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CASE STUDY

Effects of citizen participation on urban water management based on socioeconomic factors

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ABSTRACT

BACKGROUND AND OBJECTIVES: In this era of globalization, clean water management is considered a complex problem requiring the strategic management of various aspects. Citizen participation in managing polluted waters is a critical, determining factor in preventing water crises. This study predicts the socioeconomic factors influencing citizens' behaviors in polluted water management.
METHODS: A survey on Jakarta's clean water was conducted with 503 respondents in 2022. Three interest variables were studied: first action taken during contamination, water nuisance level, and willingness to pay for clean water. Control variables were also explored, including daily income, education level, age, marital status, and gender. Data were analyzed using logistic regression.
FINDINGS: In general, socioeconomic factors influence citizens' behaviors in dealing with polluted water. The specific findings regarding the probabilities for the first action on the basis of asking for immediate action from local authorities, namely, by asking other citizens, waiting for information from other citizens, and looking for sources of water pollution were –2.21, –3.50, and 0.61, respectively. The results also revealed the probabilities of nuisance level (0.07), willingness to pay for clean water (0.0495), daily income (–0.02), educational level (–0.429), and age (0.01). The probabilities for married citizens (–2.845) and men (–0.268) were lower than those for unmarried citizens and women, respectively.
CONCLUSION: The findings of this study can be used to predict the management of water pollution among Jakarta citizens, as well as serve as a reference for related stakeholders. Socioeconomic factors can affect citizens in various aspects of life, including participation in water management. However, not all socioeconomic factors are directly proportional to citizen participation. In fact, other socioeconomic indicators are inversely proportional to what are expected based on theoretical assumption. Finally, educational level and income do not always translate to behavioral changes linked to water pollution management.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
73	9	1

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INTRODUCTION

Lack of access to hygienic water and the ensuing water crises are significant issues in many nations (Muñoz *et al.,* 2020; Czajkowski *et al.,* 2021). Water is essential for many activities, and a water crisis arises if demand exceeds clean water supplies. Environmental sustainability may be negatively impacted by this phenomenon. Despite the fact that water is renewable and can be used again, the global water crisis is expected to worsen in the years (Biswas and Tortajada, 2019). According to the Brazilian and international press (BIP), water crisis is caused by climatic, geomorphological, hydrometeorological, anthropogenic, and water management factors (Milano *et al.,* 2018; Mena and Quiros, 2018; Abiriga *et al*., 2020). Several examples, such as industrial waste, landfills, agriculture, and global warming, have been identified as popular factors exacerbating this issue. Additionally, anthropogenic factors are considered the most influential due to the uncertainties they possess (Akhtar *et al.,* 2021). Over time, their impacts have increasingly become a cause for concern as many resources and infrastructure once taken for granted are now becoming scarce or damaged. As a result, ensuring clean water sources has become a complex and challenging task (Shepherd, 2019). Nonetheless, a study by Hoekstra *et al.* (2019) reported that the water crises can be lessened with the aid of water footprints, which gauge how much water is used in the production of goods and services. However, ensuring clean water supply requires contribution from various sectors. While the government has a critical role in managing polluted waters, citizen participation is also essential. In urban water management, citizen involvement plays a crucial role by allowing stakeholders to contribute their knowledge and perspectives to the decision-making process. According to Von Korff *et al*. (2012), citizen participation in water management can ensure fair and socially equitable water planning and management, as well as form participatory modeling and decision-making processes. In another study in Australia (Koop *et al.,* 2019), citizen participation is effective in promoting water conservation at the individual level. This study also found that improving household water conservation at the individual level provides a promising alternative to reduce costs and stimulate pro-environmental behaviors. Citizen participation plays a major role in averting "day zero," which refers to the day when water scarcity is expected to occur (Shepherd, 2019; Yu *et al.,* 2021). This has also been found to influence the trends and characteristics of water pollution incidents (Huang *et al.,* 2022). Citizen participation can take many forms, including public hearings, workshops, focus groups, online platforms, and social media. For example, Evans and Hollander (2010) examined public participation using social media and found that the majority of citizen initiatives focused on planning issues. Those forms of citizen participation include monitoring (Alvarado *et al.,* 2020) and compliance (Fu and Geng, 2019). On the one hand, water quality monitoring can be achieved through observing physical, chemical, and biological parameters of water. On the other hand, "compliance" refers to the implementation of rules that have been set by default. Monitoring and compliance serve as measures to control water pollution and are instrumental in preventing diseases caused by polluted water. Citizen participation in controlling water pollution cannot be separated from citizen science. Citizen science is a rigorous process of scientific discovery, indistinguishable from conventional science apart from the participation of volunteers" (McKinley *et al.,* 2017). Cultural factors, such as religious factors, impact citizens' participation via their habits and behaviors. Among these, religious obligation in terms of water conservation activities is the most likely factor affecting the rise of water conservation (Boazar *et al.,* 2019). Unfortunately, citizens' knowledge of water management has been rarely studied (Dean *et al.,* 2016). Thus, in addressing water pollution, there is a need to conduct further research on all aspects of water management (Cosgrove and Loucks, 2015), particularly in the area of citizen participation. Many factors, including internal ones related to citizens' awareness and external factors associated with socioeconomic, political, and religious factors (Akpabio *et al*., 2021), affect citizens' participation in managing polluted waters. Therefore, these also need further investigations. In this sense, socioeconomic factors influencing low-income and marginalized communities, for example, may be less likely to have access to information and resources required to participate in decision-making processes related to water management (Ferrar *et al.,* 2013). Previous studies conducted across various cultures have examined the link between willingness to pay (WTP) for clean water and citizen participation in urban water management, showing a consistent positive relationship between them. A study conducted in Switzerland found that individuals who were WTP more for clean water were also more likely to participate in activities aimed at protecting water resources (Veronesi *et al.,* 2014). In China, individuals who were WTP higher water tariffs were more likely to support water conservation policies and initiatives and take individual actions to reduce water consumption (Wang and Jia, 2012). In another study conducted in the Mediterranean region, citizens who were WTP more for clean water also tended to engage in water conservation behaviors, choosing accommodations that provide water-saving rooms (Casado-Díaz *et al*., 2020). These findings suggest that citizens' WTP for clean water can be a key driver of citizen participation in urban water management. In particular, when citizens understand the value of clean water and the importance of protecting water resources, they are more likely to engage in efforts to manage and reduce water pollution, including activities like water quality monitoring, conservation efforts, and public education campaigns. Other socioeconomic factors, such as education, race, and gender, can also influence citizen participation in water management. For example, a study by Miguel (2018) in a rural community in Mexico found that women were less likely to participate in water management due to cultural norms and gender roles that limit their mobility and ability to participate in public decision-making processes. Jablonski *et al*. (2021) found that color-based mental constructs and racial stereotypes persist, with some being stronger in certain places than others. This finding indicates that those who comprise the major racial group in an area still maintains their power compared with other groups. The persistence of racial differences will affect various vitalizations in political, economic, and social activities, including participation in water management. Meanwhile, the role of community organizations and social networks is to promote public innovations in water management (Leavell *et al*., 2019). Furthermore, education is another crucial factor in promoting public awareness of water management issues and encouraging active participation in relevant efforts, such as conservation campaigns and community decision-making processes (Shiklomanov and Rodda, 2003). Education can also provide citizens with the knowledge and skills needed to participate effectively in decision-making processes related to water management by providing workshops and trainings for promoting awareness and understanding (Chess and Purcell, 1999; Mukhtarov *et al.,* 2018). Although socioeconomic factors are quite influential in other fields, such as malnutrition (Emamian *et al.,* 2014), gradient in cancer (Singer *et al.,* 2017), and energy consumption of citizens (Zhou and Shi, 2019), there remains a lack of research on how these factors can influence citizen participation in managing polluted waters. In a non-probabilistic study conducted by de Lazaro Torres *et al.* (2020), citizens' views on autonomous communities were identified, and good and bad practices stemming from water management were detected, including efficiency gains and special problems. Feng *et al.* (2021) examined the effect of socioeconomic development on water quality, while other researchers studied the effects of polluted waters on citizens' socioeconomic development. It can be concluded that citizens' good and bad practices in water management affect water quality, which in turn, influence socioeconomic development. If citizens' practices in managing polluted waters are influenced by socioeconomic factors, then it follows that such factors can both cause and be affected by citizen water pollution management. Given the prediction regarding the importance of controlling water pollution by citizens to mitigate the water crisis, along with the influence of socioeconomic factors in various aspects, it is necessary to investigate how socioeconomic factors influence citizen participation in managing water pollution. The ever-rising rates of population, globalization, and industrialization have increasing socioeconomic impacts as well. Consequently, there should be a renewal of existing water governance, policies, and management strategies from various socioeconomic perspectives to avoid the impending water crisis. The megacity of Jakarta is at high risk of experiencing a water crisis in 2040. Limited sources of raw water have resulted in poor coverage of clean water of up to 64% (Muhtarom, 2022). Jakarta's impending water crisis has a potential effect on the city's suitability as a living space (Colven, 2022). Meanwhile, several developed countries have used tools to detect water pollution. For example, in the United Kingdom (UK), planar microwave sensors were used as a first measure (Frau *et al.,* 2021). Several other studies have reported that WTP increases with income, education, respondents' perceptions of water quality and risk, health problems, and family structure (Jianjun *et al*., 2016; Chatterjee *et al.,* 2017; Tanellari *et al.,* 2015). This indicates that the behaviors of citizens in managing water pollution cannot be separated from the socioeconomic factors that influence them. This study contributes to the literature in several ways. First, this work predicts the influence of socioeconomic factors on citizens' water management behaviors, thus filling gaps from previous research that focused on the correlation between socioeconomic factors and water quality as well as the impact of water pollution on socioeconomic growth. Second, this study uses a probabilistic survey, whereas previous studies used non-probabilistic online surveys. Third, the study is conducted in Jakarta, the capital city of Indonesia, which has a high risk of clean water shortage. Based on the above discussion, this paper examines how socioeconomic factors influence citizens' behaviors in dealing with water pollution. This study poses several research questions: 1) what is the first action taken by citizens when water is polluted? 2) What is the value level of water pollution that disturbs citizens? 3) Is there a positive relationship between WTP for clean water and citizen participation in urban water management? Other socioeconomic factors (daily income, education level, age, marital status, and gender) were also examined. This study contributes to the literature by providing various water management perspectives through an examination of how communities respond to water pollution and the availability of clean water to reduce the impact of a water crisis. This is significant for several reasons. First, the importance of citizen involvement in managing water problems (Dean *et al.,* 2016) makes an actual contribution to achieving sustainable development goals (Fritz *et al.,* 2019). Second, continuing research on how the actions of citizens at different spatial levels help create water footprints (Hoekstra *et al.,* 2019). Third, it is important to provide another perspective in mitigating the impending water crisis in Jakarta (Colven, 2022). The current study focuses on the factors affecting citizens' participation in water pollution management given the perceived importance of citizen engagement in water management based on socioeconomic factors. The aims of the current study is focuses on what affects citizens' participation in handling polluted water. Given the importance of citizen engagement in water management based on socio-economic factors. This study has been carried out in Jakarta, Indonesia in 2022.

