Household economic and health behaviors under climate change and urbanization

by

Mst. Asma Khatun

Student ID Number: 1236003

A dissertation submitted to the
Engineering Course, Department of Engineering,
Graduate School of Engineering,
Kochi University of Technology,
Kochi, Japan

in partial fulfillment of the requirements for the degree of
Doctor of Philosophy

Assessment Committee:
Supervisor: Koji Kotani
Co-Supervisor: Yoshinori Nakagawa
Co-Supervisor: Yuki Yanai
Makoto Kakinaka, Hiroshima University
Kenta Tanaka, Musashi University

March 2022

HOUSEHOLD ECONOMIC AND HEALTH BEHAVIORS UNDER CLIMATE CHANGE AND URBANIZATION

ABSTRACT

Climate change along with urbanization has devastating effects on people's life. For example, an increase in surface and ground-water salinity due to climate change is reported to have become a great threat to the health of coastal inhabitants in Bangladesh. With ongoing climate change and urbanization, there is an urgent need to adopt adaptation and mitigation strategies for reduction of the associated risks. However, different strategies are unlikely to be effective without an understanding of people's economic and health behaviors at household level. Thus, it is important to analyze household economic and health related actions under climate change and urbanization to suggest some feasible ways to minimize the risks and achieve sustainable development goals (SDGs) within the expected time frame. To this purpose, the thesis applies field experiments and questionnaire surveys to empirically examine the effects of salinity resulting from climate change on human health, explore cooperation and cognition gaps for reducing salinity problems and identify the inequality of food intake among household members at household level between urban and rural areas for the betterment of health and sustainable societies.

The first study in this thesis examines the association between water-related diseases and coastal salinity along with sociodemographic and anthropometric factors. We conduct questionnaire surveys with 527 households: 273 subjects from the non-salinity and 254 subjects from the salinity rural coastal areas of Bangladesh. The logistic regression analysis demonstrates that the probability of suffering from water-borne, water-washed and water-related diseases are 8 %, 14 % and 11 % higher in the salinity areas than in the non-salinity areas, respectively. However, it is also identified that people who consume rainwater as a drinking source even in the salinity areas have less chances and people who belong

to “underweight body mass index” have more chances of being affected by water-related diseases. Overall, the results suggest that the long-term reservation of rainwater and addressing community-based food security & nutrition programs shall be effective countermeasures to reduce the risk of health problems in the coastal population and to sustain their lives even under the threat of land salinity.

In the second study, we examine the effect of information provision on people’s cooperation and cognition for reducing salinity problems in urban and rural areas. It is hypothesized that information provision about salinity through some lecture is effective at reducing cooperation and cognition gaps among people. We conduct a field 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 sustainable development goals through affecting people’s cognition.

In the third study, we examine dietary diversity scores of household members with a focus on their family roles (fathers, mothers, sons, daughters and grandparents) and age groups (children, adults and elderly). Whereas theory suggests that members in a household should have equal dietary diversity by receiving a certain share of available foods, this research hypothesizes that they do not do so by their roles and/or age groups. We conduct questionnaire surveys, collecting sociodemographic information and dietary data using a 24-hour recall method of 3248 subjects in 811 households from one urban and two rural areas in Bangladesh. The statistical analysis demonstrates three findings. First, poor and rural people have lower dietary diversity than non-poor and urban people, respectively. Second,

grandparents (children) have lower dietary diversity than do fathers (adults), confirming an existence of intrahousehold food intake inequality by the roles and/or age groups, irrespective of poverty level and areas of residence. Third, father and mother educations are crucial determinants to uniformly raise the standard of dietary diversity for their household, however, they do not resolve the inequality. Overall, it is suggested that awareness programs of dietary diversity shall be necessary with a target group of fathers and mothers for the betterment of intrahousehold inequality and health at household level, contributing to SDGs.

Key Words: Climate change; salinity; economic behavior; health behavior; household; urbanization.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction

Climate change has been acknowledged one of the major threats for the existence of humankind due to its devastating effects on people's life and the earth. Climate change components, such as temperature, rainfall, extreme events, CO_2 concentration and ocean dynamics, will be exacerbated in the future according to climate change projections (Bellard et al., 2012; Talukder et al., 2015, 2016). Simultaneously, it appears that ongoing urbanization creates environmental problems and causes overexploitation of natural resources (Shahrier et al., 2017). Thus, it is important to cope with adverse effects associated with rapid climate change and urbanization for the continuation of human life. Environmental and climate change problems require a diverse types of strategies, ranging from enforcing the law to changing the everyday behavior of local citizens (Kok and De Coninck, 2007; Skea and Nishioka, 2008; Aitken et al., 2011). Environmental protection and climate change strategies are unlikely to be effective without an understanding of people's economic and health behaviors at household level. Therefore, we need to analyze household economic and health related actions under climate change and urbanization to suggest some feasible ways to minimize the risks and achieve sustainable development goals (SDGs) within the expected time frame.

Researches on how to increase public concerns and actions regarding environmental and climate change problems have been getting priority in the recent years. A growing number of studies have been conducted on social, environmental and climate change problems separately, analyzing the potential impact on people's life and livelihood in relation to behaviors, cognition and perceptions (see, e.g., Arbuckle Jr et al., 2013, 2015; Islam et al., 2016; Alam et al., 2017a; Al-Amin et al., 2019; Rogers et al., 2019). However, the studies on how to reduce the effects of environmental and climate change problems by focusing on household economic and health behaviors among residential areas have been scarce and the issue remains unsolved. It is important to understand people's economic and health behaviors under climate change and urbanization at household level to minimize the associated risks and achieve SDGs. Therefore, the thesis empirically examines the effects of salinity resulting from climate change on human health, explores cooperation and cognition gaps for reducing salinity problems and identifies the inequality of food intake among household members at household level for the betterment of health and sustainable societies.

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). Past studies explore the relationship between salinity and increased blood pressure (Khan et al., 2011a; Aburto et al., 2013; He et al., 2013; Talukder et al., 2016; Scheelbeek et al., 2017; Talukder et al., 2017; Shammi et al., 2019). Talukder et al. (2015); Rasheed et al. (2016) and Nahian et al. (2018) find a positive relation between salinity and the risk of stroke & cardiovascular disease. Frequent cholera and diarrhea are linked with drinking water with elevated salinity (Hunter et al., 2010; Khan et al., 2011b; Braun and Saroar, 2012; Schellnhuber et al., 2013; Talukder et al., 2015; Saha, 2017). Salinity intrusion and the expansion of brackish water bodies due to climate change increase vector-borne diseases, such as malaria and dengue (Guterres, 2008; Ramasamy and Surendran, 2012). Khan et al. (2011b); Braun and Saroar (2012); Talukder et al. (2015) and Nahian et al. (2018) document that there is a positive association between elevated salinity and the risk of skin diseases & acute respiratory infections. Overall, the cumulative effects of salinity deteriorate the general health of the coastal population.

