# Economic Model

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# Economic Model of Groundwater Damage Control in Semarang City: Prisoner's Dilemma Game

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**Abstract**:

Groundwater abstraction in Semarang City is thought to have triggered land subsidence and sea water intrusion. This research models the behavior of groundwater users through economic experiments using Prisoner's Dilemma Game. The experimental design is a $2^3$ factorial design. The independent variables or factors are payoff, framing, and communication, while the response variable is the level of cooperation. The G statistic shows a significant logit equation model. Wald statistic shows a significant framing factor, whereas communication factor, framing and communication interaction factor, all factors interaction is significant but with the opposite sign. The study implies a policy based on the treatment proxy in experiments. First, narrating the depletion and the role of groundwater users is narrated. Second, building trust before implementing information disclosure on groundwater use. Third, determining groundwater extraction fines after internalizing scarcity rent in groundwater prices calculation.

**Keywords:** Semarang City; groundwater damage; prisoner's dilemma game; economic experiments; payoff matrix; framing; communication

**JEL Classification**: C90; C72; D10; Q25.

## Introduction

Groundwater includes common pool resources (CPRs) and open access. Groundwater as CPRs is explicitly states in (Wade 1987; Elinor Ostrom 1990; Provencher and Burt 1993; Knapp and Olson 1995; Burness and Brill 2001; Apesteguia 2006; Wang and Segarra 2011; Esteban and Dinar 2013), while groundwater is an open-access is explicitly mentioned in (Schrevel 1997; Syaukat and Fox 2004). Hardin (1968) metaphor shows that the end of the use of CPRs in open access conditions is a tragedy. The tragedy of groundwater extraction is the emergence of groundwater damage in the form of land subsidence and seawater intrusion. Groundwater abstraction in Semarang City is thought to have arrived at a situation that triggered land subsidence and seawater intrusion. Based on observations from 1999 to 2011, (Abidin *et al.* 2013) reported a rate of land subsidence reaching 19 cm per year. Reference (Suhartono, Purwanto, and Suripin 2015) concluded that the area affected by seawater intrusion continues to increase at a rate of 0.575 km square per year.

Elinor Ostrom (1990) modeled Hardin's metaphor using the Prisoner's Dilemma Game (PDG). Ostrom explained the tragedy occurred if all the players chose a defect strategy. Furthermore, Ostrom explained that there are two solutions to prevent tragedy in the condition of open access. First, impose fines on players who choose defect strategies. Second, collective action in the form of arbitration so that all players work together. Penalties and arbitration fees are implemented in the form of changes in PDG payoffs. In addition to payoff, experimental studies show communication (Sally 1995; Balliet 2010) and framing (Goerg, Rand, and Walkowitz 2020) are the most influential variables increasing the probability of players choosing a cooperative strategy.

The policy of controlling groundwater damage in Semarang City is regulated in Regional Regulation No. 2 of 2013 concerning Groundwater Management. Article 39 and Article 53 explicitly state that two instruments are used for the control of groundwater damage, namely the manufacture of recharge wells and the groundwater tax. The two instruments show that the policy is only from the supply side, it does not involve active participation of groundwater users. In addition, the policy is based solely on the physical characteristics of groundwater, not yet based on the characteristics of groundwater as CPRs and open access. If related opinion of Sally (1995); Elinor Ostrom (1990); Balliet (2010); Goerg, Rand, and Walkowitz (2020), it appears that the policy on fines, communication and framing has not been used.

Regarding Hardin (1968) and Elinor Ostrom (1990), in this study the effort to increase the level of cooperation is a proxy for efforts to reduce the onset of groundwater damage. Changes to payoff matrix are the imposition of a fine payment of groundwater tax to users who use groundwater not in accordance with the provisions governed by local regulations or regulations above. Framing is the delivery of environmental framing to groundwater users about the potential emergence of groundwater damage in the event of continuous depletion. Communication is the openness of information about groundwater abstraction plans among groundwater users. The groundwater user is the owner of a licensed well, installs a groundwater extraction recording device, and pays the groundwater tax.

