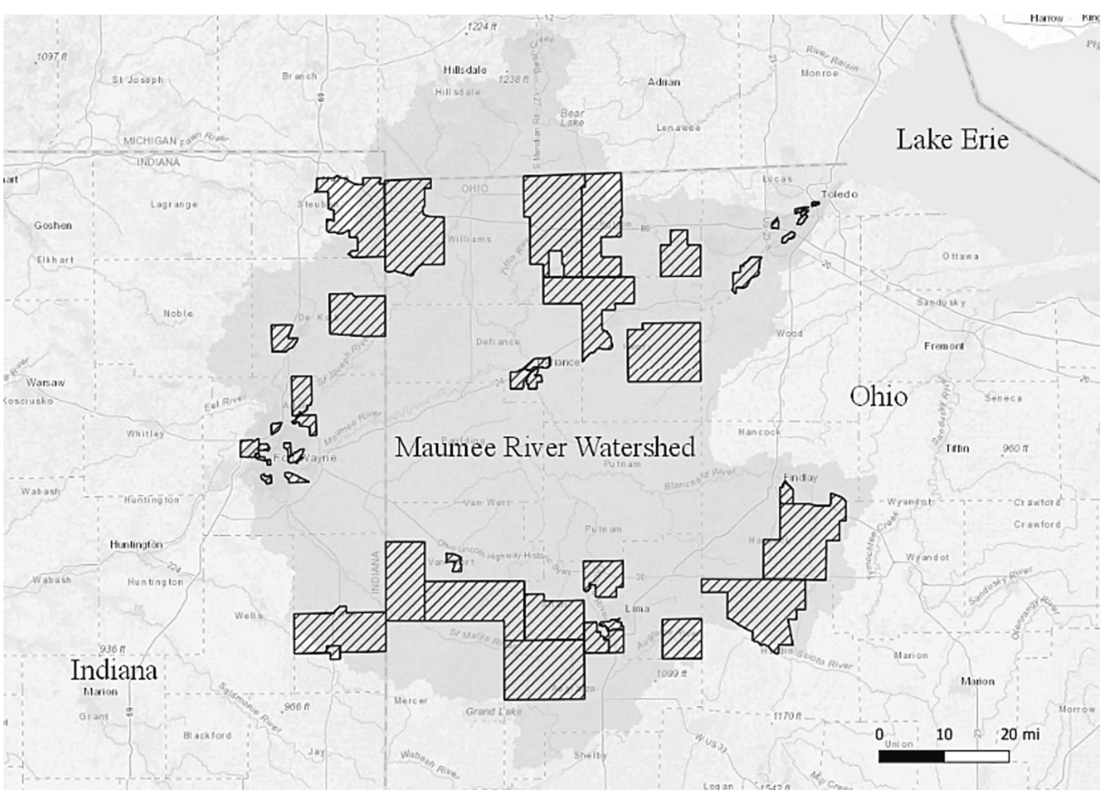

Fig. 1. Map of the Maumee River Watershed with the census tracts sampled in this study outlined.

(Stern et al., 1995b). These items were measured on a 7-point scale indicating how much each statement described the respondent from "1 - very different from me" to "7 - very similar to me".

To measure the dependent variable of local water quality perception, respondents were asked to rate the overall quality of the water in the rivers, lakes, and streams near where they live. A follow-up study of the bodies of water visualized in response to this question indicated that most participants (~70 %) were evaluating a body of water within 10 miles of their home. This item was answered on a seven-point Likert-style scale, wherein a value of 1 indicated "Very Bad", 4 indicated "Neither Bad nor Good", and 7 indicated "Very Good". Thus, higher scores indicated better-perceived water quality.

Demographic controls were assessed through self-reported gender, ethnicity, age, education, income, political affiliation, political ideology, employment ties to agriculture and/or Lake Erie, being raised in a rural or urban community, and length of residence in their current community. Finally, participants were asked to indicate which of three statements about climate change was most closely aligned with their personal beliefs, corresponding to climate change denial, belief in natural climate change, and belief in human-caused climate change. See a full list of the items and response scales included in the survey in Electronic Supplementary Material (ESM) Appendix S1, and the full survey instrument in ESM Appendix S4.

