KOCHI UNIVERSITY OF TECHNOLOGY

Social Design Engineering Series *SDES-2020-4*

Cooperation and cognition gaps for salinity: A field experiment of information provision

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1st June, 2020

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May 29, 2020

Abstract

Salinity along with climate change has devastating effects on people's life, and thus, adaptation & mitigation strategies are needed to cope with its risks. Literature establishes an existence of cooperation & cognition gaps due to informational and residential differences that make the strategies' implementation difficult. While little is known about how such gaps can be reduced, we hypothesize that information provision about salinity through some lecture is effective at reducing cooperation gaps among people by influencing their cognition in urban and rural areas. We conduct a survey experiment, collecting data on donations, prosociality, cognitive and sociodemographic factors of 900 subjects from one urban and two rural areas in Bangladesh. A climate donation game is instituted to measure cooperation among people where they are asked to donate to salinity risk reduction with or without the information provision. The analysis shows that people who have prosocial orientation and perception of human-induced climate change donate more than do those who do not, and urban people tend to donate less than do rural people. However, urban people are identified to increase their donations by receiving the information provision much more than do rural people. These results can be interpreted that urban people become more cooperative in response to the lecture than do rural people, and cooperation gaps become smaller due to a change in cognition via information provision. Overall, the results demonstrate that informational and education programs for salinity and climate change shall be effective and prioritized especially in urban areas to enhance cooperation for SDGs through affecting people's cognition.

Key Words: Salinity; cooperation; cognition; information provision

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Contents

Nomenclature

AD Adaptation donation

BDT Taka, Bangladeshi currency

CD Climate donation

MD Mitigation donation

ME Marginal effect

MP Marginal probability

NGOs Non-governmental organizations

SVO Social value orientation

TD Total donation

1 Introduction

Salinization of soil and water along with climate change in deltaic and coastal regions poses a significant threat for 600 million people in the world (Talukder et al., 2016, Jevrejeva et al., 2018, Rahman et al., 2019). Low-lying countries are suffering a lot from severe salinity problems, which will be exacerbated in future according to climate change projections (Talukder et al., 2015, 2016). In the light of continuously increasing salinity level in soil and water, there is an urgent need to adopt adaptation & mitigation strategies for reduction of the associated risks. Numerous studies examine people's cooperation or their cognition toward environmental problems such as climate change, finding an existence of the gaps in cooperation & cognition due to informational and residential differences that make the strategies' implementation difficult (McCaffrey and Buhr, 2008, Shwom et al., 2008, Ortega-Egea et al., 2014, Islam et al., 2016). Therefore, it is crucial to understand cooperation & cognition gaps of environmental problems for designing the policies and achieving sustainable development goals. This paper addresses people's cooperation, cognition and the gaps by conducting field experiments.

Past research examines people's cognition of, and cooperative behavior, toward environmental problems. Several studies identify that knowledge and information about environmental issues correlate significantly with proenvironmental activities (Kollmuss and Agyeman, 2002, Semenza et al., 2008, Weber and Stern, 2011, Shoyama et al., 2013, Spence et al., 2014, Deryugina and Shurchkov, 2016, Goff et al., 2017). For example, Lorenzoni et al. (2007) state that the degree of people's engagement with environmental activities relates to their cognition. Also, Fischer and Charnley (2012) and Islam et al. (2016) establish that accurate perception or cognition about climate change is positively related to people's cooperative behaviors. Furthermore, Arbuckle et al. (2013) show that people who recognize the consequences of climate change are likely to support climate change mitigation actions. Other researchers implement a survey on how information provision about climate change affects people's cooperation through eliciting the willingness to pay for solving climatic problems (Shwom et al., 2008, Johnson et al., 2011, Yang et al., 2014, Abbas et al., 2016).

A group of previous studies examine the effect of residential differences in explaining environmental concerns and people's cooperation for solving environmental problems (Zahran et al., 2006, Shwom et al., 2008, Bel et al., 2014). For instance, Berk and Schulman (1995) and Berk and Fovell (1999) state that places and nature of climate in which people live influence their willingness to support various climate change strategies. In addition, Rajapaksa et al. (2018) show that rural, urban and slam people have different proenvironmental behaviors to protect the environment. In another study, Huddart-Kennedy et al. (2009) show that rural and urban people have different environmental concerns and rural people have a higher tendency to participate in environmentally supportive programs. Again, Shwom et al. (2008) examine the effect of residential differences on climate change policy support, finding that effectiveness of climate change policies largely depends on people's residential differences. Overall, residence difference is a prominent factor in determining people's environmental concerns and their cooperation to support environmental protection measures.

A growing number of studies have been conducted on environmental and climate change problems, analyzing the potential impact on people's life and livelihood in relation to behaviors, cognition and perceptions. However, the studies on how to resolve cooperation & cognition gaps among residential areas have been scarce and the issue remains unsolved. Given this gap in the literature, this study analyzes cooperation & cognition gaps by taking salinity problems along with climate change in Bangladesh, seeking to provide a feasible method to reduce such gaps. Therefore, we design and institute a field experiment to examine the effect of information provision on people's cooperation for reducing salinity problems in urban and rural areas. The following research question is posed; "Does information provision about salinity through the lecture reduce cooperation gap for salinity problems by increasing people's cognition in urban and rural areas?" Specifically, we conduct a survey experiment and collect data on donations to salinity problems, prosociality, cognitive and sociodemographic factors from a total of 900 subjects in one urban area and two rural areas at Bangladesh. The novel aspects of this study are (i) to consider cognitive & noncognitive factors for analyzing people's cooperation by conducting field experiments, (ii) to employ a

climate donation game for measuring people's cooperation where they are asked to actually donate from their endowment for salinity risk reduction with or without the information provision and (iii) to empirically identify how people's cooperation differs across areas and changes in response to the information provision for reducing salinity problems.

2 Methods

2.1 Survey areas and data

We conducted questionnaire surveys & field experiments in the districts of Dhaka, Jashore and Satkhira in south-central and south-western Bangladesh (see figure 1). We consider Dhaka as an urban area, while other two areas, Jashore and Satkhira are considered rural areas in this study. Dhaka is the capital of Bangladesh, which is one of the most populated cities in the world (Shahen et al., 2019). The rural areas, Jashore and Satkhira, are regarded as coastal areas of Bangladesh where land, ocean and atmosphere interact with each other. The villages in these areas are considered some of the least developed on the whole country and are highly vulnerable to cyclones, sea level rise, land erosion, storm surge and flooding hazards which have caused terrible impacts on people's living in these low lying coastal areas (Ahmad, 2019). In Jashore, the survey was conducted in three upazilas (sub-districts) called Jashore sadar, Manirampur and Jhikargachha. In Satkhira, one upazila namely Shyamnagar was selected for the survey (see figure 1).