MATERIALS AND METHODS

Study area

The study location is in Jakarta, the capital of Indonesia. As shown in Fig. 1, Jakarta hosts an extensive array of economic activities that contribute to its rapid urbanization. According to Badan Pusat Statistik (BPSb, 2021), the most recent total population of Jakarta is around 10.6 million people, representing an increase of 0.1 million compared with the previous year (around 10.5 million). Various industries are located in Jakarta, attracting citizens from other regions to live in the city. The dense population, combined with various large-scale socioeconomic activities, has produced significant amounts of pollutants. The city's citizens have been the primary contributors to water pollution for the last few decades, although the amount of water pollutants they generate is not directly proportional to their participation in managing polluted waters. Therefore, this research provides suggestions and recommendations that can be applied to other areas facing similar problems in creating effective strategies to address water pollution.

Survey

The data used in this research were gathered from the Jakarta Clean Water Survey and included the population in the north, central, south, east, and west areas of the city. The sample consisted of 503 respondents. The logistic regression method to estimate was used (Hosmer *et al.,* 2013) how variables of interest and other socioeconomic factors affect citizens' probability of managing polluted waters. The dependent variable used in this study was the probability of managing polluted water. There were three other variables of interest in this study: 1) first action taken during water contamination, 2) citizens' nuisance score related to polluted water, and 3) citizens' WTP for clean water. Additionally, the study used control variables, including income per day (IPD), educational level, age, marital status, and gender. To estimate citizens' probability of managing polluted waters, the model specified in this study is expressed using Eq. 1 (Afroz *et al.,* 2016):

$$Y = \beta_1 X1 + \beta_2 X2 + \beta_3 X3 + \beta_4 X4 + \beta_5 X5 + \beta_6 X6 + \beta_7 X7 \quad (1)$$