The research problem is formulated as follows: "Do payoff, communication, and framing increase the level of cooperation in PDG?". The study aimed to evaluate the effect of payoff, framing, communication, and the interaction of these three factors on the level of cooperation in PDG. The PDG game was carried out in the context of groundwater extraction in the city of Semarang. The benefit of this research is the production of an economic model for controlling groundwater damage. The model built is expected to explain and predict changes in groundwater user behavior if the local government implements a fine instrument, delivers a narrative of groundwater depletion, and informs groundwater withdrawals of all groundwater users.

## 1. Literature Review

Wade (1987) states CPRs are public goods with limited benefits, so that if someone has used them, the availability for the following user is reduced. Wade's explanation shows the nature of rivalry. He gave examples of resources that met CPRs criteria, including irrigation channels, groundwater, pasture, and forests. Elinor Ostrom (1990) defines explicitly CPRs as natural resource systems or human-made resources that are so large that the costs to exclude one related party are very large. Ostrom's explanation shows nonexcludable properties. Groundwater is stored in groundwater basins and collection is carried out through wells connected to each other. Groundwater abstraction is rivalry, meaning that groundwater extraction in certain wells results in a reduction in other wells' groundwater. It is not technically possible to exclude groundwater abstraction in certain wells.

Open access is a form of resource ownership (E. Ostrom 1999) and means management regimes in taking or utilizing (Schrevel 1997; Syaukat and Fox 2004). Open access as meant by Schrevel is groundwater more accessible compared to surface water. Shallow groundwater in the same groundwater basin can be accessed through multiple wells. Besides, only by making dug wells can groundwater be exploited and utilized at the same point. This is different from surface water which can only be taken from the intake point and still requires transportation to bring it to the place where the water will be used. Syaukat and Fox conducted research on the joint use of surface and groundwater in the DKI Jakarta Province. They stated that the de facto groundwater management regime was open access.

Generally, the PDG is explained as the story of two people who were investigated separately because the police did not yet have enough information. The threat of punishment that will be delivered to the first person depends on the answer he gives and the second person's answer. Provisions on the threat of punishment also apply to second persons. The message of this game is that the payoffs of a player's decision depend on other players' decisions. Besides being portrayed as the story of two defendants and investigators, PDG is also used to illustrate the conflict between selfish and selfless. In such a context, PDG is a social dilemma game. A payoff matrix is called PDG if it meets the conditions of $T > R > P > S$ and $2R > (T + S)$. Position R (payoff), S (sucker), T (temptation), and P (punishment) are shown in Table 1.

Table 1. General Model of PDG in Strategic Form

| | | Column Players | |
|---|---|---|---|
| | | Cooperate (C) | Defect (D) |
| Row Players | Cooperate (C) | ( R, R ) | ( S, T ) |
| | Defect (D) | ( T, S ) | ( P, P ) |

Dawes (1980) suggests several proposals to increase players' probability of choosing cooperative strategies, namely changing payoff and changing the concept of payoff into utilities. Dawes states payoff is an external factor while utilities are an internal factor. According to Dawes, internal factors affect behavior more because there are concepts of altruism, conscience, and norms. Changes in payoffs to increase players' probability of choosing a cooperative strategy are also stated by (Holt and Capra 2000).

Framing is an independent variable that is widely used in experiments. J. Andreoni (1995) conducted an investigation using positive and negative externalities framing to determine the subject's desire to choose a cooperative strategy. The results show that subjects are more willing to cooperate on framing positive externalities. Goerg, Rand, and Walkowitz (2020) conducted an experiment with give and take framing on PDG and dictator games (DG). The results show that framing affects the behavior and beliefs of PDG experiment participants but has no effect on DG. The research of Georg et al. shows that the subject's decision on PDG is influenced by framing with social context characteristics.