[Figure 1 about here.]

Field surveys & experiments were conducted in both urban and rural areas and a total of 900 subjects from these areas was selected by using following random sampling procedures. We applied two different approaches for random sampling between urban and rural areas, because these areas have different geographic and sociodemographic characteristics. In urban area, we conducted a randomization based on the proportion of each occupation to accurately represent the population. At first, we calculated the percent of each occupation in the total population based on some previ-

ous surveys conducted by the government agencies (Bangladesh Bureau of Statistics, 2013, 2018). Then we randomly selected the organizations according to occupational categories and the next step, we arbitrarily selected subjects from each of the organizations. We considered the subjects from low-income to high-income occupation categories.

In rural areas, we obtained the list of all households in the selected areas with the help and support of local non-governmental organizations (NGOs). We randomly identified 600 households by using the list and random number generator, among them 300 households from Jashore and 300 households from the Satkhira districts were selected. Randomization process was also followed in selecting baseline and treatment group of information provision. In this process, households were randomly divided into baseline group and treatment group within each urban and rural area. We invited the household head (husband or wife in a household) from each of the households to participate in our surveys & experiments. All subjects willingly participated in these surveys & experiments, providing written consent signed at the beginning. With the help of local people, the trained research staffs contacted each subject and conducted surveys & experiments with a pre-defined questionnaire. The first author was the chief administrator of these surveys & experiments. Before administering the surveys & experiments, discussions were made with the local people and field observations were conducted.

2.2 Experimental setup

We implemented questionnaire surveys, climate donation (CD) game and social value orientation (SVO) game in each of urban and rural areas to collect necessary information about donations, prosociality, cognitive and sociodemographic factors.

Subjects' sociodemographic information is collected, such as their age, gender, education, household occupation and household income. Subjects are asked to provide their perception of the cause of climate change: human-induced, nature-induced climate change or others. During the survey, we introduce and explain human-induced and nature-induced climate change by using two statements with colorful pictures/diagrams to know the subject's perception of the cause of climate

change. The first statement presents that human activities are responsible for climate change and another statement shows that climate change is nature-induced & it may occur even in the absence of human activities (see the appendix material for the perception of the cause of climate change). After subjects understand the human-induced and nature-induced climate change, they are asked to choose their answer among the four options: (1) "I agree with statement 1," (2) "I agree with statement 2," (3) "Both statements are persuasive and I cannot choose," (4) "I do not understand the statements and cannot choose." We divide the answers into two categories: one category is comprised of the subjects who answer that climate change is human-induced and the other category is made up of the subjects who answer that climate change is nature-induced, cannot say and have no idea.

A climate donation (CD) game is instituted for measuring the degree of cooperation among people for reducing salinity problems. We design a new variant of a dictator game with two persons where one person is considered a dictator and another one is a receiver. In this game, a dictator decides how to divide a certain amount of money between herself and the receiver (see, e.g., Bolton et al., 1998, Engel, 2011). For example, Hirose et al. (2020) apply a similar type of game to approximate people's cooperation in climate change. However, the CD game is different from the typical dictator game in the following points: (i) Each subject is a dictator and she knows who is a receiver (i) A well-known organization is a receiver that works on different adaptation & mitigation strategies of climate change.[1]

In the CD game, each subject is given 150 BDT as an initial endowment and asked to divide it into two parts "for yourself" and "for the organization to reduce salinity problems."[2] The following procedures are employed. First, three envelopes "original money," "for yourself" and "for reducing salinity problems" are prepared, and each subject is given the "original money" envelope that contains 150 BDT. Second, she is asked to split the 150 BDT into two envelopes, "for yourself" or "for reducing salinity problems" as she wishes. Third, she is again asked to subdivide the

[1] Our donations along with the intentions are made to the organization "Adaptation Fund" that finances projects and programs by aiming at supporting developing countries to fight against salinity and climate change problems.

[2] The BDT is the Bangladeshi currency in taka (1 USD ≈ 85 BDT).

money in the "for reducing salinity problems" envelope into two parts "for adaptation" and "for mitigation" by writing and putting the memo into the envelope. Everything is recorded by an individual ID in the way that how each subject splits is considered privacy. At the end, each subject is allowed to take the "take it yourself" envelope to her home, while the "for reducing salinity problems" envelopes are collected. We consider that how much one person is cooperative for salinity problems is well proxied by the donation in the CD game.

In each of urban and rural areas, an experiment with the CD game is applied with and without information provision to examine the effect of information provision on cooperation for reducing salinity problems. With this experimental design, we seek to test the following hypothesis that information provision about salinity through the lecture is effective at reducing cooperation gaps among people by influencing their cognition in rural and urban areas. In this experiment, there are the baseline group and treatment group that are randomly assigned for a session in each of urban and rural areas. A subject in the treatment group receives a two-page summary & half an hour lecture about salinity, while a subject in the baseline group does not receive any summary and lecture regarding salinity. Salinity information is organized by referring to some books, reports and articles (Mcleod et al., 2010, Habiba et al., 2013, Hasan et al., 2013, Mahmuduzzaman et al., 2014, Khanom, 2016, Alam et al., 2017). The summary sheet of salinity intrusion contains the definition, causes, impacts and measures (adaptation & mitigation strategies) of salinity (see the appendix material of summary lecture about salinity problems). All information is presented by the first author mainly to the treatment group. By comparing the baseline group with the treatment group, we expect an increase in donations for salinity problems due to the effect of information provision in urban and rural areas.

A concept of social value orientation (SVO) is applied to identify subjects' social preferences developed by Van Lange et al. (1997, 2007). This game comprises 9 choice tasks, each task has three choice options for herself and the other. Each subject is asked to choose one option as the most preferred one among the three options, finally generating 9 choices of options in each orientation. In each task, three options are option (A): you get 500, and the other gets 100, option

(B): you get 500 and the other gets 500, and option (C): you get 560 and the other gets 330. A choice of option (A) represents the competitive orientation, because the person who chooses option (A) maximizes the gap between the self point and the other's one ($500 - 100 = 400$). The person who chooses option (B) is the prosocial, because she maximizes the joint benefit ($500 + 500 = 1000$). Finally, a choice of option (C) represents the individualistic person who maximizes her own benefits without considering the other person (see, e.g., Van Lange et al., 2007, Shahen et al., 2019). In the SVO game, four types of persons such as individualistic, prosocial, competitive and unidentified are classified based on 6 consistent choice of options or more in one orientation. If the subject does not make 6 consistent choices or more, then she is categorized as an unidentified person. In this study, we make two groups from these four types of persons, group one is comprised of only the prosocial person and another group is comprised of the other three types of SVO persons.