Where,

Y	Probability of managing polluted waters
$\beta_1 X1$	Income, respondents' IPD, stated in $US (US Dollar)
$\beta_2 X2$	Education, respondents' education level, stated in year(s) of schooling
$\beta_3 X3$	Respondents' age, stated in year(s)
$\beta_4 X4$	Respondents' marital status, binary dummy variable
$\beta_5 X5$	First action taken during contamination, in categorical dummy
$\beta_6 X6$	Nuisance level, indicates respondents' level of tolerance to polluted waters, wherein a higher score indicates low tolerability
$\beta_7 X7$	WTP for clean water, stated in $US

RESULTS AND DISCUSSION

Issued linked to water pollution

The high rates of urbanization and population growth in Jakarta (Remondi *et al.,* 2016; Alzamil, 2017; Rustiadi *et al.,* 2021) have led to the production of large amounts of anthropogenic waste, and waste products that have not been managed properly are likely to pollute the environment, including the waters. The chemical, physical and biological components produced from waste cause damage to water bodies. Apart from anthropogenic waste, other factors also contribute to water pollution, including the heavy metal arsenic (As), which contaminates groundwater (Adeloju *et al.,* 2021; Mena and Quiros, 2018).

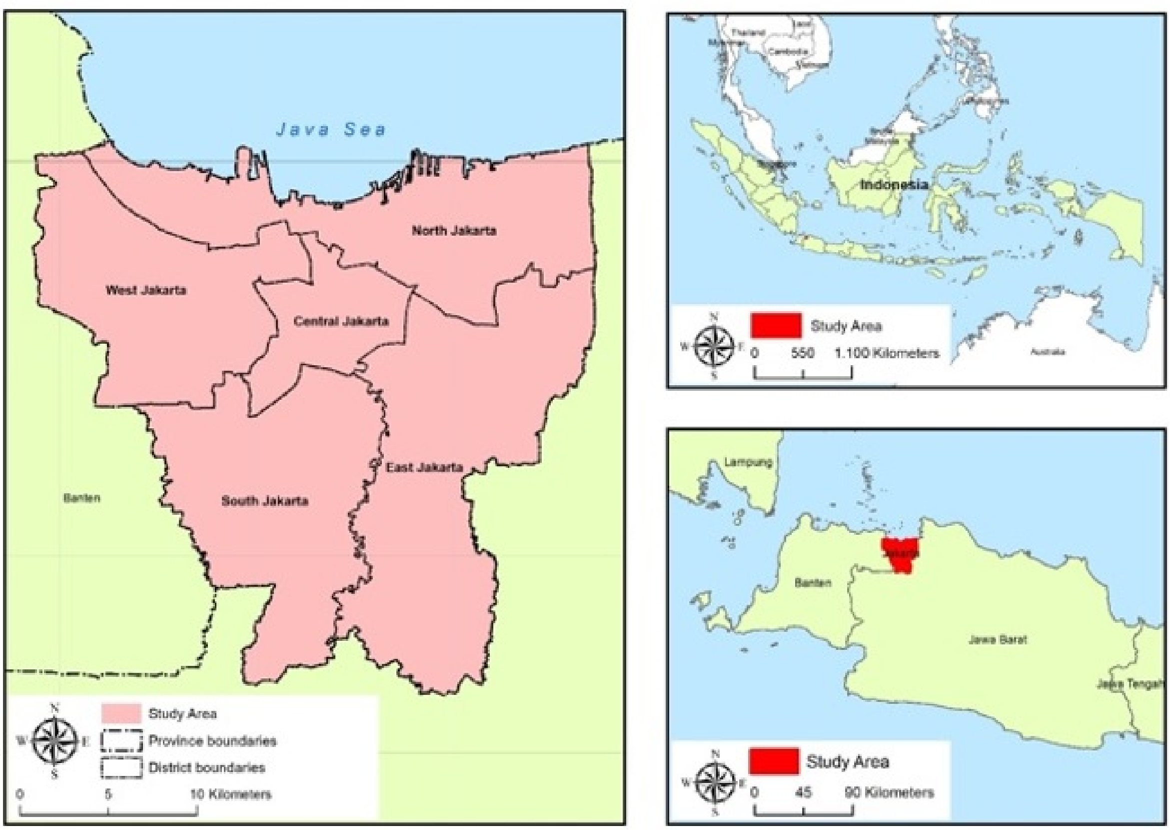

Fig. 1. Geographic location of the study area, Jakarta, Indonesia

Although most Jakarta citizens (about 60% of the population) rely on groundwater (Furlong and Kooy, 2017), their activities such as bathing in upstream rivers lead to fresh water pollution (Garg *et al.,* 2018). Citizens in the upstream who depend on the river for most of their activities also use polluted water. Based on data BPSb (2020), 219 urban villages in Jakarta have rivers, while 48 urban villages do not have them. This highlights the fact that rivers are the primary water source for Jakarta citizens. Due to the high levels of water pollution in many of these rivers, they have resorted to using groundwater as an alternative. However, the quality of groundwater for daily needs is not always guaranteed, and this poses an additional challenge that must be addressed, including the risk of waterborne diseases.

Possibility of citizens managing water pollution

Data were analyzed using logistic regression, and odds ratios were used to interpret the results. Predictor variables, including marital status and gender (represented as dummy variables), were also tested. This study identified four key estimates that can explain the impact of socioeconomic factors on water pollution management. Several continuous and dummy variables were collected from the survey to provide a more comprehensive understanding of water pollution management. The regression estimates are presented below.

Table 1 presents the regression results of the predictor variables on the probability of managing water pollution. The predictor variables that are discussed here are the variables of interest (the first action when contamination occurs, the disturbance score for polluted waters, and the WTP for clean water). The control variables were also discussed, namely, IPD, educational level, age, marital status, and gender. The first interest variable is the categorical

Table 1: Regression results (dummy variables were interpreted through odds ratio)

Variables	Probability to handle polluted water			
	-1	-2	-3	-4
	Estimate-1	Estimate-2	Estimate-3	Estimate-4
Income	-6.84e-06***	-6.05e-06***	-6.20e-06***	-2.05e-05***
	-1.56E-06	-1.54E-06	-1.58E-06	-2.54E-06
Education	-0.367***	-0.341**	-0.341**	-0.429***
	-0.137	-0.149	-0.149	-0.165
Age	0.0119	0.0119	0.0113	0.0106
	-0.0139	-0.015	-0.0151	-0.0179
Marital Status	-1.229	-1.552*	-1.542*	-2.845***
1=married; 0=else	-0.748	-0.802	-0.803	-0.884
Gender	-0.689	-0.409	-0.396	-0.268
1=male; 0=female	-0.764	-0.766	-0.765	-0.879
First action taken during water contamination Base: 1. Asking for immediate steps to local authority				
2. Asking other citizens		-2.528***	-2.556***	-2.212**
		-0.908	-0.911	-1.082
3. Looking for source of polluted water		0.404	0.406	0.61
		-0.608	-0.609	-0.67
4. Waiting information from other citizens		-2.566**	-2.563**	-3.502***
		-1.064	-1.064	-1.347
Nuisance level			-0.0463	0.0708
			-0.109	-0.125
WTP for a clean water				4.95e-05***
				-6.33E-06
Constant	8.461***	7.925***	8.382***	7.405***
	-1.961	-2.247	-2.503	-2.711
Observations	504	503	503	503