3.4. Data analysis

Confirmatory factor analyses with maximum likelihood estimation were used to evaluate averaging the trust items into a scale. Descriptive statistics such as frequencies, central tendencies and correlations were used to characterize the sample. Independent variables and controls that significantly correlated with water quality perception were included in subsequent regression analyses. Finally, we checked that parametric assumptions were met by the data for our planned regression analyses. Although our main dependent variable of interest was ordinal in nature, linear regression analysis was chosen, as simulation studies show that Likert-style scales and other ordinal measures can be approximately normal (Norman, 2010). Further, as long as regression model assumptions of normality residuals, homoscedasticity, and independence of observations are met, the data are appropriate for use in linear regression analysis (Williams et al., 2013). To assess these assumptions in Stata (version 18), density plots of residuals, plots of residuals versus predicted values, and variance inflation factors were examined. Heteroskedastic regression was used where assumptions were violated. After assessing the assumptions that must be met, we ran a linear regression analysis explaining local water quality. Finally, we engaged in exploratory mediation analysis to assess whether the relationship between agricultural work experience, political party identtification, and water quality perception may be explained by the significant hypothesized factors. This was accomplished using Hayes' PROCESS Macro (version 4.1).

4. Results

4.1. Sample composition

In total 10,109 residents were contacted, and 1,268 residents participated, yielding a response rate of 12.5 %. Notably, participants were given the option of skipping any questions and indicating if they were "not sure". Thus, the N for each test of the hypotheses differs slightly, due to missing data. Of the 1,268 respondents, 850 (67.03 %) were from Ohio and 418 (32.97 %) were from Indiana. Respondents had a mean age of 57 ($SD = 16$) years, were 42 % women, and 92 % White/Caucasian. Regarding political party affiliation, 49 % identified as Republican, 32 % as Democratic, and 18 % as Independent. Sixty percent of respondents had attended at least some college, and the most common annual income bracket was between $50,000 and $75,000, with 21 % of respondents falling in that category. Only 6 % of respondents had worked in an industry tied to Lake Erie at some point (e.g., tourism, fishing), compared with 30 % involved with the agricultural industry. 70 % of the sample had been raised in either a small town or agriculturally based community and had lived in their current community for an average of 37 (SD = 22) years. Compared to the census data for these tracts, our sample was older, included somewhat more men, and included more white respondents than the average (US Census Bureau Data, 2019). According to the Census, the average age for these tracts is 39, comprised of 50 % women, and is 87 % white. The difference in average age between the census data and our sample data is at least partially due to our sampling only including residents over the age of 18 years old.

4.2. Measurement reliability and correlations

The items used to measure trust were split into three separate measures or dimensions. Trust in local government was treated separately, while average trust in agricultural ($\alpha = 0.78$) and environmental organizations ($\alpha = 0.76$) were computed for regression analyses. See ESM Appendix S2 for the full details on the confirmatory factor analyses. The items used to measure biospheric values were averaged given acceptable reliability ($\alpha = 0.85$). Significant correlations are shown in Tables 1 and 2. Older individuals perceived local water quality to be better (than younger individuals), as did those with greater income, who lived in their communities longer, who worked in the agricultural sector, and who identified as politically conservative and Republican. Women perceived local water quality to be worse than men, as did those endorsing that "climate change is happening and is mostly caused by human activities" (compared to those who did not endorse this belief). No significant correlations with water quality perceptions were observed for education level, work experience near Lake Erie, or being raised in a rural versus urban area. As hypothesized, greater trust in agricultural entities and local government was positively correlated with perceived water quality. Trust in environmental organizations was not significantly related, but biospheric values were associated with worse perceived water quality. The full correlation matrix is available in ESM Appendix S3.

4.3. Descriptive statistics

Average perceptions of local water quality were below the scale midpoint, with the modal response being that local water quality is "neither bad nor good" ($\bar{x} = 3.81$, SD = 1.49). Mean trust in agricultural organizations ($\bar{x} = 4.26$, SD = 1.40) was higher than that of trust in environmental organizations ($\bar{x} = 3.72$, SD = 1.44), where $t(1258) = 13.80$, $p < .001$. Mean trust in agricultural organizations was also higher than trust in local government ($\bar{x} = 3.77$, SD = 1.57), where $t(1237) = 11.37$, $p < .001$). Notably, trust in agricultural organizations was, on average, above the scale midpoint, suggesting moderate trust in agricultural organizations in the present sample. These results are consistent with previous descriptive studies, which observed trust in agricultural organizations to be higher than environmental groups (Mase et al., 2015). Finally, biospheric values were relatively high ($\bar{x} = 5.25$, SD = 1.48).