2.3 Experimental procedures

We hired local supporting staffs and trained research assistants for conducting questionnaire surveys & experiments. In rural areas, the experiments were implemented at district primary or secondary schools. In urban area, experiments were mainly conducted at universities and colleges. Local supporting staffs and trained research assistants contacted and requested people to participate in our surveys & experiments following the random sampling procedures specified in each type of rural and urban areas. We conducted questionnaire surveys & experiments on a daily basis in rural areas whenever we successfully collected a sufficient number of subjects. On the other hand, in urban area, surveys & experiments were conducted on a weekly basis, because urban people are busy, and it takes time to arrange subjects in a fixed day and place. Our surveys & experiments are conducted with real monetary payment for motivating subjects to provide their actual information and seriously participate in each game.

After arriving at the locations, subjects gathered in one room and were instructed not to communicate with each other during the experiments. First, they are asked to provide their sociodemo-

graphic information in questionnaires. Next, they are asked to read the statements which describe "human-induced" and "nature-induced" climate change, providing their answer after confirming their understanding about these explanations. Then, subjects were given experimental instructions of the CD game in their native language (Bengali). We confirm that subjects fully understand the experimental rules. After finishing the CD game, subjects participate in the SVO game. We provide the experimental instructions of SVO game to the subjects and again confirm subjects' understanding. At the end of the SVO game, we randomly matched two subjects as a pair and calculate their final payoff from the SVO. Research assistants helped to distribute the questionnaires & other documents to the subjects and to calculate the associated payoffs. On average total payment 300 BDT was paid to each of the subject, where 50 BDT for the fixed participation fee, on an average 130 BDT for the CD game and 120 BDT for the SVO game, respectively. One session in our experiment included a questionnaire survey, CD and SVO games, taking 50 to 60 minutes in the control group (80 to 90 minutes in the treatment group) where 15 to 30 subjects were participated. After finishing the surveys & experiments, we sent the total amount of donated money to the organization called "Adaptation Fund."

[Table 1 about here.]

2.4 Statistical analysis

The donation through the CD game is a good proxy to estimate how much people care about or are cooperative for reducing salinity problems. This paper uses three types of donations such as (1) total donation (sum of adaptation & mitigation donations) (TD); (2) adaptation donation (AD) and (3) mitigation donation (MD) as the dependent variables that measure the degree of cooperation for reducing salinity problems. The questionnaire surveys & experiments are used to collect necessary information which is divided into three factors (i) Cognitive & noncognitive factors: information provision about salinity through the lecture, perception of the cause of climate change and social value orientation (SVO) (ii) Residential factor: area (urban and rural) (iii) sociodemographic factors: age, gender, education, household occupation and household income. These three factors are

used as independent variables in this study (table 1 provides the definitions of all variables).

The mean, median, standard deviation, minimum and maximum values of the key variables are calculated and interpreted. Then, we implement some statistical analyses such as chi-square and Mann-Whitney tests to identify some qualitative differences of the key variables by urban and rural areas. To quantitatively characterize the relationship between the donations and independent variables, we apply tobit regression due to the fact that the data include a certain number of 0 donations. In the tobit regression, the donation for reducing salinity problems by subject i is denoted by y_i and it is defined to be equal to the latent variable y_i^* when $y_i^* > 0$. Otherwise, $y_i = 0$ when $y_i^* \leq 0$. The tobit regression model is expressed as

$$y_i^* = \beta_0 + \beta_1 I_i + \beta_2 P_i + \beta_3 S_i + \beta_4 A_i + \beta_5 I_i \times A_i + \beta_6 \mathbf{Z}_i + \varepsilon_i \tag{1}$$

where y_i^* is a latent variable of the donation satisfying the relation $y_i = \max\{0, y_i^*\}$; I_i, P_i, S_i and A_i are dummy variables associated with information provision, perception of the cause of climate change, social value orientation and areas, respectively. Finally, $\mathbf{Z}_i$ is a vector of sociodemographic factors such as age, gender, education, occupation of the household head and household income (see table 1 for the definition of the variables) and ε_i is a normally distributed error term. The β_js for $j = 0, 1, 2, 3, 4, 5$ are the parameters associated with the intercept, I_i, P_i, S_i, A_i and an interaction term of $I_i \times A_i$, while β_6 is a vector of the parameters associated with $\mathbf{Z}_i$, respectively. These parameters are estimated via the maximum likelihood methods to characterize y_i with a specification of equation (1) in the tobit regression framework, enabling to calculate the marginal effect of an independent variable on the donations (Wooldridge, 2010, 2019). A series of these tobit regression models are estimated by taking the total donation (TD), adaptation donation (AD) and mitigation donation (MD) as dependent variables for robustness check.

The conceptual framework in figure 2 visualizes the relationships among cognitive, noncognitive factors and people's cooperation for reducing salinity problems along with some sociodemographic factors in urban and rural areas (see figure 2). With the framework in mind, our focus is on estimating the coefficients β_1 and β_5 associated with information dummy and its interaction

with area dummy, controlling for other key variables as described in figure 2.[3] Recall our research question in this research: "Does information provision about salinity through the lecture reduce cooperation gaps among people in rural and urban areas?" In this regard, the estimated coefficients of β_1 and β_5 in equation (1) are key parameters enabling us to answer the research question. Specifically, the hypotheses of our research question are posed as $H_0 : \beta_1 = 0$ & $H_0' : \beta_5 = 0$ and the alternatives are $H_1 : \beta_1 > 0$ & $H_1' : \beta_5 \neq 0$. It is expected that subjects' cognition is influenced by the lecture about salinity problems so that subjects become more cooperative for salinity problems, however, the change in cooperation may differ across urban and rural areas in response to the information provision.

[Figure 2 about here.]