*p<0.1, **p<0.05, ***p<0.01

dummy of first action taken by the respondents. In the model, there are four types of first action taken: (1) asking local authorities for immediate steps to be taken, (2) asking other citizens, (3) looking for the source of water pollution, and (4) waiting for information from other citizens. The model used "asking for immediate steps" as the base option. According to the regression table, individuals who choose to ask other citizens (Option 2) have a lower probability of dealing with water pollution compared with those who ask local authorities for immediate action. The probability is 2.21 times lower than the baseline, and this result is statistically significant at the 95% confidence level (estimate 4). At estimates 2–3, people with these characteristics have a much lower probability than the baseline and are statistically significant at the 99% confidence level. In addition, people waiting for information from other citizens have a much lower probability of managing water pollution, where the probability is –3.50 times lower than the baseline, which is statistically significant (estimate 4) with a 99% confidence level. Meanwhile, communities that exhibit both characteristics of asking other citizens and waiting for information from other citizens theoretically have a lower probability of effectively dealing with water pollution compared with communities that request immediate action from the local government. On the one hand, these findings indicate that passive behaviors (waiting and asking) will result in significantly lower participation in managing water pollution (i.e., the possibility of managing water pollution always decreases). On the other hand, individuals who actively seek sources of water pollution tend to have a higher probability of effectively dealing with polluted waters, with a probability that is 0.61 times higher than the baseline (estimate 4). These findings suggest that proactive behaviors may increase the probability of effectively dealing with water pollution, although the effect is not statistically significant. This finding is relevant to the study of Hur *et al.,* (2019) about proactive behaviors. Such behaviors have a positive relationship with perceptions related to water pollution management. In turn, better perceptions on water management may increase the probability of dealing with water pollution through proactive behaviors. Notably, being proactive does not always guarantee an increase in the probability of managing water pollution, as there are other factors at play. To further strengthen the analysis, this research also conducted graphical analysis to investigate how the probability of water pollution management differs among the kinds of first action taken. The analysis indicates that individuals who actively seek the source of water pollution have the highest probability of effectively dealing with polluted waters compared with the baseline. Conversely, individuals who choose passive actions (options 2 and 4) have a much lower probability. This graphical analysis is consistent with the regression results as previously stated.

Based on the information presented in Fig. 2, the basic option of asking local authorities for help has a probability of more than 60% in effectively dealing with water pollution. At the same time, asking questions and waiting for information from other citizens has a probability of more than 20%, but it is lower than the basic option. These findings suggest that seeking immediate action from local authorities may be the most effective approach in managing water pollution. Meanwhile, looking for sources of water pollution has more than 80% likelihood, which is higher than the basic option in terms of dealing with water pollution. Looking for sources of water pollution has a higher probability of effective management than passive behavior (waiting and asking). This finding is consistent with both the regression results and the graphical analysis presented in the study. Aprile and Fiorillo (2017) stated that environmental knowledge and active participation through donations of time and money are the main drivers of water conservation behaviors. Participation is mediated by increasing environmental knowledge and connectedness to nature (Otto and Pensini, 2017). This shows that increasing environmental knowledge by finding sources of water pollution encourages better water conservation behaviors. Furthermore, active participation from citizens is needed in managing water pollution. The next variable of interest is respondents' nuisance score related to polluted waters, which indicates how much pollution a certain respondent can tolerate. In particular, a higher nuisance score indicates lower tolerance. According to the regression table, a higher nuisance score is associated with a higher probability of managing water pollution, although this relationship is not statistically significant. An increase of nuisance level by 1 will increase the probability by 0.07 or 7% (estimate 4). As the result