Piñon and Gambara (2005) conducted a meta-analysis of the effect of framing on experiments. They evaluated 51 articles collected from various online sources, printed journals, and requests for articles by e-mail to the Society for Judgment and Decision Making. The articles are selected based on the type of framing and the experiment's year (1997-2003). The results show there are different effects on various types of framing. In risky framing, the essential characteristics are gender and the number of available strategy options. The essential characteristics of framing attributes are gender, year, and the problem presented, whereas in goal framing the essential characteristics are the type of problem and the many strategy options given to the subject.

Sally (1995) conducted a meta-analysis of experimental articles about decision-making in PDG. He analysed 37 articles published from 1958 to 1992. The results showed the dependent variable in all experiments was the rate of cooperation, which is the percentage of players who chose a cooperative strategy. The independent variables used are diverse, namely subject characteristics, instructions, repetition, payoff matrix, anonymity, group identity, communication, etc. The descriptive analysis by Sally showed that one-third of all experiments allowed subjects to communicate, 26 experiments allowed conversations, and 15 experiments allowed the exchange of written messages. Further analyses - multiple linear regression and logistic regression - on all experimental results showed that communication most significantly influenced the response rate of cooperation. Balliet (2010) also conducted a meta-analysis of 45 social dilemma experimental articles with the criteria of having a control group (no communication) and an experimental group (there was communication). The results show communication has a positive influence on cooperation. More specifically, Balliet shows that face-to-face communication has a more significant effect than written messages.

In psychological experiments, Kopelman, Weber, and Messick (2002) mention that payoff, framing, and communication are factors influencing cooperation on commons dilemmas. Other factors are social motivation, gender, uncertainty, status and power, group size, and causes. James Andreoni and Miller (1993) show experimental evidence that a cooperative strategy's choice becomes rational for a player if the game is finitely repeated prisoner's dilemma. The results of Andreoni and Miller's experiment confirm the experiment, which was published more than ten years earlier by Kreps *et al.* (1982). Other publications state various concepts or efforts to improve players choosing cooperative strategies, such as prosocial behavior (Cremer and Van Lange 2001) and punishment (Cason and Gangadharan 2015).

The explanation above shows changes in payoff, framing, and communication positively affect cooperation in economic experiments that use social dilemma games in general and PDG in particular. In this article, the research hypothesis was formulated: "payoff, framing, communication, and interactions of these factors have a positive influence on the level of cooperation in economic experiments using PDG". This hypothesis's public policy implications are the imposition of fines, the delivery of groundwater depletion narratives, and information disclosure among fellow groundwater users to control the destructive damage of groundwater in Semarang City effectively.

## 2. Methods

Data were collected using economic experiments conducted in laboratory settings. The intended laboratory setting is a situation where the influence of factors other than treatment is minimized. Before being set up as an experimental subject, participants explained the game mechanism, conducted 2 game sessions, and worked on 2 test questions.

The experimental design is a $2^3$ factorial design. The independent variables or factors are payoff (A), framing (B), and communication (C). There are two levels of treatment in each factor, namely payoff 1 ($A_1$) and payoff 2 ($A_2$), no framing ($B_1$) and framing ($B_2$), no communication ($C_1$) and communication ($C_2$). The combination of factors resulted in 8 treatments, namely $A_1B_1C_1$, $A_2B_1C_1$, $A_1B_2C_1$, $A_2B_2C_1$, $A_1B_1C_2$, $A_2B_1C_2$, $A_1B_2C_2$, dan $A_2B_2C_2$. Subjects who get the same treatment are called experimental groups. K is the experimental group $A_1B_1C_1$ and $A_2B_1C_1$, and L is $A_1B_2C_1$ and $A_2B_2C_1$, M is $A_1B_1C_2$ and $A_2B_1C_2$, and N is $A_1B_2C_2$, and $A_2B_2C_2$. Participants placement in the experimental group was randomly carried out through the attendance list.

Each treatment is only done in one experiment. The A factor treatment is carried out on the same subject. When the subject gets A1 treatment, the game session is called the first experiment, while the session when the subject gets $A_2$ treatment is called the second experiment. The treatment of factor B and factor C is performed on different subjects.