3 Results

Table 2 presents the summary statistics of the dependent variables with and without information provision for each of urban and rural areas with the total sample. Without receiving information regarding salinity, urban subjects donate on an average 8.95 BDT, 5.18 BDT and 3.77 BDT, while these averages are 20.29 BDT, 10.99 BDT and 9.30 BDT with receiving information for each of total, adaptation and mitigation strategies of salinity, respectively. On the other hand, without receiving information, rural subjects donate on an average 19.79 BDT, 10.46 BDT and 9.39 BDT, while these averages are 22.27 BDT, 11.71 BDT and 10.56 BDT with receiving information for each of total, adaptation and mitigation strategies of salinity, respectively. Regardless of information provision, rural subjects donate more than urban subjects for each of total, adaptation and mitigation strategies of salinity. Table 2 demonstrates that information provision about salinity through the lecture increases donation for each of total, adaptation and mitigation strategies in both urban and rural areas. However, the donation gaps between with and without receiving information for each

[3] In this framework, the coefficients β_1 and β_5 are considered to represent the effects of information provision as well as its interaction with areas on people's cooperation for reducing salinity problems, respectively, after the effects of all other key variables have been netted out (Wooldridge, 2010, 2019).

of total, adaptation and mitigation strategies of salinity are higher in the urban area than rural areas, potentially suggesting that urban subjects react more in response to the information provision about salinity than rural subjects.

[Table 2 about here.]

Table 3 summarizes the basic statistics of the major independent variables for the urban, rural and overall subjects in the sample. Regarding the subject's perception of the cause of climate change, $77\,\%$ of urban subjects and $72\,\%$ of rural subjects perceive that climate change is caused by human-induced factors. The major difference between the urban and rural areas is observed in the SVO dummy variable. It indicates that $13\,\%$ of urban subjects are prosocial, while $44\,\%$ of rural subjects are prosocials. Specifically, 40 out of 300 urban subjects are prosocial, while 265 out of 600 rural subjects are prosocial. This implies that prosociality among people is significantly higher in the rural areas than the urban area. In fact, a similar result is confirmed by several other studies, such as Shahrier et al. (2016, 2017), Timilsina et al. (2019), demonstrating that prosocial people are more dominant in rural areas than in urban areas.

The mean age of the subjects does not vary between urban and rural areas, and the overall average age is 40 years old (see table 3). With respect to gender, $25\,\%$ of urban subjects are female, while $56\,\%$ of rural subjects are female. Regarding education, urban subjects possess 12 years of schooling as a median, while rural subjects usually receive 8 years of schooling as a median. According to occupation, all of urban subjects are engaged in non-agricultural activities such as business, government & private job, or working as a day laborer. On the other hand, $40\,\%$ of rural subjects are engaged in agricultural activities such as rice cultivation, shrimp and crab culture. The average monthly household income of urban subjects is almost three times ($37\,460.28$ BDT) higher than rural subjects ($13\,674.21$ BDT). The standard deviation (SD) of urban households' monthly income is almost seven times as much as the SD of rural households' monthly income. This indicates that urban subjects' earnings are significantly higher than rural ones, whereas rural subjects experience less income disparity and standard of living than urban ones. Overall, the summary statistics of cognitive & noncognitive and sociodemographic factors indicate that urban

subjects have higher income, education and knowledge about climate change but they are less prosocial than rural subjects.

[Table 3 about here.]

We apply a Mann-Whitney test to check the distributional differences for each of total, adaptation and mitigation donations of salinity between urban and rural areas. A null hypothesis is that the distributions of the donations between urban and rural areas are the same. The results reject the null hypotheses, showing that there are distributional differences of TD ($Z = -7.02, p < 0.01$), AD ($Z = -5.17, p < 0.01$) and MD ($Z = -8.24, p < 0.01$) between urban and rural areas. This can also be interpreted that cooperation for salinity problems differs between urban and rural subjects, being consistent with table 2. We also run a Mann-Whitney test to examine the relationship between income and areas with the null hypothesis that the income distributions between urban and rural areas are the same. The result confirms that there is a difference in the income distributions between urban and rural areas ($Z = 16.53, p < 0.01$). Finally, the chi-square tests are applied to qualitatively examine whether the frequencies of the key explanatory variables are independent of areas. The following pairs of the variables are considered: (1) information provision *vs* areas, (2) perception of the cause of climate change *vs* areas, (3) SVO *vs* areas, (4) gender *vs* areas, (5) education *vs* areas and (6) occupation *vs* areas. We find that cases (1), (3), (4), (5) and (6) reject the null hypotheses at $1\,\%$ significance level. Case (2) also rejects the null hypothesis at $10\,\%$ significance level. Overall, it appears that the key variables are qualitatively correlated with areas, and thus are controlled as independent variables in the regression analyses that follow.

Tobit models 1, 2 and 3 in table 4 present the regression results for total, adaptation and mitigation donations, respectively. Models 1-1, 2-1 & 3-1 report the estimated coefficients for independent variables in the tobit regression. Models 1-2, 2-2 & 3-2 present the estimated marginal probability of each independent variable based on the estimated coefficients in each model, indicating a change in the likelihood for a subject to donate a strictly positive amount of money when the independent variable increases by one unit, holding other factors fixed. Models 1-3, 2-3 & 3-3 present the estimated marginal effect of each independent variable, indicating a change in

the donation when the independent variable increases by one unit, holding other factors fixed. In model 1-1, it is identified that information provision, perception of climate change, SVO and area dummies have positive effects at $1\,\%$ significance levels, while an the interaction term between information provision and area dummies as well as occupation of the household head have negative effects on total donation at $1\,\%$ and $5\,\%$ significance levels, respectively.

In model 2-1, information provision, perception of climate change, SVO and area dummies exhibit positive effects at $1\,\%$, $10\,\%$, $1\,\%$ and $1\,\%$ significance levels, while an the interaction term between information provision and area dummies and the gender dummy show negative effects on adaptation donation at $1\,\%$ and $10\,\%$ significance level, respectively. In model 3-1, we also find that information provision, perception of climate change, SVO, area dummies as well as household income have positive effects at $1\,\%$, $10\,\%$, $1\,\%$, $1\,\%$ and $5\,\%$ significance levels, while an the interaction term between information provision and area dummies as well as occupation of the household head have negative effects on mitigation donation at the $1\,\%$ and $10\,\%$ significance level, respectively.

Some consistent tendencies are observed in models 1-1, 2-1 and 3-1 regarding information provision, perception of climate change, prosociality and area dummy.[4] On the basis of such estimated coefficients in models 1-1, 2-1 and 3-1, we next report the associated marginal probability in models 1-2, 2-2 and 3-2 as well as the associated marginal effect in models 1-3, 2-3 and 3-3 together. In what follows, we mainly focus on reporting the marginal probabilities and effects of information provision, perception of climate change, prosociality, area dummy and the interaction term between information provision and area dummy, because they are identified to remain significant in all models.