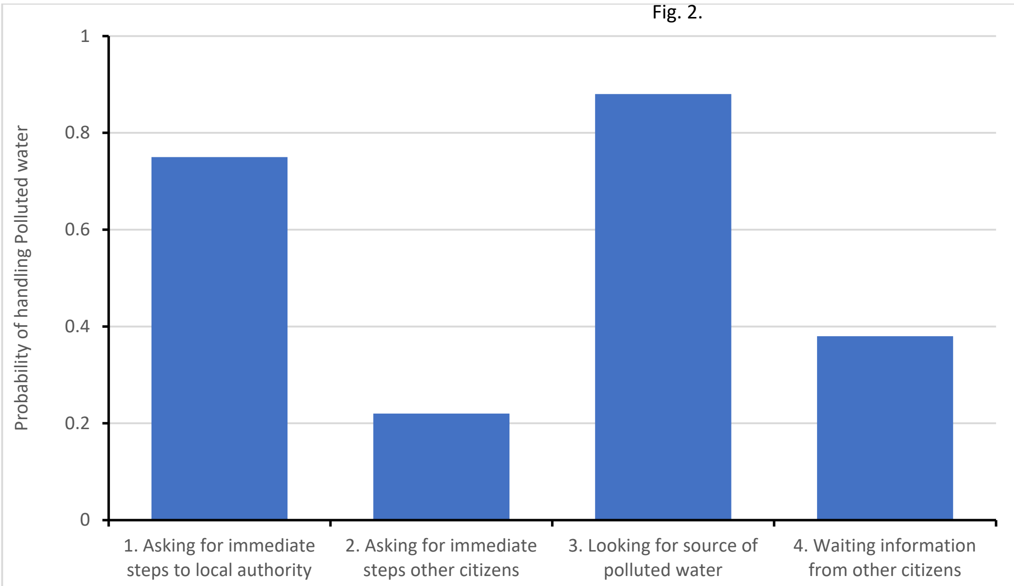

Fig. 2. Probability of managing water pollution based on first action taken

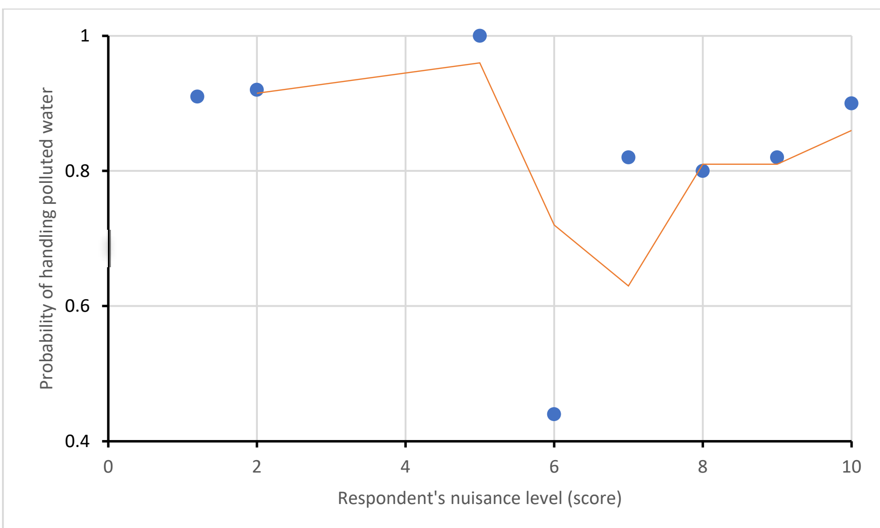

Fig. 3. Probability of managing water pollution based on respondents' nuisance level

is not statistically significant, we conducted graphical analysis to confirm how nuisance level affects citizens' probability of managing water pollution.

As shown in Fig. 3, the probability of managing water pollution decreases until the nuisance level reaches level 7, at which point the probability increases. This finding indicates that citizens' actions to handle water pollution will increase after a certain level of nuisance. This confirms the theoretical notion that people will take counteractions when they become annoyed by a certain level of nuisance. The level of respondents' nuisance related to water is positively related to the probability of managing water pollution, in which the higher the respondent's level of nuisance, the higher the probability of managing pollution and the lower their tolerance. This can be likened to Newton's third law, which is the law of action and reaction. The reaction is obtained when the action is given. The action here is the level of disturbance related to water, while the reaction is an act of managing water pollution. This is in accordance with the study conducted by Schielen *et al*., (2022) regarding the reactions of participants. They found that the participants' reaction times correlated most with the reaction times of agents that expressed functional behavior (true action). This indicates that their responses depend on what is considered correct. The same thing can be said with the level disturbance in terms of the emergence of reactions from participants when the perceived level of water disturbance is appropriate to manage. The next interest variable is citizens' WTP for clean water. According to the regression table, WTP for clean water has a positive relationship to the probability of citizens managing water pollution, although it is not statistically significant. In estimate 4, an increase of $US 0.66 on citizens' WTP will increase the probability of managing water pollution by 0.0495. As the regression result is not significant, we conducted graphical analysis to confirm the relationship of citizens' WTP to the probability of them handling polluted waters.

As shown in Fig. 4, the probability of managing water pollution increases at a higher rate until WTP reaches $US 13.16. At this point, it further increases but at a slower rate. This finding indicates that higher WTP indicates high personal valuation for clean water, resulting in higher effort to handle water pollution, as citizens with high WTP for clean water value water more than those with lower WTP. Those with high WTP have a high probability of managing water pollution, while lower WTP indicates that controlling water pollution is not a main priority (Choe *et al.,* 2019). It is assumed that people's WTP shows their concern for clean water. One study has shown that WTP is most strongly influenced by behavior control (Wang *et al.,* 2020). Furthermore, it has been reported that WTP is due to individual insights and anticipation of future improvements in water quality (Makwinja *et al.,* 2019). In other words, behavioral control from individual insights into clean water and anticipation of water quality lead to a high WTP for clean water and a greater probability of managing water pollution. Trust is the foundation for excellent cooperation with one another. Shi (2001) stated that trust is an important ingredient for social and economic progress in public institutions. Greater public trust has been shown to increase policy

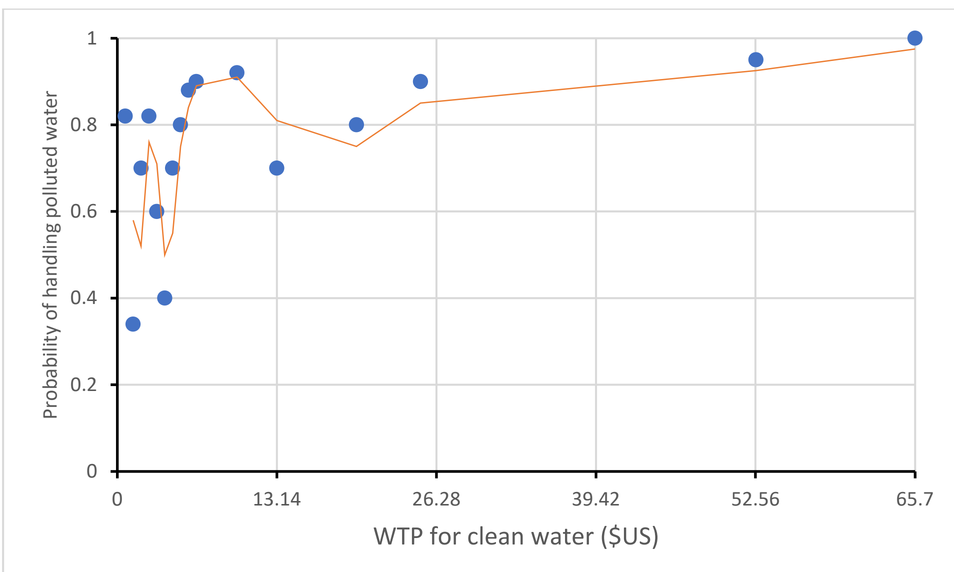

Fig. 4. Probability of managing water pollution based on WTP ($US)

compliance, such as active participation in urban water management programs. After analyzing the variables of interest, the current research analyzes the control variable and how it affects the probability of citizens managing water pollution. The first control variable is the daily income of citizens, and the results show that it has a negative impact on the likelihood of citizens dealing with polluted water. According to estimate 4, an increase in income of $US 0.66 reduces the probability of treating water pollution by –0.0205, which is statistically significant at the 99% confidence level (estimate-4). Estimates 1–3 indicate an even greater probability of decline at –0.06, which is significant with a 99% confidence level. This finding means that high-income citizens tend to have a lower probability of dealing with polluted waters because they have the ability to pay others to treat it or to buy clean water. To deepen the analysis, a graphical analysis of citizens' IPD and their probability of managing water pollution were also contacted. The graph below shows a U-shaped curve, indicating that the probability increases again after the IPD reaches a certain value. This additional finding reveals that Jakarta citizens with higher incomes will always have a lower probability of managing polluted waters. In contrast, their probability of handling polluted waters will increase again past a certain level of income. This indicates that citizens' behaviors in managing water pollution might change as their IPDs increase.