The experimental unit consisted of 2 subjects, as player 1 and player 2. The subject's task was to choose a cooperative strategy (C) or defect (D). The response variable is the level of cooperation, i.e. the number of subjects in each experimental unit that chooses a cooperative strategy. The payoff matrix of the first and second experiments is shown in Table 2 and Table 3. The payoff magnitudes of the two matrices meet the PDG criteria.

Table 2. The First Experiment PDG Payoff Matrix

| | | Player 2 | |
|---|---|---|---|
| | | Cooperate (C) | Defect (D) |
| Player 1 | Cooperate (C) | 12 , 12 | 1 , 20 |
| | Defect (D) | 20 , 1 | 5 , 5 |

Tabel 3. The Second Experiment PDG Payoff Matrix

| | | Player 2 | |
|---|---|---|---|
| | | Cooperate (C) | Defect (D) |
| Player 1 | Cooperate (C) | 12 , 12 | 1 , 14 |
| | Defect (D) | 14 , 1 | 3.5 , 3.5 |

The payoff difference treatment shows the amount of the fines imposed on the subject who chose the defect strategy. Technically this difference is demonstrated by the payoffs of a smaller defect strategy in the second game matrix. The framing treatment is that the subject receives a narrative text about the social context of the emergence of groundwater damage in Semarang City. The communication treatment is the message transmission in the form of a subject's statement before deciding. The subject chooses one of the three messages: choosing C, choosing D, and no notification of choosing C or D.

The payoff, framing, and communication are qualitative treatment factors to input data using coding. Montgomery (2013) states the coding factor for a $2^k$ factorial design is $-1 \leq x \leq +1$. In this study $A_1$, $B_1$, and $C_1$ treatments were given -0.5 coding, whereas treatments $A_2$, $B_2$, and $C_2$ were given 0.5 codings. Response variables are qualitative data in the form of strategy choices of each player in the experimental unit. The response variable expressed as $y_{ijkl}$ where i = 1, 2 represents treatment $A_1$ and $A_2$, j = 1, 2 represents treatment $B_1$ and $B_2$, k = 1, 2 represents treatment $C_1$ and $C_2$, and l = 1, 2, 3, ..., n where n is a replication. In this experiment, the replication is the number of experimental units in each experimental group. Coding for strategy choice DD = 0, DC = CD = 1, and CC = 2. The DD strategy choice means player 1 chooses D and player 2 chooses D, and so on for DC, CD, and CC.

Data were analyzed using multinomial logistic regression techniques. The research hypothesis is modeled using a logit equation (Equation 2.1).

$$g(x) = \beta_0 + \beta_1(x_1) + \beta_2(x_2) + \beta_3(x_3) + \beta_4(x_1.x_2) + \beta_5(x_1.x_3) + \beta_6(x_2.x_3) + \beta_7(x_1.x_2.x_3) + \varepsilon \quad 2.1$$

where g (x) = logit π (x) = $\ln\left[\frac{\pi(x)}{1-\pi(x)}\right]$, namely linear transformation of odds ratio, $x_1$ = payoff factor, $x_2$ = framing factor, $x_3$ = communication factor, $x_1.x_2$ = payoff and framing interaction factor, $x_1.x_3$ = payoff and communication interaction factor, $x_2.x_3$ = framing and communication interaction factor, $x_1.x_2.x_3$ = payoff, framing, and communication interaction factor. The suitability of the logit equation model is done through hypothesis testing as follows:

$H_0$: $\beta_1 = \beta_2 = \cdots = \beta_p = 0$

$H_a$: There is at least one parameter not equal to zero.

The multinomial logistic regression model decision is significant if the value of G statistic is greater than the value of table $\chi^2$ with a degree of freedom p or reject $H_0$ if $G > \chi^2_{(p)}$. In this study p = 7, so that at the 5% significance level, the decision to reject $H_0$ if G > 14.07. The $\beta_i$ parameter test is partially carried out through testing the hypothesis as follows:

$H_0$: $\beta_i = 0$

$H_a$: $\beta_i \neq 0$

The decision to reject $H_0$ uses Wald statistics at a 5% significance level. The $\beta_i$ parameter is tested for i = 1, 2, ..., 7.