[4]The estimations also reveal some other significant independent variables. Regarding gender dummy, female is interpreted to be significant with negative sign in the donation for adaptation, but not significant for total and mitigation (see table 4). This may be due to the fact that Bangladeshi females usually play a main role in managing household issues. When they get extra money from some sources as they did in our experiment, they are more likely to think about their household needs as the first priority than males. Regarding occupation dummy, agricultural households are found to be significant with negative sign in the donations for total and mitigation. We conjecture that agricultural households in Bangladesh have already taken various measures against salinity in their daily life, discouraging themselves to donate. Finally, household income is identified to be statistically significant at positive sign for mitigation in table 4. However, the practical magnitudes are judged to be small.

Subjects who receive the treatment of information provision about salinity through the lecture (in the treatment group) are more likely to donate by $7\,\%$, $9\,\%$ & $7\,\%$ and donate 4.39 BDT, 2.67 BDT & 1.90 BDT more for total, adaptation and mitigation than subjects who do not (in the baseline group), respectively (see the results associated with "information provision" row in MP and ME of table 4). The results demonstrate that the treatment of information provision is quite effective at increasing the donations for salinity problems, being in line with some literature. Botzen et al. (2009), Acquah and Onumah (2011) and Yang et al. (2014) report that information disclosure can increase people's willingness to pay for climate change, especially when there exists the lack of knowledge. Borghans et al. (2008) and Chen et al. (2020) argue that processing new information is part of cognitive factors in human-decision processes. In this sense, we interpret that subjects' cognition or understanding is influenced by receiving the information, inducing subjects to be more cooperative for salinity problems through the channel of cognitive factors as described in figure 2.

Subjects with the perception of human-induced climate change are more likely to donate by $7\,\%$, $5\,\%$ & $6\,\%$ and donate 3.76 BDT, 1.56 BDT & 1.63 BDT more for total, adaptation and mitigation than subjects with other perceptions, respectively (see the results associated with "perception of climate change" row in MP and ME of table 4). This result is considered another confirmation of how cognitive factors are important for cooperative behaviors toward salinity problems. Kragt et al. (2016) find a similar result that people who do not believe that climate change is caused by human actions have a lower willingness to pay for greenhouse gas emissions than those who believe. Regarding the SVO dummy, prosocial subjects are more likely donate by $9\,\%$, $9\,\%$ & $8\,\%$ and donate 5.56 BDT, 2.83 BDT & 2.27 BDT more for total, adaptation and mitigation than those with other SVOs, respectively (see the results associated with "prosocial" row in MP and ME of table 4). The result demonstrates that the noncognitive factor such as prosociality is also an important factor to determine people's cooperation for reducing salinity problems as argued in Borghans et al. (2008) and Chen et al. (2020). It is also considered consistent with some previous studies that establish positive association between prosociality and cooperation to other issues (see, e.g., Van Lange et al., 2007, Shahrier et al., 2017).

Rural subjects are more likely donate by $14\,\%$, $13\,\%$ & $26\,\%$ and donate 7.68 BDT, 3.95 BDT & 6.66 BDT more for total, adaptation and mitigation than urban subjects, respectively (see the results associated with "area" row in MP and ME of table 4). This result suggests that rural subjects generally donate more than urban subjects towards salinity problems, reflecting that rural subjects have experiences or observe the consequences of salinity problems. Therefore, they possess a high motivation to improve these problems. Botzen et al. (2009) find that the probability of rural inhabitants to undertake flood mitigation action is almost one third larger than urban inhabitants. Huddart-Kennedy et al. (2009) also argue that urban and rural subjects have different types of concerns about environmental problems to influence their proenvironmental behaviors. Therefore, we believe that experiences and observations by rural subjects in salinity problems induce themselves to become more cooperative than urban subjects.

The coefficients of the interactions term between information provision and area dummy are estimated to be consistently significant with negative sign for total, adaptation and mitigation (see table 4). The results imply that rural subjects are less likely to increase the donations in response to the treatment of information provision than urban subjects. In other words, urban subjects are more likely to increase the donations when the information is provided through the lecture. To quantitatively characterize the impact of information provision between urban and rural areas, the marginal probabilities and marginal effects of the interaction terms between information provision and area dummy for total, adaptation and mitigation are reported (see the "information $\times$ urban (rural)" row in MP and ME of table 4).[5]

The MP and ME results of the interaction terms demonstrate that urban subjects who receive the treatment of information provision about salinity through the lecture are more likely to donate by $21\,\%$, $18\,\%$ & $17\,\%$ and donate 9.08 BDT, 4.60 BDT & 3.41 BDT more for total, adaptation and mitigation than urban subjects who do not, respectively, at $1\,\%$ significance levels. Regarding rural

[5]The marginal probability (MP) of the interaction term, "information $\times$ urban (rural)," can be interpreted as a change in the likelihood for a urban (or rural) subject to donate in the treatment group of information provision as compared with the baseline group of no information provision. Likewise, the marginal effect (ME) of the interaction term, "information $\times$ urban (rural)," can be interpreted as a change in the donations by a urban (or rural) subject in the treatment group of information provision as compared with the baseline group of no information provision.

subjects, such significant results are not exhibited in any model. These results suggest that urban (rural) subjects highly (do not) react to the treatment in the way that urban subjects become more cooperative or increase the donations to salinity problems in response to the lecture, while rural subjects do not change. In fact, the MP and ME results in table 4 are confirmed to be quite consistent with the observed tendency in the donations by rural and urban subjects between treatment and baseline groups in table 2.

Now, we are ready to provide the answers to our research question "Does information provision about salinity through the lecture reduce cooperation gaps among people in rural and urban areas?" The research question is expressed as the following hypotheses; the null hypotheses are $H_0 : \beta_1 = 0$ & $H_0' : \beta_5 = 0$, while the alternatives are $H_1 : \beta_1 > 0$ & $H_1' : \beta_5 \neq 0$ in the regression of equation (1). Overall, the regression results consistently reject the null hypotheses, supporting the alternatives with $\hat{\beta}_1 > 0$ and $\hat{\beta}_5 < 0$ with $1\,\%$ statistical significances. The estimation results can be interpreted that urban people donate less than rural people on average, while the treatment of information provision is generally effective irrespective of areas. However, urban people are identified to increase their donations by receiving the information provision much more than rural people. It means that our answer to the research question is "yes," i.e., cooperation gaps between urban and rural areas are reduced by the treatment of information provision.