4.4. Regression analyses

We ran a demographics-only model, and a full model that also included the three measures of trust (i.e., trust in government, environmental organizations and agricultural organizations) and the measure of biospheric values to explain local water quality perceptions. Demographic variables that significantly correlated with water quality perceptions were included in the demographics-only model. The full model included significant demographic predictors from the first model, as well as the social-psychological variables that correlated with water

Table 1
Correlation Table: Demographics and Water Quality Perceptions. Pairwise correlations (Pearson's *r*) between demographic variables and water quality perception. Significance values (*p*) are shown in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) local water quality perception	1.000								
(2) age	0.162 (0.000)	1.000							
(3) gender	−0.084 (0.004)	0.022 (0.450)	1.000						
(4) agricultural work experience	0.112 (0.000)	0.041 (0.154)	−0.227 (0.000)	1.000					
(5) political conservatism	0.127 (0.000)	0.054 (0.060)	−0.089 (0.002)	0.123 (0.000)	1.000				
(6) Republican political identity	0.124 (0.000)	0.031 (0.308)	−0.119 (0.000)	0.075 (0.012)	0.584 (0.000)	1.000			
(7) minoritized ethnicity	0.029 (0.325)	−0.041 (0.150)	0.022 (0.445)	−0.033 (0.245)	−0.073 (0.011)	−0.095 (0.001)	1.000		
(8) income	0.064 (0.039)	−0.124 (0.000)	−0.230 (0.000)	0.074 (0.015)	0.066 (0.029)	0.199 (0.000)	−0.200 (0.000)	1.000	
(9) residence length	0.174 (0.000)	0.521 (0.000)	−0.078 (0.006)	0.152 (0.000)	0.083 (0.004)	0.083 (0.005)	−0.018 (0.537)	−0.058 (0.057)	1.00
(10) climate beliefs	−0.162 (0.000)	−0.058 (0.042)	0.092 (0.001)	−0.105 (0.000)	−0.396 (0.000)	−0.362 (0.000)	−0.022 (0.472)	0.003 (0.925)	−0.106 (0.000)

Table 2
Correlation Table: Independent Variables and Water Quality Perception. Pairwise correlations (Pearson's *r*) between independent variables and water quality perception. Significance values (*p*) are shown in parentheses.

	(1)	23)	(3)
(1) local water quality perception	1.000		
(2) trust: agricultural organizations	0.179 (0.000)	1.000	
(3) trust: local government	0.205 (0.000)	0.475 (0.000)	1.000
(4) biospheric values	−0.097 (0.001)	0.064 (0.025)	0.022 (0.432)

quality perceptions. All continuous and ordinal predictor variables were standardized, using the z-distribution, to create meaningful zero-values for regression analysis, and easily comparable regression coefficients.

In the demographics-only model, demographic variables explained 5.70 % of the variance in local water quality perception, F(9, 899 = 7.10, $R^2_{\text{adj}} = 0.057$, see Table 3). Age and having worked in agriculture were associated with perceiving water quality as better, and women (relative to men) were predicted to have lower perceptions of water quality. Each of these effect sizes was small ($\eta^2 = 0.01$), and no other demographic variables were significant predictors.

The full model explained 9.83 % of variance in local water quality perceptions, F(6, 1,122) = 21.49, $R^2_{\text{adj}} = 0.09831$ (Table 3). On average, local water quality was perceived to be better among persons who were older, had worked in agriculture, as well as persons with higher trust in agricultural organizations and local government. Women and persons with higher biospheric values had worse perceptions of water quality. These effect sizes were again small ($\eta^2 < 0.01$ - 0.02). In a reduced model containing only significant predictors, conclusions remained unchanged.

Table 3
Regression Model Predicting Local Water Quality Perception.

Effect	Estimate	*SE*	95 %CI		*p*	η^2
			LL	*UL*		
Demo-graphics-only model						
Intercept	3.73	0.10	3.53	3.93	< 0.001	
age	0.15	0.06	0.04	0.27	0.008	0.01
gender	−0.24	0.10	−0.44	−0.04	0.021	0.01
agricultural work experience	0.22	0.11	0.01	0.43	0.042	0.01
conservatism	0.07	0.06	−0.05	0.19	0.275	< 0.01
Republican political identity	0.21	0.12	−0.03	0.45	0.086	< 0.01
residence length	0.09	0.06	−0.03	0.20	0.126	< 0.01
minoritized ethnicity	0.37	0.24	−0.10	0.84	0.121	< 0.01
income	0.05	0.05	−0.06	0.15	0.378	< 0.01
Climate beliefs	−0.09	0.05	−0.20	0.01	0.074	< 0.01
Full model						
Intercept	3.85	0.07	3.71	3.98	< 0.001	
Demographics						
age	0.21	0.04	0.13	0.30	<0.001	0.02
gender	−0.24	0.09	−0.41	−0.06	0.007	0.01
agricultural work experience	0.22	0.10	0.03	0.41	0.021	< 0.01
Trust						
Trust in agricultural organizations	0.18	0.05	0.08	0.28	<0.001	0.01
Trust in local government	0.23	0.05	0.14	0.33	< 0.001	0.02
Biospheric values	−0.15	0.04	−0.24	−0.07	<0.001	0.01