## 3. Results

The experiment was conducted at the Computer Laboratory of the Faculty of Economics and Business of Diponegoro University on May 31, 2018. Prospective participants of the experiment were undergraduate students from various study programs at Diponegoro University. Recruitment announcements were posted and distributed online for three weeks. Participants registered online. The total experimental subjects were 49 people. Conversion of payoff 1 = Rp. 1,000, - (one thousand rupiah). Table 4 shows the total subjects displayed were 48. One subject paired with a dummy subject was not analyzed.

Table 4. Cooperation Level in Each Treatment

| Treatment | Cooperation Level | | | |
|---|---|---|---|---|
| | DD | CD | DC | CC |
| $A_1B_1C_1$ | 1 | 1 | 2 | 2 |
| $A_2B_1C_1$ | 3 | 0 | 2 | 1 |
| $A_1B_2C_1$ | 0 | 0 | 3 | 3 |
| $A_2B_2C_1$ | 0 | 2 | 1 | 3 |
| $A_1B_1C_2$ | 1 | 3 | 1 | 1 |
| $A_2B_1C_2$ | 3 | 1 | 1 | 1 |
| $A_1B_2C_2$ | 1 | 2 | 1 | 2 |
| $A_2B_2C_2$ | 2 | 1 | 2 | 1 |
| Total | 11 | 10 | 13 | 14 |

The analysis was carried out with the DD reference category (Table 5). The DC or CD category logit equation is presented in Equation 3.1, while the CC category logit equation is presented in Equation 3.2.

$$g(x) = 5.646 - 0.997(x_1) + 10.455(x_2) - 10.049(x_3) + 1.301(x_1.x_2) - 0.490(x_1.x_3) - 20.386(x_2.x_3) - 0.405(x_1.x_2.x_3) \quad 3.1$$

$$g(x) = 5.061 - 1.069(x_1) + 10.873(x_2) - 10.670(x_3) + 0.752(x_1.x_2) - 0.347(x_1.x_3) - 20.648(x_2.x_3) - 2.079(x_1.x_2.x_3) \quad 3.2$$

Table 5 shows the statistics G > 14.07 meaning that at a 95% confidence level there is sufficient evidence to reject $H_0$. Besides, starting with $H_0$ means that there is enough evidence to state that at the 5% significance level, the three factors and their interactions are good predictors of the two above-mentioned logit equation models.

The significant factors in DC or CD category logit equations are framing, communication, and interaction of framing and communication factors. The odd ratio value or Exp (B) of framing factor is greater than 1 meaning that if the intensity of framing treatment increases then the subjects' tendency to choose DC or CD is greater than DD. The odd ratio value of communication factor is less than 1 meaning that if the intensity of communication treatment increases the subjects' tendency to choose DC or CD is smaller than the tendency to choose DD. That of framing and communication interaction factor is less than 1, meaning that if the two factors' interaction intensity increases, the tendency of DC or CD subjects is smaller than DD.

The CC category logit equation's significant factors are framing, communication, framing and communication interaction, and payoff, framing, and communication interactions. The odd ratio value of framing is greater than 1 which means that if the intensity of framing treatment increases the subjects' tendency to choose CC is greater than the tendency to choose DD. The odd ratio value of communication factor is less than 1 meaning that if the intensity of communication treatment increases the subjects' tendency to select CC is smaller than the tendency to choose DD. That of two significant interaction factors in equation 3.2 is less than 1 meaning that if the intensity of the two interaction factors increases the subject tendency to take CC is smaller than the tendency to take DD.