Past research examines people's cognition, cooperative and prosocial behaviors toward environmental and climate change 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). 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. Neaman et al. (2018) examine the relationship between prosocial and proenvironmemtal behaviors among university students in Chile, finding that these two behaviors are positively related to each other. A group of studies examine the effect of residential differences on environmental concerns and people's cooperation for environmental and climate change problems (Zahran et al., 2006; Shwom et al., 2008; Bel et al., 2014). Rajapaksa et al. (2018) show that rural, urban and slam people have different proenvironmental behaviors to protect environment. In another study, Huddart-Kennedy et al. (2009) show that rural and urban people have different environmental concerns and rural people have a tendency to participate in environmentally supportive programs. Thus, it is important to examine people's cognition about environmental and climate change problems between urban and rural areas to understand their cooperation for reducing such problems.

Individual nutritional status largely depends on food allocation among household members (Akerele, 2011). Inequality in intrahousehold food intake is a major concern that promotes nutrient deficiencies and perpetuates the malnutrition problem (Rizvi, 1983; Engle and Nieves, 1993; Luo et al., 2001; Hadley et al., 2008; Akerele, 2011). Literature analyzes intrahousehold adequacy in food intake with respect to gender, focusing on specific-age groups (Carloni, 1981; Nelson, 1986; Chaudhury, 1988; Gittelsohn, 1991; Wheeler, 1991; Messer, 1997; Harris-Fry et al., 2018; Madjdian, 2018; Fadare et al., 2019; Sassi et al., 2019). They establish gender discrimination in food intake at intrahousehold level by focusing on certain age groups. Again, some researches identify that household food intake behavior is influenced by the poverty and residential areas. For example, Rabbani (2014) compares dietary diversity of poor and non-poor households in Bangladesh by using secondary data and concludes that dietary diversity in poor families is lower than that in non-poor families. Ponce et al. (2006) find that the urban poor have higher dietary diversity than the rural poor in Mexico. Literature argues that family roles influence how people perceive and behave toward food and nutritional outcomes in a certain way (Boutelle et al., 2003; Therborn, 2004; Fulkerson et al., 2006; Chan and Sobal, 2011; Madjdian and Bras, 2016; Humphries et al., 2017). Therefore, it is important to understand the dimensions of food intake inequality among household members by their family roles and/or age groups, regardless of the poverty and residential places.

None of the past studies have examined people's economic and health behaviors at household level under climate change and urbanization. Therefore, in this research, first we empirically characterize the effects of salinity on human health by segregating water-borne, water-washed and water-related diseases. In the second stage, we examine the effect of information provision on people's cooperation and cognition for reducing salinity problems in urban and rural areas. Finally, we analyze dietary diversity scores (DDSs) of all members per household to identify the inequality in food intake by the family roles and/or age groups along with sociodemographic factors in a single framework. The lessons learned from this study are applicable to other developing and developed countries that are highly vulnerable to climate change and environmental problems where exist gaps between urban and rural areas.

The later parts of this thesis organized as follows: chapter 2 entitled "Salinity and water-related disease risk in coastal Bangladesh" examines the association between water-related diseases and coastal salinity in Bangladesh. The study of cooperation and cognition gaps for salinity, which presents the field experiment and the main findings related to this experiment, is presented in chapter 3 entitled "Cooperation and cognition gaps for salinity: A field experiment of information provision in urban and rural areas of Bangladesh." Chapter 4 entitled "Intrahousehold food intake inequality by family roles and age groups " addresses intrahousehold food intake inequality by subgrouping household members according to their family roles and age groups as well as identifies the vulnerable food intake subgroups within households. Finally, chapter 5 renders the conclusion.

Chapter 2

Salinity and water-related disease risk in coastal Bangladesh

2.1 Introduction

Water and food are two basic elements of human life, however, supplying clean water and adequate food for people is a great challenge throughout the world at present. For instance, it is reported that contaminated water and inadequate food are the major concerns for human health and mortality worldwide (UNICEF and WHO, 2015; Elahi, 2016; Nahian et al., 2018). Contamination of both surface and groundwater resources by different degrees of salinity in the deltaic and coastal regions poses a significant threat for 600 million people in the world (Talukder et al., 2016; Jevrejeva et al., 2018). Being a low-lying country, Bangladesh is highly susceptible to climate change and its coastal area is more vulnerable than any other part of the country due to the salinity level associated with a sea-level rise resulting from climate change (Alam and Murray, 2005; Brammer, 2010; Mallick et al., 2011; Brammer, 2014; Huq et al., 2015; Alam et al., 2017a). Salinity intrusion is a particular concern for Bangladesh, where more than 35 million people drink water with an elevated salinity level (Vineis et al., 2011; Talukder et al., 2016). Salinity prevalence drives human health in complex direct and indirect ways, (Paul and Jabed, 2018; Shammi et al., 2019) and it is also linked with higher water-related diseases (Nahian et al., 2018). However, research on the human health risks of salinity in this context is scarce. Therefore, this paper addresses the association between salinity and water-related diseases.

Past studies explore the relationship between coastal salinity and water-borne diseases. Frequent cholera and diarrhea are linked with drinking water with elevated salinity (Hunter et al., 2010; Khan et al., 2011b; Braun and Saroar, 2012; Schellnhuber et al., 2013; Talukder et al., 2015; Saha, 2017). Warner et al. (2012) report that water-borne diseases such as diarrhea and dysentery are increasing in coastal areas because of high salinity. Salinity intrusion and the expansion of brackish water bodies due to climate change increase vector-borne diseases, such as malaria and dengue (Guterres, 2008; Ramasamy and Surendran, 2012). Jardine et al. (2007); Talukder et al. (2015) and Rakib et al. (2019) state a potential increase in health impacts such as diarrhea, acute respiratory infections and mosquito-borne diseases due to high exposure of saline-contaminated water.

Another group of research focuses on the relation of drinking water with elevated salinity and water-washed diseases. Khan et al. (2011b); Braun and Saroar (2012); Talukder et al. (2015) and Nahian et al. (2018) document that there is a positive association between elevated salinity and the risk of skin diseases. Jabed et al. (2020) indicate that coastal people suffer from skin diseases and hair loss due to the use of saline water. Similarly, Paul and Jabed (2018) mention that skin diseases such as skin allergies, skin rashes, infection, irritation of skin, eczema and skin abscess are caused by excess use of saline water. Müller et al. (2019) report that salinity adversely affects skin or other target organs, causing regulatory effects on cardiovascular disease, inflammation, infection and autoimmunity. Lam et al. (2018) state that coastal inhabitants who use saltwater for bathing and other personal hygiene suffer from itching, skin, eye and darking problems.