4.5. Exploratory mediation analyses

While we did not originally hypothesize trust or biospheric values as mediators of demographic factors, it may be that previous research supporting particular demographic differences in perception are simply capturing indirect indicators of water quality perceptions. As a result, we wanted to explore if some commonly-assessed demographic variables that do correlate with water quality perception in this context are indirect correlates through the significant effect of trust (see Fig. 2). To test the most theoretically likely mediation paths, Hayes' PROCESS Macro (version 4.1) for SPSS (version 28), Model 4 was used. As outlined above, existing work links agricultural work experience and political affiliation with trust, and trust with water quality perception. Therefore, we opted to focus on these mediated pathways. We did not test mediated pathways for age, gender, and residence length through trust, as to our knowledge such a relationship is not well-supported in existing

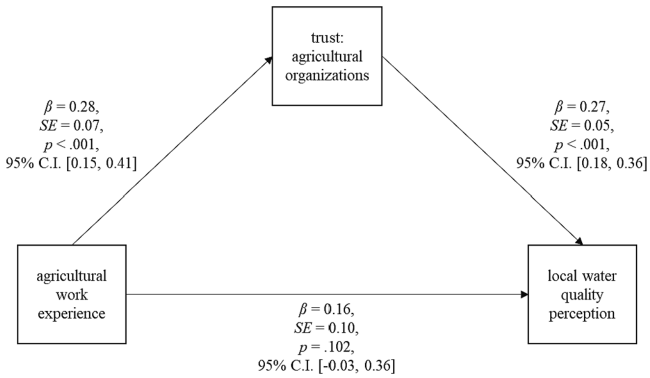

Fig. 2. Mediation model testing the indirect effect of agricultural work experience on perception through trust. The total model significantly predicted local water quality perceptions, F(5, 1032) = 13.42, p <.001, R^2 = 0.061. Covariates included age, gender, Republican political identity, and climate change beliefs.

literature.

As mentioned previously in the introduction, trust in the organizations responsible for water quality is associated with more favorable perceptions of water quality (Grupper et al., 2021), and individuals working in agriculture may have greater trust in agricultural organizations to manage their contributions appropriately (Arbuckle, et al., 2015). As a result, individuals who have worked in agriculture may have more favorable perceptions of water quality due to their trust in agricultural organizations. Controlling for age, gender, political party, and climate beliefs we find that the relationship between working in agriculture and local water quality perceptions was mediated by trust in agricultural groups (F(5, 1032) = 13.42, p <.001, R^2 = 0.061). Specifically, agricultural work experience explained greater trust in agricultural organizations, which in turn significantly explained more favorable water quality perceptions (see Fig. 2). The confidence intervals around this indirect effect did not include zero, and are therefore statistically significant (β = 0.08, SE = 0.02, 95 % CI [0.03, 0.12]).

While we could not theorize a likely mediation path from age or gender, we also explored if the correlation between identifying as Republican and local water quality perception is mediated by trust in local government, trust in agricultural groups, and biospheric values. In thinking about these relationships, previous research indicates that Republicans have greater trust in local governments (Morgeson et al., 2021; Gimpel et al., 2020), while pro-environmental orientations tend to be lower among Republicans, compared to other political identities (McCright and Dunlap, 2011). As in the previous model, the remaining significant demographic factors (age, gender, agricultural work history) were entered as covariates. Results indicated that the effect of Republican political identity on local water quality perception was mediated by trust in agricultural organizations and local government, but not biospheric values (F(4, 1015) = 13.91, p <.001, R^2 = 0.052) (see Fig. 3). In other words, Republican political party identification significantly explained greater trust in agricultural organizations and local government as well as lower biospheric values. In turn, each of these variables explained local water quality perceptions (i.e., a belief that water quality was better compared to those who did not identify as Republican). The indirect (or mediated) effects through trust in agricultural organizations and local government were significant.