Table 5. Estimated Multinomial Logistic Regression Parameters

| Factor | Category | B | SE | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|---|
| Constant | DC or CD | 5.646 | 0.558 | 102.428 | 1 | 0.000 | |
| | CC | 5.061 | 0.604 | 70.242 | 1 | 0.000 | |
| Payoff ($x_1$) | DC or CD | -0.997 | 1.116 | 0.799 | 1 | 0.371 | 0.369 |
| | CC | -1.069 | 1.208 | 0.784 | 1 | 0.376 | 0.343 |
| Framing ($x_2$) | DC or CD | 10.455 | 1.116 | 87.806 | 1 | 0.000 | 34705.136 |
| | CC | 10.873 | 1.258 | 74.668 | 1 | 0.000 | 52740.402 |
| Communication ($x_3$) | DC or CD | -10.049 | 1.097 | 83.936 | 1 | 0.000 | 4.322E-5 |
| | CC | -10.670 | 1.242 | 73.854 | 1 | 0.000 | 2.322E-5 |
| Payoff and framing interaction ($x_1 . x_2$) | DC or CD | 1.301 | 2.231 | 0.340 | 1 | 0.560 | 3.674 |
| | CC | 0.752 | 2.517 | 0.089 | 1 | 0.765 | 2.121 |
| Payoff and communication interaction ($x_1 . x_3$) | DC or CD | -0.490 | 2.194 | 0.050 | 1 | 0.823 | 0.612 |
| | CC | -0.347 | 2.483 | 0.019 | 1 | 0.889 | 0.707 |
| Framing and communication interaction ($x_3 . x_3$) | DC or CD | -20.386 | 1.465 | 193.673 | 1 | 0.000 | 1.401E-9 |
| | CC | -20.648 | 0.000 | . | 1 | 0.000 | 1.079E-9 |
| Payoff, framing, and communication interaction ($x_1 . x_2 . x_3$) | DC or CD | -0.405 | 2.930 | 0.019 | 1 | 0.890 | 0.667 |
| | CC | -2.079 | 0.000 | . | 1 | 0.000 | 0.125 |
| Statistics G = 28.002 | | | | | | | |

## 4. Discussion

The analysis showed that payoff did not significantly influence the cooperation level. This result does not confirm (Dawes 1980; Elinor Ostrom 1990; Holt and Capra 2000; Kopelman, Weber, and Messick 2002). Theoretically, payoff is expected to result in a change in subject choice from D in the first experiment and C in the second one. The reason for choosing D in the first experiment is that the payoff difference between D and C is relatively large, so it is worth taking the risk of choosing D. While the reason for choosing C in the second experiment is the small payoff difference between D and C so that it is not worthy enough to stake. This mindset is based on the assumption of maximizing standard utility.

Elinor Ostrom (1990) uses a change in the payoff matrix to explain the effect of fines to avoid tragedy. Technically the change is indicated by the shifting in Nash's equilibrium from DD to CC. DD equilibrium is found in the first payoff matrix, before the penalty, and CC in the second payoff matrix after the penalty. The consequence of this change is that the second payoff matrix no longer meets the PDG criteria as explained in Table 1. In contrast to Ostrom, the two payoff matrices in this study (Table 2 and Table 3) is designed so that Nash equilibrium occurs in DD. The fines concept in this experiment is the difference of smaller payoffs between selfless and selfish choices. This difference in the payoff matrix seems to explain why the experimental results do not confirm Ostrom.

The effect purely caused by the change in payoff was shown by the experimental group K. In the first experiment 5 subjects chose D and 7 subjects chose C. In the second experiment, 8 subjects chose D and 4 subjects chose C. The experimental results showed the opposite results, namely, in the second experiment subjects choose D more. Reasons for choosing D in the second experiment include: the worst results (DD) still get a payoff, do not believe in the playing partner, the nature of the free-rider, the first experiment result reference, still choose to take risks to get greater payoffs. All the reasons put forward are similar, namely, the subject wants to maximize payoffs, despite the different ways of achieving them. There are at least two mindset ways to maximize payoffs based on the stated reasons, namely maximizing payoffs by taking risks and maximizing payoffs based on previous interactions.