Based on Fig. 5, the probability of managing water pollution among citizens with an income of less than $US 13.17 tends to increase. This means that those with low income have a higher probability of dealing with water pollution, because they cannot afford to buy clean water, while the need for clean water is essential. At the same time, there are certain respondents who have a higher probability of managing water pollution even though their daily incomes are greater than $US 26.34. This suggests that their perception of controlling water pollution is high, even though they can afford clean water. The high probability at low-income levels indicates that people with middle to lower economic status are more likely to manage water pollution. However, this does not rule out the possibility that some citizens with high income levels can also handle polluted waters. Gomez *et al*. (2019) stated that income plays a role in forming perceptions and behaviors related to water management. Those with high incomes have greater access to clean water than those with low incomes. This means that the level of daily income does not have a linear relationship with the possibility of citizens dealing with water pollution. Another study reported that health problems due to water pollution arise from low-income respondents (Wang and Yang, 2016). This reinforces the idea

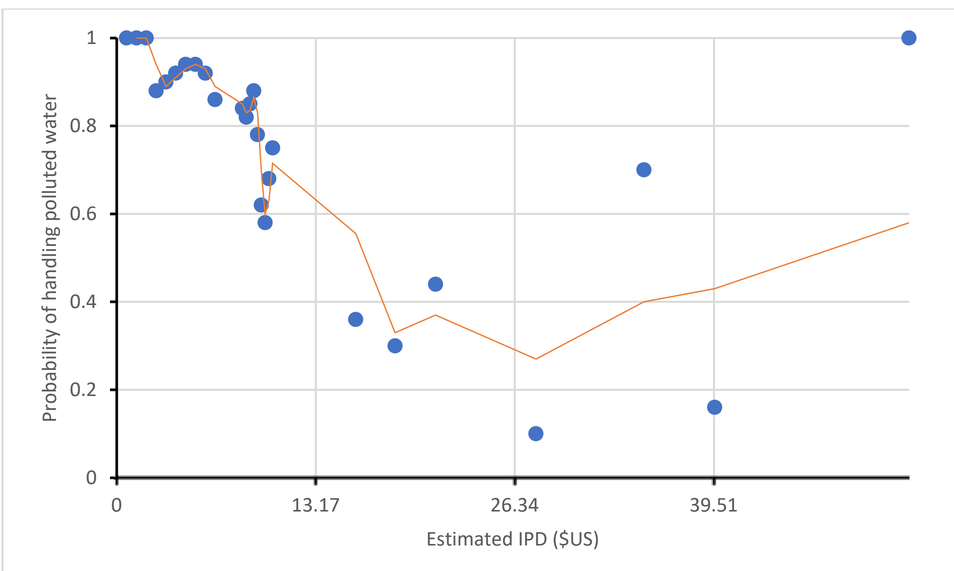

Fig. 5. Probability of managing water pollution by Estimate IPD ($US)

that low-income citizens tend to experience health problems due to water pollution, so they have greater awareness of and ability to overcome these problems. The next control variable to be analyzed is the level of education. Based on the regression table above, education level has a negative and statistically significant effect on the possibility of managing water pollution. An increase in education level of 1 year will reduce the probabilities by –0.429 (estimate 4) and –0.367 (estimate 1), which are statistically significant at the 99% confidence level. Estimates 2 and 3 reduce the probability –0.341 which is statistically significant with a 95% confidence level. These four estimates indicate that the higher the level of education, the lower the probability of dealing with water pollution. This is certainly a strange phenomenon. In theory, the higher the educational level of citizens, the greater the opportunity to deal with water pollution. To investigate this phenomenon further, it was conducted a graphical analysis to estimate how an increase in educational level would affect the possibility of dealing with polluted waters.

As shown in Fig. 6, the results are the same as those in the regression table, where more educated Jakarta citizens tend to have a lower probability of dealing with polluted waters. Those who have an educational level at the elementary school level have the greatest estimated probability of managing water pollution. In contrast, those who have a higher educational level have a low probability of doing the same. Theoretically, this is odd because ideally, highly educated citizens should have a higher environmental awareness than less educated citizens. Meyer (2015) has proven that educational level influences pro-environmental behaviors based on causal estimation not only based on descriptive relationships. Causal estimation can give us a better idea of what would happen to the extent of individuals' pro-environmental behaviors. Muttarak and Lutz (2014) found 11 original empirical studies set in diverse geographic, socioeconomic, cultural, and hazard contexts, which provide consistent and robust evidence of the positive impact of formal education on reducing vulnerability to environmental problems. Educational level affects perceptions regarding protecting the environment, which in turn, impacts individuals' willingness to participate in urban water management programs. It is necessary to consider whether water education is should be added in the education curriculum. For example, Compulsory 9-year water education programs in China are extremely rare (representing 0.2%–1.4% of the curriculum; Xiong *et al.,* 2016). Moreover, the education curriculum focuses more on theoretical than practical aspects