5. Discussion

In a regression model that accounted for shared variance between demographic factors and the hypothesized more proximate indicators of trust and values, local water quality perceptions were associated with age, gender, agricultural work experience, trust in agricultural organizations, trust in local government, and biospheric values. These effects were consistent with the hypotheses that those with greater trust in the potential managing entities (compared to those with lower trust) would have more favorable perceptions of water quality. In this case, the managing entities driving the effect were agricultural organizations and local government. There was no correlation between water quality perception and trust in environmental organizations.

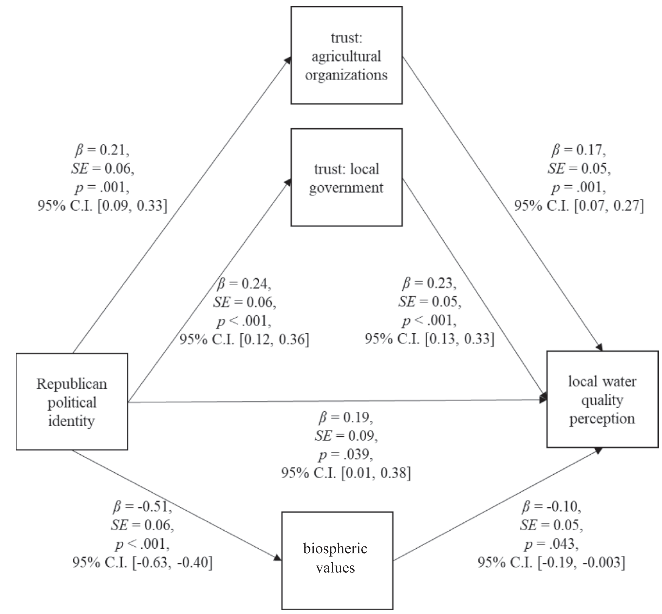

Fig. 3. Mediation model testing the indirect effect of political identity on perception through trust and values. The total model significantly predicted local water quality perceptions, F(4, 1015) = 13.91, p <.001, R^2 = 0.052). Covariates included age, gender, and agricultural work experience. The indirect effects through trust in agricultural organizations (β = 0.03, SE = 0.02, 95 % CI [0.01, 0.07]) and local government were significant, (β = 0.06, SE = 0.02, 95 % CI [0.02, 0.10]), but the indirect effect through biospheric values was not significant (β = 0.05, SE = 0.03, 95 % CI [-0.001, 0.10]).

The results were also consistent with the hypothesis that those with stronger biospheric would have less favorable perceptions of water quality. In fact, biospheric values had a stronger direct effect on water quality perceptions than political identification, political ideology and climate change beliefs, which only have effects indirectly through trust or values (if they have an effect at all). Although water quality issues in the Great Lakes have been politicized (Hula et al., 2017) and climate change beliefs tend to differ by political party, neither significantly explained local water quality perceptions in the demographics-only regression model. Notably, these predictors did not show multicollinearity. However, when exploring the mediating effect of biospheric values on the relationship between political identity and water quality perception, significant mediation (although not complete mediation) was found. Therefore, it appears that among these three politically driven predictors, the most proximate indicator, biospheric values, is the best explanation of local water quality perception. While biospheric values overall were high in the sample, their effect on perception is partially driven by those identifying as liberal or politically moderate.

Consistent with some prior research (e.g., Withanachchi et al., 2018, Adhikary et al., 2022), we do find that women perceive local water quality as worse than men, while older individuals tend to perceive it as better than younger individuals. However, we generally find that demographics are only distally related to water quality and do not directly influence water quality perceptions. Indeed, the mediation analyses explored were consistent with the hypothesis that the relationship between water quality perceptions and some demographic factors, Republican political orientation and agricultural work experience,is mediated by trust and values. Notably, causal conclusions are prohibited due the correlational nature of the data, but results are consistent with the mediation hypotheses. Results are also consistent with previous studies that examined indirect effects of demographic factors on environmental concern through pro-environmental values (Hmielowski et al., 2014; Stern and Dietz, 1994; Stern et al., 1993).