[Table 4 about here.]

Berenguer et al. (2005), Huddart-Kennedy et al. (2009), Shahrier et al. (2016, 2017) and Rajapaksa et al. (2018) report some clear differences between urban and rural people in many aspects, such as cognition, experiences, motivations and attitudes that influence their daily cooperative behaviors to various social issues. In general, rural people are established to take more cooperative behaviors to environmental and public goods provision problems than urban people, even after controlling for prosocial value orientations (Shahrier and Kotani, 2016, Shahrier et al., 2016, Timilsina et al., 2017, 2019). They argue that the differences in daily life experience and practice between urban and rural people shape their culture to characterize such cooperative behaviors. It is also reported that rural people have experienced and observed salinity problems as impacts of their life,

livelihoods, health and wellbeing (Vineis et al., 2011, Talukder et al., 2016, Paul and Jabed, 2018, Asma and Kotani, 2019). Based on these findings in literature, we argue that rural subjects are highly motivated to donate due to their experiences, practices and observations regarding salinity problems as compared with urban subjects.

A key question is now "why do urban subjects increase their donations in response to the treatment of information provision as compared with rural subjects?" As described in our conceptual framework of figure 2, it is well known that human behaviors are mainly characterized by the three factors, economic factors, noncognitive factors and cognitive factors (Borghans et al., 2008, Chen et al., 2020). In particular, they claim that noncognitive factors are something impossible to change in the short run by some interventions such as education or policies. In our experiment, social value orientation of prosociality is considered a noncognitive factor, while the perception of climate change and some sociodemographic variables are cognitive and economic factors, respectively. With these ideas in mind, the treatment of information provision is interpreted to affect cognitive factors in human-decision processes for salinity problems (figure 2).

Urban people in Bangladesh are usually considered to have few experience & observations about salinity problems. That is, they are generally unfamiliar with salinity problems. However, they have more chances and better amenities to acquire cognitive abilities than rural people. For instance, it is well known that education of schooling and availability of various opportunities in living environment are positively correlated with people's cognitive abilities (see, e.g., Rindermann, 2008, Ritchie and Tucker-Drob, 2018, Rogers et al., 2019). If this is the case, it is our conjecture that urban people have better cognitive abilities than rural people. Because understanding and processing new information is part of cognitive abilities, urban subjects in our experiment are considered to properly understand and react to the information provision, increasing their donation when they are unfamiliar with salinity problems. On the other hand, we conjecture that rural people do not react to the information provision, because they are familiar with salinity problems which are all described in the lecture.

In the globalization process, urban areas will expand and grow, and near about 65-$75\,\%$ of the

world population are predicted to concentrate on urban areas in Asia and Africa over the next 50 years (American Association for the Advancement of Science, 2016, Shahen et al., 2019). Therefore, urban areas will play a more important role in addressing environmental and climate change problems through urban planning and policies than ever (Fujii et al., 2017). Environmental policies are promoted by political leaders to protect natural environment and climate (Rosenzweig et al., 2010). To cope with such issues, it shall be very important to increase urban people's environmental cognition by providing programs and educations, especially when urban people do not have enough experience and observations about environmental and climate change problems in their daily life. Our results suggest that the priority of such programs and education to increase environmental cognition should be given to urban people whose life is more likely to be detached from natural environment and climate. Systematically organizing such programs and education at national and global levels shall help reduce cognition and cooperation gaps between urban and rural areas, contributing to sustainable development goals (SDGs).

4 Conclusion

This paper has examined the effect of information provision on people's cognition and cooperation for reducing salinity problems in urban and rural areas. We hypothesize that information provision about salinity through the lecture is effective at reducing cooperation gaps among people by influencing their cognition in rural and urban areas. To this end, we have implemented the climate donation game, social value orientation game and questionnaire surveys for collecting data on donations to salinity problems, cognitive & noncognitive and sociodemographic factors of 900 subjects from one urban area and two rural areas in Bangladesh. The results show that people who have prosocial orientation and perception of human-induced climate change donate more than those who do not, and urban people tend to donate less than rural people. However, it is identified that urban people increase their donations by receiving information provision much more than rural people. We argue that urban people become cooperative in response to the lecture,

because they are unfamiliar with salinity problems, but have cognitive abilities to understand the new information in the lecture.

We note some limitations to our research and possible directions of future research. This research focuses on salinity to examine cognition and cooperation gaps, because it is one of the most important problems in Bangladesh for achieving SDGs. To generalize the findings in our research regarding the effectiveness of information provision, future research should apply to other types of environmental and poverty problems where there exists gaps between urban and rural areas. This study neither addresses the long-run effect of information provision on people's cooperative behaviors nor directly quantifies cognitive abilities due to several constraints such as time, subjects and budgets. Future research can be implemented to track the long-run effect of information provision by tracking a temporal change in people's behaviors over time as well as to collect some cognitive factors for further characterization. However, it is known that directly measuring cognitive abilities is a difficult tasks. Therefore, some caution shall be necessary to conduct such research. These caveats notwithstanding, it is our belief that this research becomes an important first step in understanding cooperation and cognition between urban and rural areas, contributing to SDGs.

5 Appendix

We provide (i) an instruction summary used for collecting the data associated with the perception of climate change and (ii) a brief summary of the lecture about salinity problems to Bangladeshi people in the field as materials of the appendices.