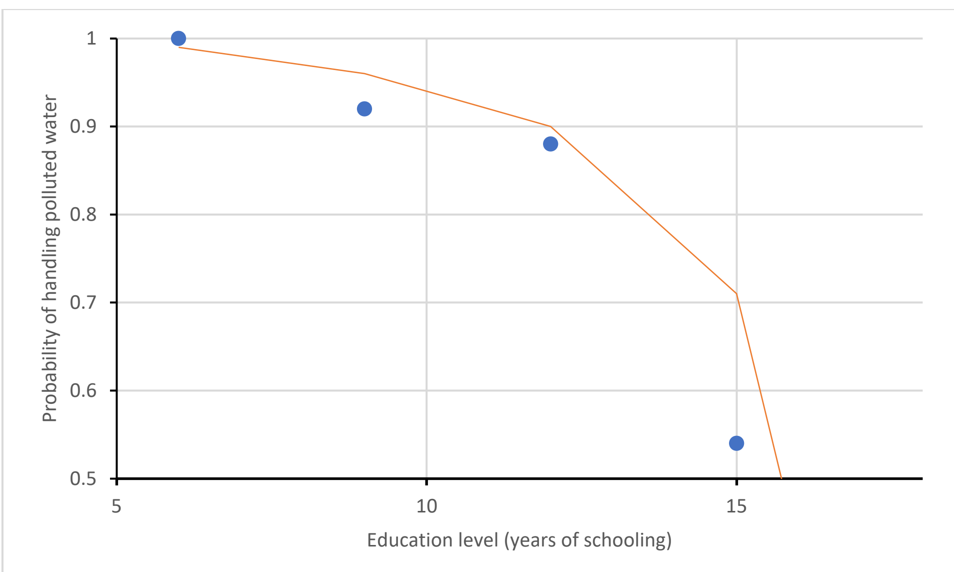

Fig. 6. Probability of managing water pollution based on educational level

(Al-Maliki *et al.,* 2021). The results of a recent study show that environmental education is just starting to be included in educational programs, taking green buildings as a reference, and that there has been an increase in efforts to reduce the environmental footprint through education in 21 countries (Díaz *et al.,* 2023). It can be concluded that the importance of including water education in the curriculum is not limited to theoretical but should also include practical education. This finding suggests that, in the case of Jakarta, citizens with higher education might be more apathetic to managing polluted waters. However, it does not mean that they are not bothered by water pollution or do not care about water conservation at all. More educated citizens might be involved in more strategic activities to handle water pollution or they could pay or ask someone else to handle pollution when contamination occurs. The next control variable is age. Based on the regression results in the previous discussion, age has a positive effect on the possibility of managing water pollution, although it is not statistically significant (it can reduce the probability and does not always increase). Based on estimates 1–4, an increase in age of 1 year will increase the likelihood of water pollution management by 0.01 or 1%. To further analyze this, it is conducted a graphical analysis.

Fig. 7 shows that the effect of age on the probability of managing water pollution has a very small level of decline when the age is between 0–50 years. Once citizens pass the age of 50, their chances of dealing with polluted waters decrease at a higher rate. This finding confirms that most of the water management activities are conducted by people of productive age. After passing such an age, the possibility of handling polluted waters will shift to younger and more productive citizens. At the same time, findings from Malaysia reveal that age has a significant effect on individuals' perceptions of water pollution (Afroz *et al.,* 2016). This suggests that the perception of water pollution increases with age, accompanied by a higher probability of managing water pollution. However, for the elderly who may have difficulty carrying out physical activities, their probability of water pollution management may be smaller, even though their perceptions of water pollution are high. The next control variable is marital status, which has a negative effect on the probability of managing polluted waters based on the regression results. In particular, married citizens tend to have a lower probability of managing water pollution by up to –2.85 times than unmarried citizens, which is statistically significant at the 99% confidence level (estimate 4). Estimates 2 and 3 both have a probability of –1.5

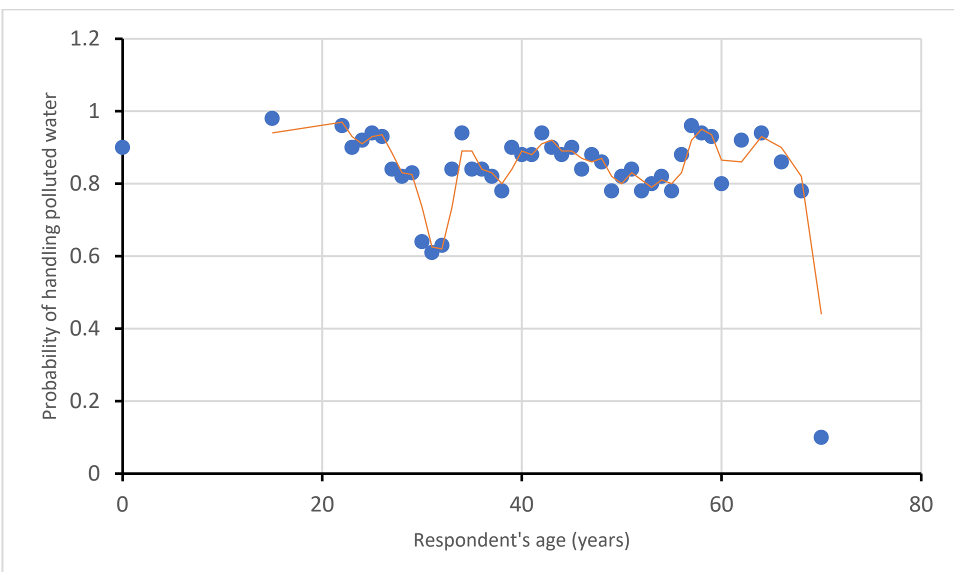

Fig. 7. Probability of managing water pollution based on respondents' age

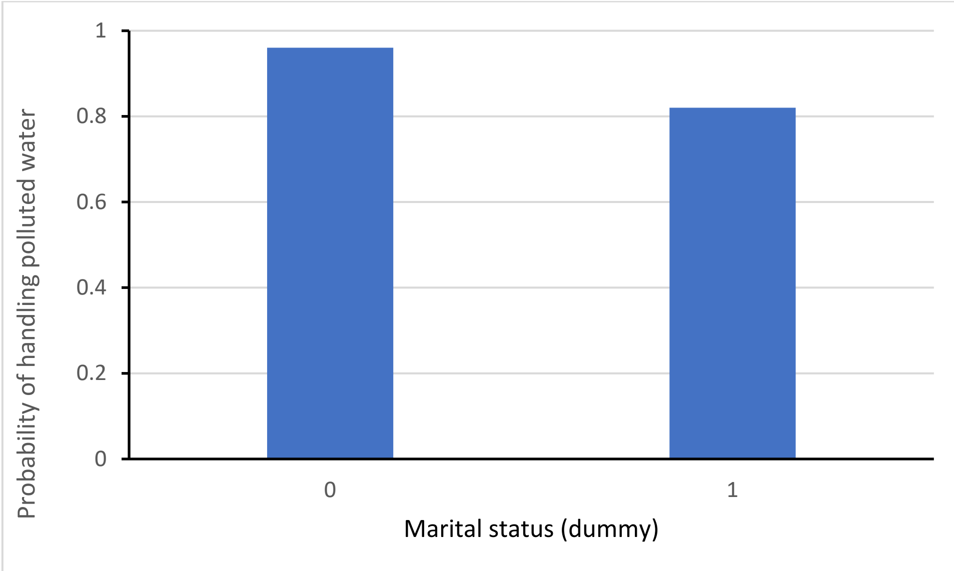

Fig. 8. Probability of managing water pollution based on marital status

times lower with a confidence level of 90%, while estimate 1 has a probability of –1.229 times lower but is not statistically significant. This suggests that married citizens have a lower probability of dealing with water pollution than single people, although it is possible that the opposite may occur in other areas. A graphical analysis was also conducted to examine how the probability of water pollution management differs between married and unmarried citizens.