The significant direct effects of trust and biospheric values, coupled with the fact that in the full model only a few of the demographic controls were significantly associated with perception, suggests that perceived water quality is better understood by knowing who the public trusts, and how these entities are representing local environmental quality and associated risks. While biospheric values associate with worse perceptions of local water quality, the biggest effect was of trust, with this effect fully mediating the direct effect of socio-demographic factors like agricultural work experience. Lacking the ability to objectively assess local water quality, residents may be turning to simplifying heuristics as cues to judge water quality, as the use of heuristics to navigate uncertainty and complexity is a well-known tendency in the judgment and decision making literature (Tversky and Kahneman,1974). Prior research does indicate that knowledge about water management, watersheds, and waterways is limited in Ohio (Hersha et al., 2014; Johnson and Courter, 2020) and across the United States (Dean et al., 2016; Lamm et al., 2015; Hubbard, 2023).

While trust in environmental stakeholders did not have a significant effect on perception, this may be due to the dominance of agriculture and rural upbringings in the study area. Many persons in the region are directly involved in agriculture (~30 %) and/or come from a rural upbringing (~70 %). Thus, individuals in the study area have probably interacted more with agricultural organizations than environmental groups, and as a result, tend to trust the agricultural organizations more (Lubell, 2007). Future studies can also include trust in scientists and scientific consensus as a predictors of water quality perceptions. As discussed, the consistent threat to water quality from harmful of algal blooms is formed through myriad conditions such as phosphorous contamination, climactic shifts in precipitation and temperature, as well as invasive species (Smith et al., 2015). These factors are scientific, and therefore public information on such issues will likely cite sources that are scientific in nature. Persons who have higher trust in scientists may be more likely to accept scientific consensus about water quality issues (Van der Linden, 2021), and thus perceive water quality less favorably given prevailing narratives in the region.

5.1. Limitations and future research

The models explained less than ten percent of the overall variation in perceptions of water quality. This means that there are other factors that influence perceptions, which were not measured. For example, the present study could not account for visual or olfactory cues about quality. Because organoleptic factors are known to be a heuristic by which people assess water quality (e.g., see de França Doria, 2010), these factors could explain much of the remaining variation. Future studies could focus on the organoleptic factors that are present at different sites, or on how people perceive those factors, to understand how respondents are developing their perceptions, accounting for both physical cues as well as social-psychological cues.

Finally, the survey data for this study was collected before the Toledo water crisis in 2014 when a large algal bloom in Lake Erie made drinking water unsafe for Toledo residents for two days (Henry, 2019). This event brought awareness to harmful algal blooms in Lake Erie, and consequently could have had a significant impact on water quality perceptions in the area. While we would expect that perceptions and our descriptive findings could have shifted since 2014, we would not expect the relationships between the variables of interest to have changed (e.g., between trust and perception; or political identity, trust and perception). This limitation is also an opportunity for a point of further research comparing water quality perceptions in the same area over time. Another survey of the same area, with additional questions about awareness of the Toledo water crisis, could be used to measure the effect that a large crisis event and change over time has on perceptions.

6. Conclusions

When trying to communicate with the public in this study region, and in similar midwestern or Great Lakes communities about local water quality, it is important to recognize the influence that trusted organizations have on respondents' perceptions, how that trust may vary across the population, and how those organizations are ultimately communicating about water quality. It is well known in the strategic communication and persuasion literature that influence is only partially based on logical utility, and often driven by heuristics and based in culture (Cialdini, 2001). Recognizing this reality, it may be best to work with agricultural organizations engaging the public as agricultural stakeholders are significantly more trusted and identities related to agriculture and politics are drivers of perception. There is a clear need for strong messaging from this trusted group that is driving perception,— messaging stating that although progress has been made, water quality issues, especially those regarding harmful algal blooms, still abound and must be addressed. However, some agricultural organizations have avoided communicating the impacts of agricultural nutrient loss on water quality, instead focusing on the benefits of agriculture (Isaac and de Loë, 2022), which can lead to a sense of complacency about water quality challenges. Future communication should be clear about the multitude of human activities that contribute to water issues, where no one individual is to blame, but the aggregated small losses from millions of fields create significant problems downstream (Mateo-Sagasta et al., 2017). Future communication could also focus on feasible and effective solutions to water quality issues rather than focusing on the state of water quality or the pollution sources, so as not to belabor the cause but to highlight win–win solutions (e.g., soil health practices that increase on-farm resilience and reduce nutrient loss). Triggering a sense of hope over fear is a well-recognized, but underused approach in the broader conservation literature (Park et al., 2020), that is critical to engaging individuals in action (Kelsey, 2020).

CRediT authorship contribution statement

C. Dale Shaffer-Morrison: Writing – original draft, Investigation, Methodology, Formal analysis. **Robyn S. Wilson:** Conceptualization, Writing – review & editing, Supervision, Resources.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jglr.2024.102311.

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