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Figure 1: Study area

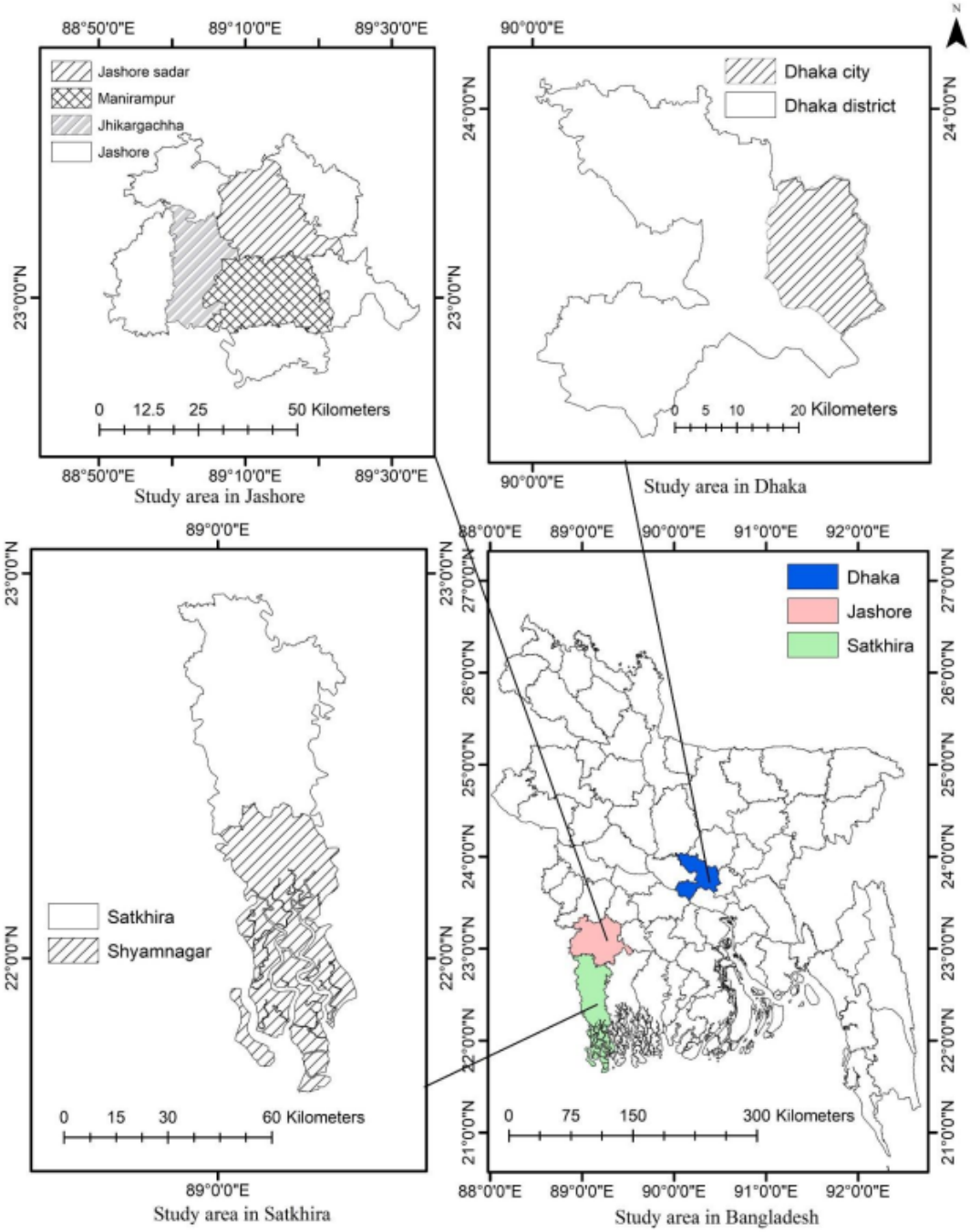
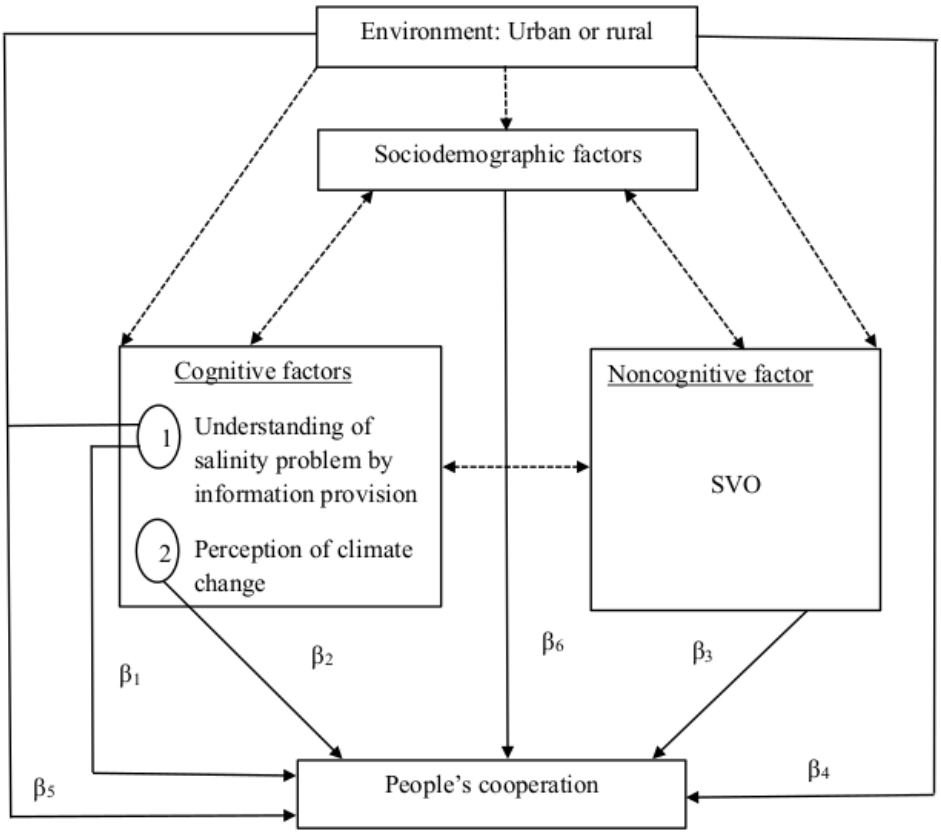


Figure 2: A conceptual framework describing the relationships among cognitive, noncognitive, sociodemographic factors and people's cooperation



Legend

→ : One-way relationship

↔ : Two-way relationship

Plain arrow: Estimated relationships

Dashed arrow: Not estimated relationships

β_1, β_2, β_3, β_4, β_6: Single coefficients

β_5: Interaction coefficient

List of Tables

Table 1: Definitions of variables

Variables	Description
Dependent variables (BDT)[1]	
Total donation	Donation for reducing salinity problem (sum of adaptation and mitigation donations in BDT).
Adaptation donation	Donation for salinity adaptation strategies in BDT.
Mitigation donation	Donation for salinity mitigation strategies in BDT.
Independent variables	
Cognitive & noncognitive factors	
Information provision	Takes the value 1 when the subject receives information about salinity through the lecture, otherwise 0.
Perception of the cause of climate change	Takes the value 1 when the subject chooses human-induced climate change, otherwise (Nature-induced, can not say and no idea) 0
Prosocial	Takes the value 1 when the subject is prosocial, otherwise (individualistic, competitive and unidentified) 0.
Residential factor	
Area	Urban 0 and Rural 1.
Sociodemographic factors	
Age	Years.
Gender	Male 0 and Female 1.
Education	Years of schooling 0 to 14 (0 = No schooling & refused group[2], 1 = Class one, 2 = Class two, 3 = Class three, 4 = Class four, 5 = Class five, 6 = Class six, 7 = Class seven, 8 = Class eight, 9 = Class nine, 10 = SSC/equivalent, 11 = Eleven class/equivalent, 12 = HSC/equivalent, 13 = Graduate/equivalent, 14 = Post graduate/equivalent).
Occupation of the household head	Non-agriculture 0 and Agriculture 1.
Household income	Monthly income in BDT.