Inhabitants of coastal communities are reported to have suffered from salinity problems for a long time. However, few studies reported that the relationship between salinity and the risk of water-related diseases. This research seeks to empirically characterize the effects of salinity on human health by segregating water-borne, water-washed and water-related diseases, using a survey with 527 households in two types of coastal regions, non-salinity and salinity areas in the southwest of Bangladesh. A novelty in our research lies in (i) evaluating overall water-related health risk in coastal populations by considering six types of water-related diseases (diarrhea, malaria, dengue, respiratory infections, skin diseases and ocular diseases) depending on whether people live in non-salinity or salinity areas; (ii) systematically comparing and estimating the effects of salinity for water-borne, water-washed and water-related diseases along with a new set of sociodemographic and anthropometric factors, such as body mass index (BMI), within a single framework.

2.2 Methods

2.2.1 Study design, setting and study population

Jashore and Satkhira districts are located in the southwestern coastal region of Bangladesh. In Jashore, three upazilas (sub-districts) are selected purposively. Within these upazilas, six villages are selected randomly and categorized as the non-salinity areas. Again, by following the same procedure, an upazila from Satkhira district is selected. Within this upazila, six villages are selected randomly and regarded as the salinity areas (see figure 2.1). The categorization of non-salinity and salinity areas is based on the absence and presence of salinity in these areas. For measuring salinity level in the selected areas, we encounter groundwater and surface water salinity electrical conductivity (EC) score that is measured by units of deciSiemens per metre (dS/m). In Bangladesh, salinity EC values of groundwater and surface water are measured by the Soil Resources Development Institute (SRDI) and they categorize the saline and non-saline areas based on EC value where EC value < 2 dS/m is considered as no saline and EC value > 15 dS/m considered as strongly saline. The estimated groundwater and surface water EC values are 19.8 dS/m and 35.9 dS/m in Satkhira district (salinity areas) while these values are 0.7 in Jashore district (non-salinity areas) (Soil Resources Development Institute, 2010; Shammi et al., 2019).

To implement random sampling of subjects in each area, we obtained lists of all households in the selected villages with help and support of local NGOs. During February-March 2019, we randomly identified 550 households by using the list and random number generator, and 275 households from the non-salinity areas and 275 households from the salinity areas were finally selected. Trained research staff contacted each household and conducted a survey for data collection with a pre-defined questionnaire. All households willingly participated in this survey, and the household head mainly answered the questionnaire, providing data with written consent signed at the beginning. Overall, 527 questionnaires were successfully collected, with 23 questionnaires missing observations.

Figure 2.1: Study area

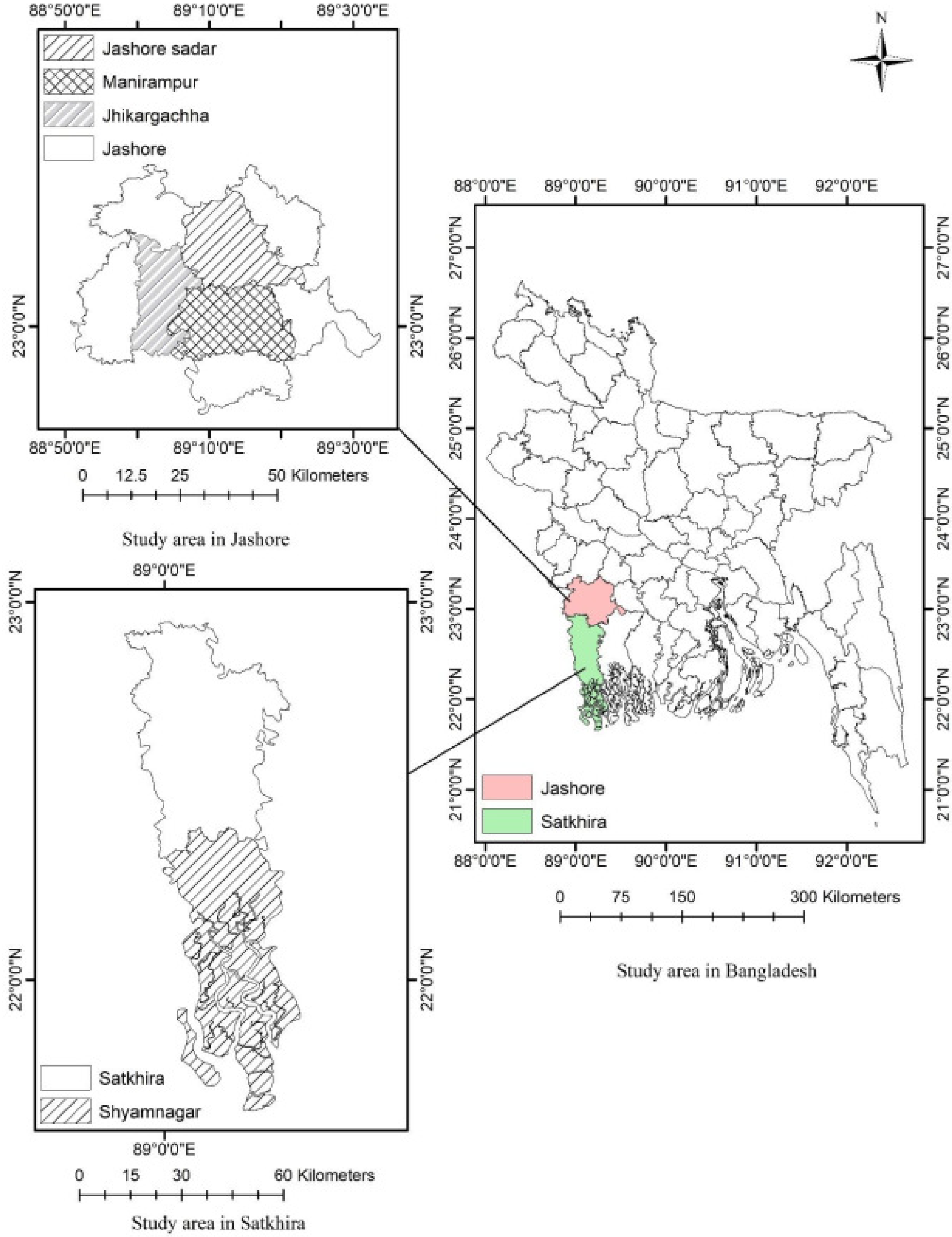


Table 2.1: Disease-related questions

Number	Questions
1.	Had you suffered from any water-related disease(s) in the last six months? 1. Yes 2. No 3. I do not know
2.	If your answer of question 1 is "yes," then what disease(s) had you suffered from? 1. Malaria/Dengue 2. Diarrhea 3. Respiratory infections 4. Skin diseases 5. Ocular diseases 6. Others, specify:
3.	If your answer of question 1 is "no," then had your any family member suffered from water-related disease(s) in the last six months? 1. Yes 2. No 3. I do not know
4.	If your answer of question 3 is "yes," then what disease(s) had your family member suffered from? (If multiple family members had suffered from the same number of disease cases, please give priority to those of adult age) 1. Malaria/Dengue 2. Diarrhea 3. Respiratory infections 4. Skin diseases 5. Ocular diseases 6. Others, specify:

2.2.2 Key variables

A simple baseline survey was conducted to gather information on diarrhea, malaria, dengue, respiratory infections, skin diseases and ocular diseases. At first, a household head was asked (sometimes, a household head's wife was asked, if the household head was absent) whether he had suffered from these diseases in the last 6 months and the data were recorded. If the household head was not affected by these diseases, then the same question was asked to other family members and if any member had suffered from these kinds of diseases, then data were documented. If multiple family members had suffered from the same number of disease cases, we gave priority to those of adult age. The disease-related survey questions are presented in table 2.1. At the time of data collection, trained research staff asked the subjects to provide the evidence of diseases such as prescription/test documents that were provided by doctor/hospital/diagnosis center.

In this study, we follow Bradley's classification of water-related diseases and make three groups of diseases: water-borne diseases, water-washed diseases and water-related diseases (White et al., 2002; Cotruvo et al., 2004; Hunter et al., 2010). According to this classification, we make diarrhea, malaria, dengue and respiratory infections into one category and named water-borne diseases. Skin and ocular diseases are categorized as water-washed diseases. The final categorization is developed based on the combination of water-borne and water-washed diseases and called water-related diseases. Suffering from water-borne, water-washed and water-related diseases are the three dependent variables in this research. A household is categorized as "suffering from diseases" if any family member had suffered from any of the above-mentioned diseases.

Information was collected on households' sociodemographic characteristics, such as age, gender, family structure, education, occupation, income, household drinking sources and anthropometric characteristics, such as the height & weight of the subjects during household visits. In this study, a digital electronic machine was used to measure the weight and height of each subject. Accordingly, the body mass index (BMI) of each subject is calculated using their height and weight. Body mass index can be categorized into three groups: underweight (below 18.5), normal weight (18.5 - 24.9) and overweight (above 24.9) based on body mass score. The description of all variables is presented in table 2.2.

2.2.3 Statistical analysis

We compute descriptive statistics such as the mean, median and standard deviation of the key variables, and compare the differences between the non-salinity and salinity areas. One of our focuses is on occurrences of water-borne, water-washed and water-related diseases between the non-salinity and salinity areas, and we compare them by using statistical methods, such as a chi-squared test. In addition, some sociodemographic and anthropometric variables, such as gender, education of the household head, occupation of the household head, family structure, drinking water sources and body mass index (BMI), are assessed by areas (non-salinity and salinity areas). We apply logit regression to identify the effects of salinity on health by separating water-borne, water-washed and water-related diseases. Each category of the disease has a binary value 0 or 1. Let y_i denote a variable such that $y_i = 1$ if subject i suffers from any kind of water-related disease, and $y_i = 0$ otherwise. The probability of suffering from disease for subject i, Prob$(y_i = 1)$, is represented by the distribution function F evaluated at $X_i\beta$, where X_i is a vector of explanatory variables and β is a vector of unknown parameters. The distribution function of the logit regression model is as follows:

$$\text{Prob}(y_i = 1) = \frac{\exp(X_i\beta)}{1 + \exp(X_i\beta)}. \tag{2.1}$$

Equation (2.1) enables us to compute the probability of disease occurrence.