The experimental results show that the subject is still trying to maximize utility, but the situation is different in game theory. In the illustration of maximizing utility with a choice of two items, for example, apple and orange, the outcome is only determined by the objective function and the constraint function. The decision-making situation is deterministic. The outcome is determined by the capacity of the economic agent itself. The outcome on game theory is probabilistic. The payoffs of game theory are determined by choice of the player and the playing partner. In such a situation, it is natural that the player does not base his choices on the best response logic that is commonly explained and ends in Nash equilibrium. Thus, the experiment results deviating from the arithmetic best response does not indicate the irrational subject. The decisions choice with risk and based on the previous interaction results illustrate economic agents' rationality in probabilistic decision-making situations. Davis (2010) states that decisions on game theory are based on the results of interactions.

The implication of the above description does not have enough evidence to conclude that the fine will reduce Semarang City's groundwater use. At least two relevant reasons can be stated, namely: (1) there is no alternative other than groundwater extraction due to the limited-service coverage of PDAM (the Local Water Company); and (2) the price of groundwater usage or in the legislation called the groundwater tax is still relatively cheap. Groundwater tax bill data published by Bapenda (the Regional Revenue Agency) confirms the alleged low groundwater prices. For example, the July 2018 groundwater usage tax bill for some hotels is less than Rp. 1,000,000, - for example, there are hotels whose groundwater tax bill is only Rp. 49,455.

The implementation of the fines application policy in the use and utilization of groundwater can be pursued if the groundwater price is raised. If groundwater prices are still lower than surface water, fines will certainly not be effective. Groundwater payment bills are still cheap to make them continue to choose fines. In practice, as long as no sanctions have been imposed in connection with the excess amount of groundwater extraction, which already exists is the late payment of groundwater tax. Penalties for groundwater use can be applied if the cost of groundwater scarcity has been internalized in the determination of the HAB (Raw Water Price) for groundwater.

The analysis showed that the framing factor significantly influenced the response variable. This result confirms (J. Andreoni 1995; Kopelman, Weber, and Messick 2002; Pin˜on and Gambara 2005; Goerg, Rand, and Walkowitz 2020). In this study, framing is done by giving a groundwater depletion narration to be read by subjects before deciding. The experiment narrative implicitly shows positive framing. This is indicated by the statement that cooperation is a behavior that puts the common interests first. Thus, it confirms J. Andreoni (1995), which states that the subject would rather cooperate on framing. The groundwater depletion narration is one form of social context. Experimental results confirm Goerg, Rand, and Walkowitz (2020) which states that PDG subject decisions are influenced by framing with social context. The experimental results' implication is that information exposure increases efforts to prevent the onset of groundwater damage.

Subjects who received framing treatment were experimental groups L and N. The effect of the narration appears on the reasons stated by subjects who chose strategy C. These reasons include paying attention to the interests of others, reducing negative impacts on the future, efforts to increase the water usage from PDAM, considering positive impacts in the long run, thinking about common interests, not being selfish, and understanding the importance of cooperation. The reasons stated show prosocial behavior correlated with the possibility of choosing collective decisions.

The implementation of the experiment results is the need for framing-building policy to create or improve groundwater users' prosocial nature. The prosocial behavior-building public policy to improve cooperative behavior is in line with (Cremer and Van Lange 2001) research results. The success of framing efforts is measured from the change in selfish to selfless behavior. This is not easy to do because it must change the cognitive and affective areas. The framing concept's penetration can be increased using a variety of media, such as documentary films, video socialization and campaigns, social media, or interactive game applications. The results of interviews with the authorized agencies to manage groundwater (Dinas ESDM Provinsi Jawa Tengah (Department of Energy and Mineral Resources of Central Java Province) and Bapenda) shows that framing program has not been carried out.

The communication factor is significant but with a different direction sign. The implication of the experimental results shows that communication among groundwater users reduces efforts to prevent groundwater damage. The results of this study do not confirm (Sally 1995; Balliet 2010). The interaction of significant factors but with different signs is that of framing and communication factors and all factors interaction in the experiment. This shows that the communication factor is more powerful than the framing factor.