[1] BDT stands for Bangladeshi currency in taka.

[2] The subjects who do not provide their educational qualification is refused group. We merge refused group with no schooling because most of the uneducated subjects refused to provide their educational level.

Table 2: Summary statistics of the dependent variables

	Area				Overall
	Urban		Rural		
	Without information provision	With information provision	Without information provision	With information provision	
Total donation					
Average (Median) [1]	8.95 (10.00)	20.29 (10.00)	19.79(10.00)	22.27 (10.00)	18.89 (10.00)
SD [2]	10.23	22.73	24.08	23.97	22.54
Min	0.00	0.00	0.00	0.00	0.00
Max	50.00	150.00	150.00	150.00	150.00
Adaptation donation					
Average (Median)	5.18 (0.00)	10.99 (5.00)	10.46 (5.00)	11.71 (10.00)	10.08 (5.00)
SD	7.63	14.31	17.18	14.45	14.71
Min	0.00	0.00	0.00	0.00	0.00
Max	50.00	50.00	150.00	100.00	150.00
Mitigation donation					
Average (Median)	3.77 (0.00)	9.30 (0.00)	9.39 (5.00)	10.56 (5.00)	8.82 (5.00)
SD	7.13	18.21	11.56	16.43	14.25
Min	0.00	0.00	0.00	0.00	0.00
Max	50.00	150.00	100	140	150.00
Sample size	150	150	300	300	900

[1] Median in parentheses.
[2] SD stands for standard deviation.

Table 3: Summary statistics of the independent variables

	Area		Overall
	Urban	Rural	
Perception of the cause of climate change			
Average (Median) [1]	0.77 (1.00)	0.72 (1.00)	0.73 (1.00)
SD [2]	0.42	0.45	0.44
Min	0.00	0.00	0.00
Max	1.00	1.00	1.00
Prosocial			
Average (Median)	0.13 (0.00)	0.44 (0.00)	0.34 (0.00)
SD	0.34	0.50	0.47
Min	0.00	0.00	0.00
Max	1.00	1.00	1.00
Age			
Average (Median)	41.56 (40.00)	40.19 (40.00)	40.64 (40.00)
SD	12.36	11.61	11.87
Min	19.00	16.00	16.00
Max	78.00	80.00	80.00
Gender			
Average (Median)	0.25 (0.00)	0.56 (1.00)	0.46 (0.00)
SD	0.43	0.50	0.50
Min	0.00	0.00	0.00
Max	1.00	1.00	1.00
Education			
Average (Median)	10.37 (12.00)	6.49 (8.00)	7.78 (9.00)
SD	4.28	4.18	4.60
Min	0.00	0.00	0.00
Max	14.00	14.00	14.00
Occupation of the household head			
Average (Median)	0.00 (0.00)	0.40 (0.00)	0.27 (0.00)
SD	0.00	0.49	0.44
Min	0.00	0.00	0.00
Max	0.00	1.00	1.00
Household income			
Average (Median)	37460.28 (30000)	13674.21 (11966.67)	21602.90 (14741.67)
SD	49638.01	7837.26	31405.05
Min	3333.33	1333.33	1333.33
Max	800000	76166.67	80000
Sample size	300	600	900

[1] Median in parentheses.
[2] SD stands for standard deviation.

Table 4: Regression coefficients and marginal effects of the independent variables in the tobit regressions

	Tobit regression 1 (TD)			Tobit regression 2 (AD)			Tobit regression 3 (MD)		
	Coefficient	MP[1]	ME[2]	Coefficient	MP	ME	Coefficient	MP	ME
	Model 1-1	Model 1-2	Model 1-3	Model 2-1	Model 2-2	Model 2-3	Model 3-1	Model 3-2	Model 3-3
Cognitive & noncognitive factors									
Information provision (r[3]= Did not receive information)	13.68***	0.07***	4.39***	8.42***	0.09***	2.67***	8.78***	0.07**	1.90**
Perception of climate change (r = Others)	5.01***	0.07***	3.76***	2.49*	0.05*	1.56*	2.98*	0.06*	1.63*
Prosocial (r = Others)	7.14***	0.09***	5.56***	4.33***	0.09***	2.83***	3.94***	0.08***	2.27**
Residential factor									
Area (r = Urban)	16.33***	0.14***	7.68***	9.60***	0.13***	3.95***	16.90***	0.26***	6.66***
Information provision × Area	−11.91***			−6.36**			−8.11***		
Information provision × urban		0.21***	9.08***		0.18***	4.60***		0.17***	3.41***
Information provision × rural		0.02	1.42		0.04	1.40		0.10	0.43
Sociodemographic factors									
Age	−0.01	−0.0002	−0.01	−0.01	−0.0003	−0.01	0.03	0.001	0.02
Gender (r = Male)	−1.87	−0.02	−1.43	−2.74*	−0.06*	−1.74*	1.11	0.02	0.62
Education	−0.20	−0.003	−0.15	−0.16	−0.003	−0.10	−0.18	−0.004	−0.10
Occupation of household head (r = Non-agriculture)	−4.57**	−0.06**	−3.43**	−2.05	−0.04	−1.29	−3.05*	−0.06∗	−1.67*
Household income[4]	1.04	0.01	0.80	−0.94	−0.02	−0.60	2.67**	0.05**	1.50**

***significant at the 1 percent level, **at the 5 percent level and *at the 10 percent level.

TD, AD and MD stand for total, adaptation and mitigation donations, respectively.

[1] MP stands for a marginal probability to indicate a change in likelihood for a subject to donate (above zero) when an independent variable increases by one unit, holding other factors fixed.

[2] ME stands for a marginal effect to indicate a change in the donation when one independent variable increases by one unit, holding other factors fixed.

[3] r stands for base group.

[4] The tobit regressions are computed with the natural logarithm of household monthly income.