Table 2.2: Definitions of variables

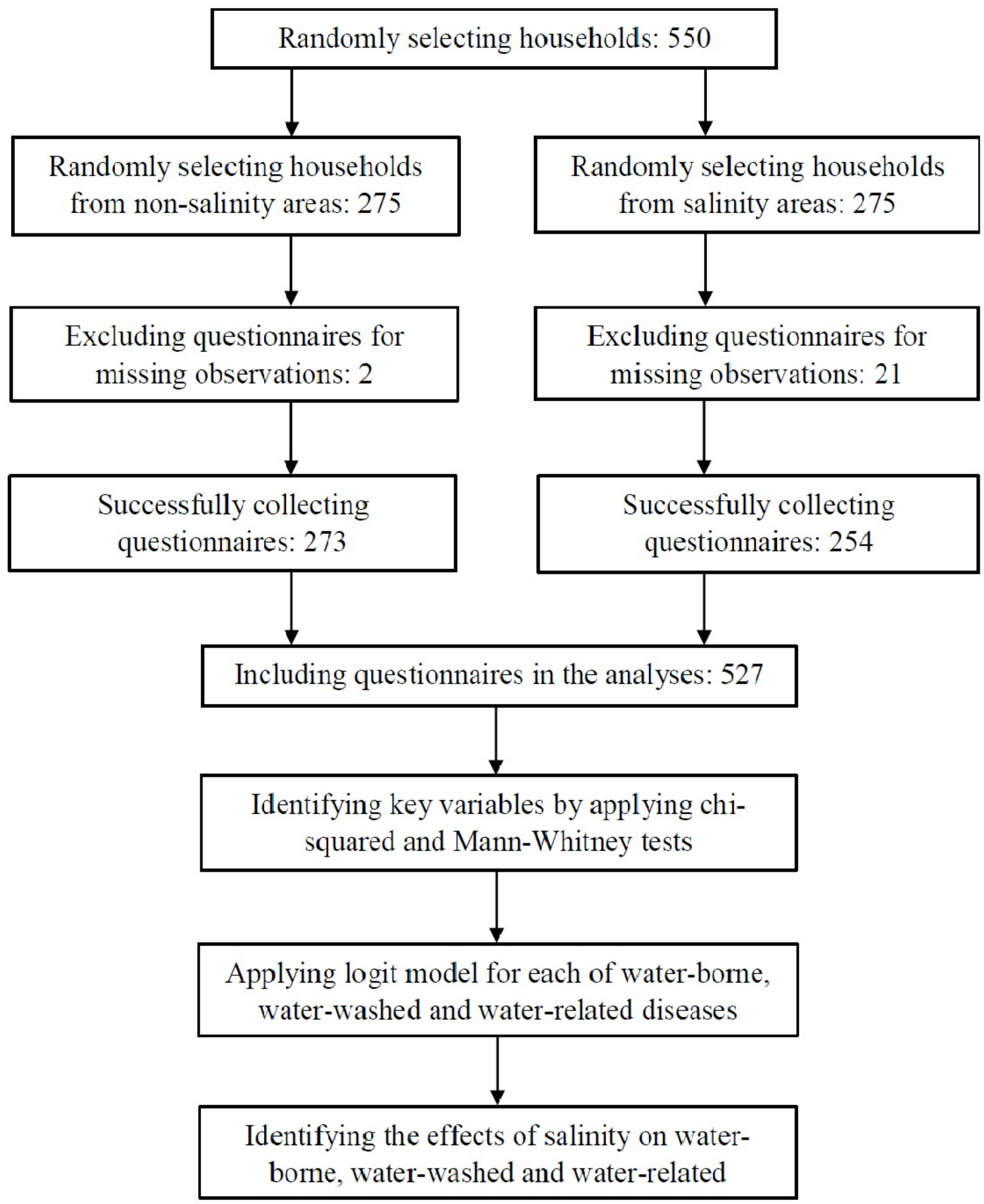
Variables	Description
Water-borne diseases	If a member of a household had suffered from any types of water-borne diseases, then the value of the dependent variable is 1, otherwise 0 (reference category).
Water-washed diseases	If a member of a household had suffered from any types of water-washed diseases, then the value of the dependent variable is 1, otherwise 0 (reference category).
Water-related diseases	If a member of a household had suffered from any types of water-related diseases, then the value of the dependent variable is 1, otherwise 0 (reference category).
Age	Years
Gender	Male (0) and female (1).
Education of the household head	Years of schooling (0 to 14) (0 = No schooling, 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/twelve class, 13 = Graduate/equivalent, 14 = Post graduate/equivalent).
Occupation of the household head	Non-agriculture (0) and Agriculture (1).
Household income	Monthly household income in BDT.
Family structure	Nuclear family (0) and Extended family (1).
Body mass index (BMI) dummy variables (Base group = Normal BMI).	
Underweight BMI	Normal weight (0) and Underweight (1).
Overweight BMI	Normal weight (0) and Overweight (1).
Drinking sources	Rainwater (0) and Ground/pond water (1).
Area	Non-salinity area (0) and Salinity area (1).
Area-wise drinking sources (Base group = Households who live in non-salinity area and drink ground/pond water, NSG/P (0)).	
NSR	Households who live in non-salinity area and drink rainwater, NSR (1), otherwise 0.
SR	Households who live in salinity area and drink rainwater, SR (1), otherwise 0.
SG/P	Households who live in salinity area and drink ground/pond water, SG/P (1), otherwise 0.

The empirical analysis is categorized into three parts. In the first part, our aim is to identify the effect of salinity on the occurrence of water-borne diseases. The logit analysis uses the variable y_i^a satisfying that $y_i^a = 1$ if subject i suffers from any kind of the above mentioned water-borne diseases, and $y_i^a = 0$ otherwise, where the superscript of a in y_i^a represents "suffering from water-borne diseases." In the second part, we identify the effect of salinity on the occurrence of water-washed diseases. The logit analysis uses the dependent variable y_i^b, satisfying that $y_i^b = 1$ if subject i suffers from any kind of the aforementioned water-washed diseases, and $y_i^b = 0$ otherwise, where the superscript b represents "suffering from water-washed diseases." In the final part, we combine water-borne and water-washed diseases into one group called water-related diseases. We run logit model for identifying the effect of salinity on water-related diseases, taking the choice variable y_i^c satisfying that $y_i^c = 1$ if subject i suffers from the above-mentioned water-related diseases, and $y_i^c = 0$ otherwise, where the superscript c represents "suffering from water-related diseases." A series of logit regression models are applied step by step to check the robustness of the results. First, the relationship between water-borne diseases and areas (non-salinity and salinity) is examined. Second, some sociodemographic characteristics (not including body mass index) are added. Finally, we include the anthropometric variable such as BMI in the model. The same procedure is applied in each regression for water-borne, water-washed and water-related diseases. The main results of logit regression analyses are summarized in table 2.5. We apply descriptive statistics, tests and regression analysis to empirically characterize the effects of salinity on human health by segregating water-borne, water-washed and water-related diseases in non-salinity and salinity areas. Overall, we identify the relationship between salinity and water-related diseases by controlling the sociodemographic and anthropometric factors. A methodological flowchart is presented for explaining each method part in figure 2.2.

2.3 Results

Table 2.3 presents the summary statistics of the major dependent and independent variables for the non-salinity and salinity areas. The percentages of the subjects who suffer from water-borne, water-

Figure 2.2: A methodological flowchart of the study



washed and water-related diseases are 54 %, 20 %, 60 % in the non-salinity areas, respectively, while these percentages are 62 %, 29 %, 69 % in the salinity areas, respectively. The overall average age in the sample is 39 years (see Table 2.3), and the mean age of the subjects does not vary between of the non-salinity and salinity areas. Table 2.3 shows that 58 % of the subjects in the non-salinity areas are male, while 65 % of the subjects are male in the salinity areas. With respect to education, subjects in both of the non-salinity and salinity areas possess 8 years of schooling (they usually receive secondary education degrees) as the median. Regarding occupation, 44 % and 42 % of subjects in the non-salinity and salinity areas are engaged in agriculture. A similar result is observed in Paul et al. (2011) indicating that agriculture is not the primary source of income for coastal people because the incidence of landlessness is higher in coastal areas than in non-coastal areas.

The average household income in the non-salinity areas (approximately 16 thousand Bangladesh taka, BDT per month) is higher than in the salinity areas (around 12 thousand BDT per month). The dominant family structure in the sample in both types of areas is the nuclear family; however, the number of the extended families is higher in the salinity areas than in the non-salinity areas. Regarding drinking water sources, ground/pond water is the major source in both types of areas. However, the percentage of ground/pond water users is relatively higher (95 %) in the non-salinity areas than in the salinity areas (76 %). The anthropometric variables of the subjects in the non-salinity areas (underweight BMI (0.09) & overweight BMI (0.29)) do not differ substaintially from those in the salinity areas (underweight BMI (0.11) & overweight BMI (0.22)), and most of the subjects belongs to normal BMI. In summary, subjects in the salinity areas are considered to have suffered more from water-borne, water-washed and water-related diseases than the subjects in the non-salinity areas. Some sociodemographic variables such, as household income, family structure and drinking water sources, vary between the non-salinity and salinity areas.