The reason given by the subjects for a significant but negative result is that trust is not built among them. Most subjects do not know each other because they are from different study programs and years of entry. Subjects are also not introduced to each other. In an experimental situation where all subjects argue that the play partner is trying to get the greatest payoff, it is certainly difficult to believe the playing partner's message. Table 2 and Table 3 show the playing partner will get the maximum payoff when we get the minimum payoff. This was shown when we chose C and the play partner chose D, meaning that when we behaved selfless others also behaved selfishly. This social context is the same as the social concept of the dilemma put forward by Dawes (1980), where each individual gets higher payoffs for selfish choices than making socially cooperative choices. Reference Liebrand *et al.* (1986) explicitly state that there are three social models of the dilemma game: PDG, chicken game, and trust game (TG). The grouping of PDG and TG in the same category implies trust as the underlying factor determining the effectiveness of the communication effect on increasing cooperation.

The above research results imply that communication programs be preceded by building trust, both among fellow groundwater users and with the authorities in groundwater management. Matters that prevent the establishment of mutual trust are the dishonesty of users in reporting the number of owned wells, and the inaccuracy or dishonesty of groundwater meter registers. This study shows the possibility of the opposite effect if the user does not trust messages from managers or other users. Users must be assured that groundwater rivalry characteristics can be managed to minimize the possible emergence of groundwater damage.

The data of groundwater usage shown by STPD (Local Tax Bill) can cause distrust among groundwater users. This was due to the relatively small amount of groundwater tax bills from 2011 to 2018, so that if each subject knew the STPD realization they would not trust the communication messages transmitted by fellow users. The implementation of this fact is that it is important to honestly inventory the number of wells including the tax object category and the recording of groundwater extraction meters.

In addition to being determined by the statistical significance of the above experimental factors, the effectiveness of implementing a groundwater damage prevention policy is also determined by how the manager and the user place groundwater status. So far, the preparation of groundwater utilization policies is not based on groundwater characteristics as CPRs and open access. This mindset fallacy will result in a pricing policy with a static approach, i.e. MB = MC. This concept is commonly used in microeconomic textbooks. Consequently, the cost of obtaining groundwater is the same as the cost of extracting groundwater. Another implication of the static approach is that groundwater tax is still the dominant source of funding for APBD (Local Budgets and Expenditures) and has not been positioned as an instrument to limit groundwater extraction.

Changes in the policy makers' knowledge of groundwater characteristics will result in a dynamic approach to groundwater acquisition pricing. The dynamic approach produces the equation $MB = MC + \Phi$, namely the cost of obtaining groundwater is equal to that of extraction plus the shadow price (Grafton *et al.* 2008). In natural resource utilization, Howe (1979) and Moncur and Pollock (1988) use the term scarcity rent for shadow prices. Scarcity rent is used to internalize the costs of groundwater resources scarcity. When scarcity rent is implemented on groundwater tax bills, the tax function changes to become instruments for limiting groundwater extraction and utilization.

## Conclusion

The research hypothesis is expressed in the logit equation model. The G statistical value shows that the overall model is significant. The implications of the model test results are deemed necessary to make policies on the imposition of fines, narratives about depletion, and disclosure of groundwater abstraction information among fellow groundwater users. This policy mix is a complementary policy on the control of groundwater damage that has been established by local regulations on groundwater management in Semarang City.

The implication of the partial test results with Wald statistic value is the gradual application of the policies. First, the cognitive and affective penetration policy regarding groundwater depletion in Semarang City. The *framing* narrative is the possibility of users reducing the probability of the emergence of groundwater damage. Second, build trust among fellow users about groundwater extraction. The policy is carried out by publishing all groundwater wells' inventory results, lists of licensed well owners, and the monthly average usage within one past year period. Third, the fines policy is applied to users who take groundwater above the provisions. Wald's statistical value shows that payoff is insignificant, meaning that there is not enough evidence to make the implications of the imposition of penalty that will reduce groundwater uptake. Nevertheless, penalties can be applied if groundwater prices have been determined based on dynamic analyses and the service coverage of PDAM is increased.

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