As shown in Fig. 8, married citizens in Jakarta (dummy = 1) have a lower probability of handling water pollution than unmarried ones. This finding indicates that married citizens tend to pass on the water conservation activities to unmarried citizens. This is supported by the statement that the intentions to participate and consequent behaviors of citizens are highly limited by the objective conditions of the citizens themselves (Huang *et al.,* 2021). In this study, the objective condition is being married, which means that when a citizen is married, their focus shifts to the interests of their family. The last control variable is gender. Based on the regression results shown in Fig. 9, gender has a negative but statistically insignificant effect on the probability of managing water pollution. Male citizens tend to have –0.27 times lower probability of dealing with polluted waters than female citizens which is not statistically significant (estimate 4). Estimate 1 has a lower probability at –0.689. Furthermore, estimates 2 and 3 have –0.409 and 0.396 times lower probabilities, respectively. Although not statistically significant, this phenomenon is quite strange.

Based on Fig. 9, the graphical analysis results seem to be convergent, in which male citizens (dummy = 1) have a lower probability of handling water pollution than women. Theoretically, men should have a higher probability of doing so because water conservation activities require more physical abilities. Men tend to be more sensitive to symptoms that try to change their behaviors (Vicente *et al.,* 2018). Another study finding that strengthens the results of the study states that gender does not have an effect (De Lázaro Torres *et al.,* 2020). Gender refers to the different roles, rights, responsibilities, behaviors, and identities of men and women and the relationships between them. These relationships and responsibilities can and do change over time (UNDESA, 2014). Differences and inequalities between women and men affect how individuals respond to changes in the management of water resources. In recent years, it has been increasingly accepted that women must play an important role in water management, and certainly,

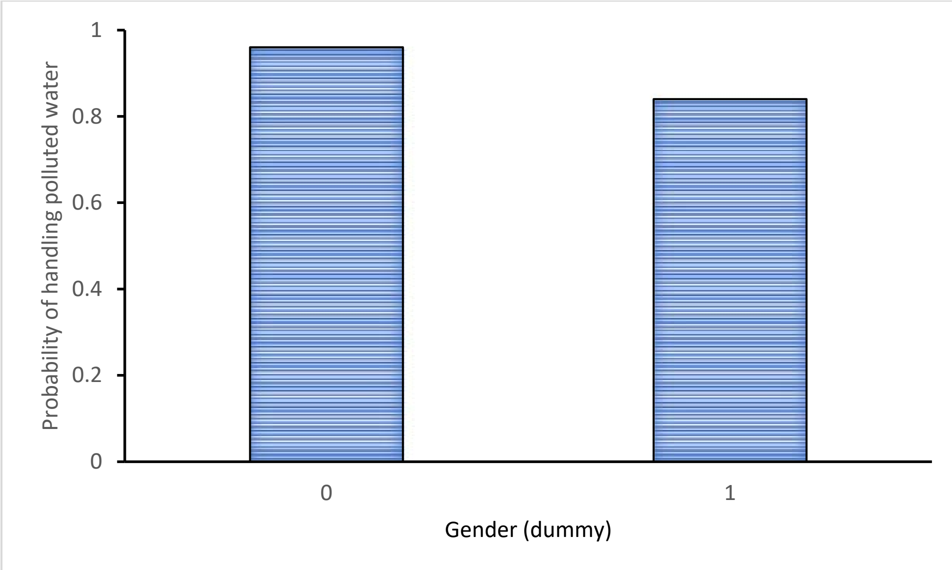

Fig. 9. Probability of managing water pollution based on gender

the response given by women is different when they are not accepted. The gender gap in environmental concern and political knowledge is explored by Lafuente *et al.* (2021) who found that women's preferences are related not only to their greater environmental proactiveness in the domestic sphere, but also to variables related to political knowledge. In the current study, gender does not have a significant relationship with the dependent variable; thus, it may not be concluded which gender tends to have a greater probability of managing polluted waters.

CONCLUSION

This study was conducted to add to the perspective that socioeconomic factors can influence behaviors in managing water pollution, filling gaps from previous research that focused on the correlation between socioeconomic factors and water quality and the impact of water pollution on socioeconomic growth. The study was conducted through a clean water survey held in Jakarta in 2022 using the probabilistic survey method. Interest and control variables were tested against this possibility. The interest variables tested were initial action, level of water disturbance, and WTP for clean water. The results showed that people with higher income and educational levels had a lower probability of dealing with polluted waters, while those with lower income and educational levels had a higher probability of doing the same. This suggests that education and income do not always translate to behavioral changes in managing water pollution. The study also found that age played a role, with older citizens having a higher perception of water pollution but lower probability of managing it due to physical limitations. Finally, married citizens were found to have a lower probability of managing polluted waters than unmarried citizens. Overall, this study adds to the understanding that socioeconomic factors and personal characteristics play a significant role in shaping behaviors related to water pollution. It further highlights the importance of considering these factors in designing interventions to promote water conservation and pollution reduction. In particular, a higher WTP reflects a high personal valuation of clean water, resulting in a higher effort to handle polluted waters, mainly because citizens with a high WTP for clean water value water more than those with a lower WTP. Jakarta citizens with higher incomes are less likely to handle polluted water, but their probability of doing so will increase again after a certain income level. Moreover, citizens with higher educational levels may have a lower probability of dealing with water pollution compared with those with lower education levels. However, this does not necessarily mean that the former do not care about water conservation or are completely apathetic towards polluted water. It is possible that more educated citizens are involved in more strategic activities related to water conservation or may delegate the task of water pollution management to others. Thus, the relationship between educational level and the probability of dealing with water pollution still needs to be explored**.** In the case of Jakarta, water management activities are generally carried out by people of productive age. After passing their productive age, their ability to treat polluted waters will shift to younger and more productive citizens. In addition, the results revealed that married Jakarta citizens are less likely to be affected by water pollution than unmarried people. In terms of gender, it cannot be concluded which gender is more likely to handle polluted waters. Overall, this study contributes to the literature by examining the possibility of socioeconomic factors influencing actions taken to deal with water pollution. This can help stakeholders in designing and implementing strategies to mitigate short-term clean water crisis in the capital region and support relevant decision-making processes.

AUTHOR CONTRIBUTIONS

D. Elfina Purba perfomed conceptualization,; methodology, literature review and project administration. F. Madianti performed the validation and formal analysis. All authors have read and agreed to the published version of the manuscript.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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ABREVIATIONS

%	Percentage
$US	US Dollar
As	Arsenic
BIP	Brazilian and International Press
BPS	Badan Pusat Statistik (Statistics Indonesia)
C.S.	Citizens science
E or e	10 to the power of
e.g.	For example
Eq.	Equation
Est.	Estimation
Fig.	Figure
i.e.	That is or that are
IPD	Income per day
p	Level of significance
UK	United Kingdom
WTP	Willingness to Pay

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