Figure 2.3 shows the percentages of subjects who suffer from water-borne, water-washed and water-related diseases in the non-salinity and salinity areas. Overall, it can be confirmed that the percentages of water-borne, water-washed and water-related diseases are higher in the salinity areas than in the non-salinity areas. Figure 2.3 highlights that 47 % of subjects in the non-salinity areas and 53 % of

Table 2.3: Summary statistics of the variables

	Area		Overall
	Non-salinity area	Salinity area	
Water-borne diseases			
Average (Median)[1]	0.54 (1.00)	0.62 (1.00)	0.58 (1.00)
SD[2]	0.50	0.49	0.49
Water-washed diseases			
Average (Median)	0.20 (0)	0.29 (0)	0.24 (0)
SD	0.40	0.45	0.43
Water-related diseases			
Average (Median)	0.60 (1.00)	0.69 (1.00)	0.65 (1.00)
SD	0.49	0.46	0.48
Age			
Average (Median)[1]	37.93 (39.00)	37.56 (39.00)	37.76 (39.00)
SD[2]	14.78	13.96	14.38
Gender (Base group = Male)			
Average (Median)	0.42 (0.00)	0.35 (0.00)	0.39 (0.00)
SD	0.49	0.48	0.49
Education of the household head			
Average (Median)	7.36 (8.00)	7.19 (8.00)	7.28 (8.00)
SD	3.97	3.66	3.82
Occupation of the household head (Base group = Non-agriculture)			
Average (Median)	0.45 (0.00)	0.42 (0.00)	0.43 (0.00)
SD	0.50	0.49	0.50
Household income			
Average (Median)	15548.18 (13500.00)	11887.19 (10208.33)	13783.68 (12000)
SD	9144.17	5804.32	7924.38
Family structure (Base group = Nuclear family)			
Average (Median)	0.19 (0.00)	0.31 (0.00)	0.24 (0.00)
SD	0.39	0.46	0.43
Body mass index (BMI) dummy variables (Base group = Normal BMI)			
Underweight BMI			
Average (Median)	0.09 (0.00)	0.11 (0.00)	0.10 (0.00)
SD	0.29	0.31	0.0.30
Overweight BMI			
Average (Median)	0.29 (0.00)	0.22 (0.00)	0.26 (0.00)
SD	0.45	0.42	0.44
Drinking water sources (Base group = Rainwater)			
Average (Median)	0.95 (1.00)	0.76 (1.00)	0.86 (1.00)
SD	0.22	0.43	0.34
Area-wise drinking sources (Base group = Ground/pond water in the non-salinity areas, NSG/P)			
Rainwater in the non-salinity areas, NSR			
Average (Median)	0.05 (0.00)	0.00 (0.00)	0.03 (0.00)
SD	0.22	0.00	0.16
Rainwater in the salinity areas, SR			
Average (Median)	0.00 (0.00)	0.24 (0.00)	0.11 (0.00)
SD	0.00	0.43	0.32
Ground/pond water in the salinity areas, SG/P			
Average (Median)	0.00 (0.00)	0.76 (1.00)	0.37 (0.00)
SD	0.00	0.43	0.48
Sample size	273	254	527

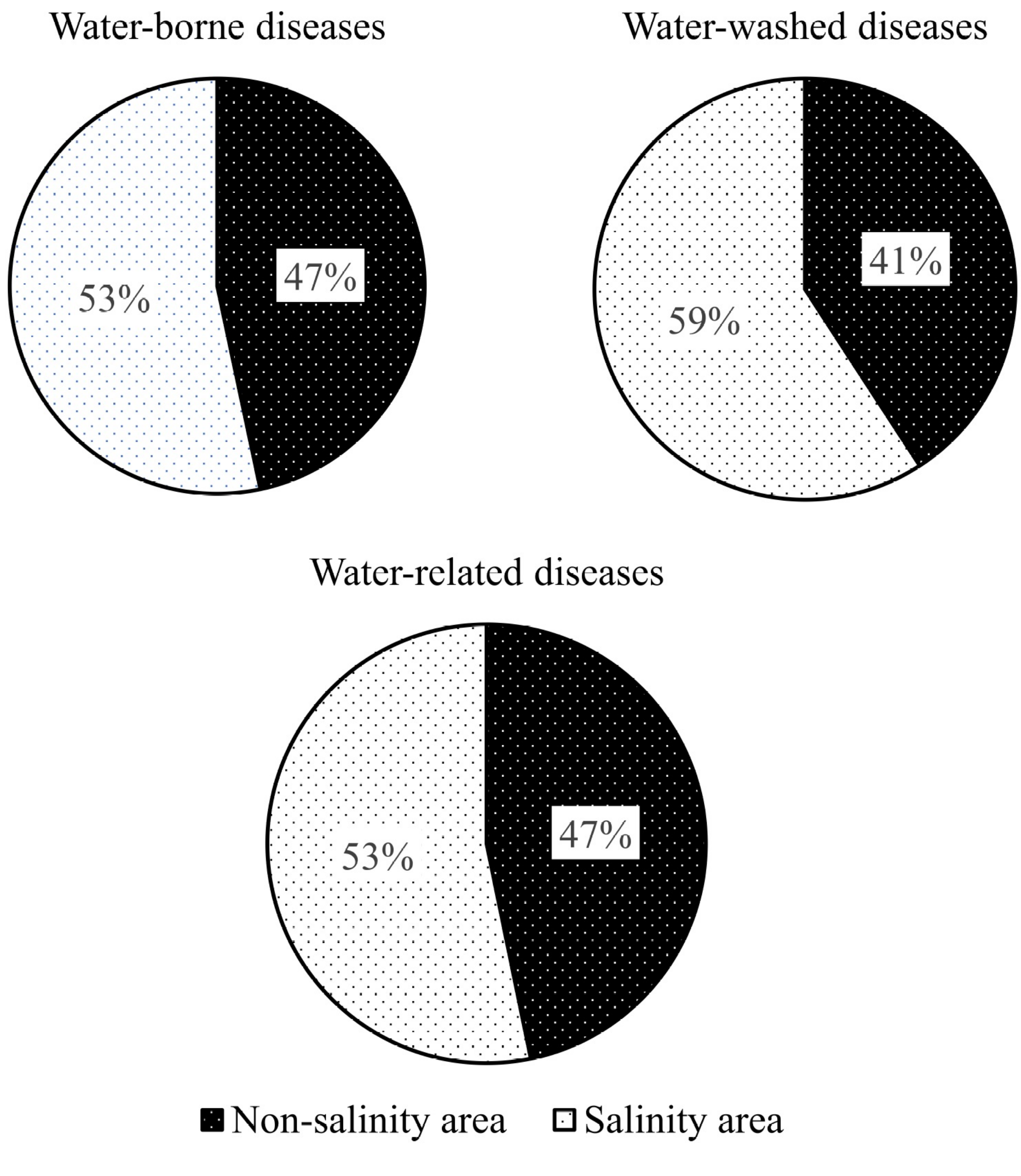
[1] Median in parentheses.
[2] SD stands for standard deviation.

subjects in the salinity areas had suffered from any type of water-related disease. In the non-salinity areas, 41 % (47 %) of subjects had suffered from water-washed diseases (water-borne diseases), while this percentage is 59 % (53 %) in the salinity areas.

Chi-squared tests are applied to qualitatively examine whether the frequencies or occurrences of the key variables are independent of areas (salinity or non-salinity areas). The following pairs of variables are considered: (1) water-borne diseases *vs* areas, (2) water-washed diseases *vs* areas, (3) water-related diseases *vs* areas, (4) family structure *vs* areas, (5) BMI *vs* areas and (6) drinking water sources *vs* areas. We find that cases (1), (2) and (3) reject the null hypotheses at the 5 % significance level, meaning that the occurrences of water-borne, water-washed and water-related diseases depend on whether the subject is in a non-salinity and salinity area. Cases (4) and (6) also reject the null hypotheses at the 1 % significance level, whereas case (5) does not. Overall, it appears that the key variables are qualitatively correlated with areas. Finally, to characterize the income data, we run a Mann-Whitney test with the null hypothesis that the income distributions are the same between the non-salinity and salinity areas. The result shows that there is a difference in the income distributions between the non-salinity and salinity areas at the 1 % significance level ($Z = 5.60$). The summary statistics, diagram of disease occurrences and statistical tests suggest that not only the occurrences of diseases but also household characteristics vary between the non-salinity and salinity areas.

Models 1-1, 1-2 and 1-3 in table 2.5 report the estimated marginal effects of the independent variables on the likelihood of suffering from water-borne, water-washed and water-related diseases using the same specification, respectively. Likewise, the results in models 2-1, 2-2 and 2-3 can be interpreted. The marginal effects of each independent variable on the likelihood of suffering from the diseases in models 1-1, 1-2, 1-3, 2-1, 2-2 and 2-3 are derived from the estimated coefficients of the logit regression in table 2.4, evaluated at the sample means (Wooldridge, 2010, 2019). In model 1-1, family structure, underweight BMI, area and drinking water sources have positive effects at the 1 %, 5 %, 10 % and 1 % significance levels, while age and gender have negative effects on the likelihood of suffering from water-borne diseases at the 1 % significance level, respectively. In model 1-2, age, household income, area and drinking water sources exhibit positive effects at the 10 %, 5 % and 1 % significance levels,

Figure 2.3: The pie charts showing the percentages of water-borne, water-washed and water-related disease occurrences by areas



while only one variable, gender, shows negative effect on the likelihood of suffering from water-washed diseases at the 1 % significance level, respectively. In model 1-3, we find that occupation, family structure, underweight BMI, area and drinking water sources have positive effects at the 5 %, 1 %, 5 % and 1 % significance levels, while age and gender have negative effects on the likelihood of suffering from water-related diseases at the 1 % significance level, respectively.

The estimated coefficients of both age and its square are significant and take negative and positive signs, respectively (see table 2.4). This means that the marginal effect of age changes non-monotonically, and the likelihood of suffering from water-borne and water-related diseases are higher at younger & older age and lower in middle age (see, e.g., figure 2.4 for the predicted probabilities of suffering from water-borne and water-related diseases, holding other independent variables at the sample means). This tendency is consistent with some previous literature reporting that children and older adults are more vulnerable to all kinds of disease than the middle-aged people (Bhunia and Ghosh, 2011).

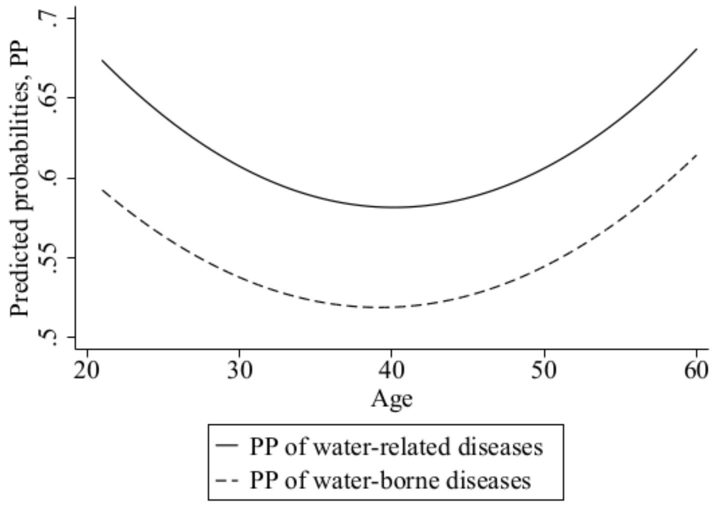
Among the subjects, females are 29 %, 10 %, and 22 % less likely to suffer from water-borne, water-washed and water-related diseases, respectively, than males (table 2.2). A possible reason for this is that males always stay outside for their activities and are forced to drink contaminated water because fresh drinking water is not always available. Large family size has a significant relationship with suffering from water-borne and water-related diseases. Specifically, the probabilities that households with a large family size suffering from water-borne and water-related diseases are 15 % and 12 % higher than those of households with a nuclear family, respectively (see table 2.2). Our results are consistent with Sarker et al. (2016), showing that the prevalence of diarrhea is higher in households with more family members and that male children suffer more than do female children.

Occupation is statistically significant in model 1-3 in table 2.2, indicating that households that are engaged in agricultural activities are 9 % more likely to suffer to from water-related diseases than households that are engaged in non-agricultural activities. Agricultural activities are mainly related to soil and water that are mostly affected by salinity, and this result can generally be considered quite intuitive in Bangladesh. If household income increases by 1 %, then the likelihood of suffering from water-washed disease increases by 9 % (see table 2.2). In many cases, high-income households also have their own ponds, usually using pond water for their daily activities and cultivating fish in the pond. As a result, they frequently contact contaminated water and suffer considerably from water-washed diseases. Paul et al. (2011) demonstrate the same result via household surveys in a of study post-cyclone illness patterns in Bangladeshi coastal areas, finding that the disease occurrence among high-income people is higher than among low-income people.

The probabilities of suffering from water-borne, water-washed and water-related diseases are 8 %, 14 % and 11 % higher in the salinity areas than the non-salinity areas, respectively (logit regression 1 in table 2.2). Some studies claim that elevated salinity in coastal areas through drinking, cooking, bathing increases the chances of skin diseases, acute respiratory infection and diarrheal diseases (Talukder et al., 2015). Jabed et al. (2020) also claim that an overwhelming number of villagers in the salinity areas suffer from skin-related diseases such as skin paleness, allergy, rashes and skin infections. In terms of drinking water sources, we find that the users of ground/pond water are 16 %, 15 % and 19 % more likely to suffer from water-borne, water-washed and water-related diseases than the rainwater users. Several other studies also show that the salinity level in drinking water is positively associated with the consumption of sodium, which has negative effects on human health (Khan et al., 2014; Talukder et al., 2016). Overall, our results with respect to the salinity areas are in line with the literature.

Body mass index (BMI) is an important health indicator that assesses people's health status. We identify that the underweight BMI is a statistically significant predictor of water-borne and water-related diseases, indicating that the subjects who belong to underweight BMI are 16 % and 15 % more likely to be affected by water-borne and water-related diseases, respectively, than the subjects who belong to normal BMI. It is established that people with poor nutritional status could be easily affected by any type of disease. A study by Rahman et al. (2004) is consistent with our result, demonstrating that maternal depression is a risk factor for malnutrition and illness in infants living in a low-income country and that infants with low birth weight are likely to suffer from excessive diarrheal episodes. The effects of poor nutrition have an impact on the social, economic and cultural development of societies and nations. It will be impossible to achieve many of the sustainable development goals, including the

Figure 2.4: Predicted probabilities of suffering from water-borne and water-related diseases as a function of age



goals related to extreme poverty and hunger, primary education, child mortality, and other diseases, if malnutrition cannot be reduced or prevented.

In logit regression 2, we create a new variable named area-wise drinking sources by combining area and drinking water sources to clearly see the effects of different combinations on the diseases. We find that the households that live in the salinity areas and consume ground/pond water are more likely to suffer from water-related diseases than those in the non-salinity areas who use the same drinking water sources. The reason is that the salinity level in drinking water sources is high in the salinity areas. The households that consume rainwater as a drinking source are less likely to suffer from water-related diseases even in the salinity areas. The results of this study show that subjects who live in the salinity areas and consume ground/pond water are 10 %, 15 % and 13 % likely to be affected by water-borne, water-washed and water-related diseases, respectively, than subjects who live in the non-salinity areas and use the same drinking water sources (see model 2-3). In model 2-1, we also observe that subjects who live in the salinity areas but consume rainwater as a drinking source have a 10 % lower probability of suffering from water-borne diseases than subjects who live in the non-salinity areas but consume ground/pond water. Other variables used in logit regression model 2 exhibit similar results as their counterparts in logit regression model 1.

Table 2.4: Coefficients of the independent variables in the logit regression

	Logit regression 1			Logit regression 2		
	Water-borne	Water-washed	Water-related	Water-borne	Water-washed	Water-related
	Model 1-1	Model 1-2	Model 1-3	Model 2-1	Model 2-2	Model 2-3
Age	−0.11***	0.003	−0.15***	−0.11***	0.003	−0.14***
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)
Age square	0.001**	0.0002	0.001***	0.001**	0.0002	0.001***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Gender (Base group = Male)	−1.38***	−0.60**	−1.06***	−1.40***	−0.60**	−1.07***
	(0.23)	(0.26)	(0.23)	(0.23)	(0.26)	(0.23)
Education of the household head	−0.03	−0.005	−0.03	−0.02	−0.005	−0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.23)
Occupation of the household head (Base group = Non-agriculture)	0.24	0.09	0.49**	0.25	0.09	0.50**
	(0.20)	(0.22)	(0.20)	(0.20)	(0.22)	(0.21)
Household income[1]	−0.01	0.55**	0.31	0.01	0.56**	0.32
	(0.20)	(0.22)	(0.20)	(0.20)	(0.22)	(0.20)
Family structure (Base group = Nuclear family)	0.73***	0.18	0.62**	0.76***	0.18	0.64**
	(0.24)	(0.25)	(0.25)	(0.24)	(0.25)	(0.25)
BMI dummy (Base group = Normal weight)						
Underweight BMI	0.81*	−0.35	0.87*	0.80*	−0.35	0.86*
	(0.42)	(0.45)	(0.47)	(0.42)	(0.45)	(0.47)
Overweight BMI	0.08	0.29	0.31	0.12	0.30	0.34
	(0.22)	(0.24)	(0.23)	(0.22)	(0.24)	(0.23)
Area (Base group = Non-salinity)	0.37*	0.82***	0.57***			
	(0.21)	(0.23)	(0.22)			
Drinking water sources (Base group = Rainwater)	0.78***	1.08***	0.93***			
	(0.29)	(0.38)	(0.29)			
Area-wise drinking sources (Base group = NSG/P)						
NSR				0.02	−0.96	−0.33
				(0.61)	(1.07)	(0.62)
SR				−0.54*	−0.27	−0.46
				(0.33)	(0.41)	(0.32)
SG/P				0.47**	0.83***	0.65***
				(0.22)	(0.24)	(0.23)

***significant at the 1 percent level, **at the 5 percent level and *at the 10 percent level. Numbers in parentheses are standard errors.
NSG/P stands households who live in non-salinity area and drink ground/pond water,
NSR stands for households who live in non-salinity area and drink rainwater,
SR stands for households who live in salinity area and drink rainwater,
SG/P stands households who live in salinity area and drink ground/pond water.

[1] The logit regressions are computed with the natural logarithm of household income.

Table 2.5: Marginal effects of the independent variables in the logit regression

	Logit regression 1			Logit regression 2		
	Water-borne	Water-washed	Water-related	Water-borne	Water-washed	Water-related
	Model 1-1	Model 1-2	Model 1-3	Model 2-1	Model 2-2	Model 2-3
Age	−0.01***	0.003*	−0.01***	−0.01***	0.003*	−0.01***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Gender (Base group = Male)	−0.29***	−0.10**	−0.22***	−0.29***	−0.10**	−0.22***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
Education of the household head	−0.01	−0.001	−0.01	−0.005	−0.001	−0.005
	(0.01)	(0.005)	(0.01)	(0.01)	(0.005)	(0.01)
Occupation of the household head (Base group = Non-agriculture)	0.05	0.01	0.09**	0.05	0.01	0.10**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Household income[1]	−0.001	0.09**	0.06	0.003	0.09**	0.06
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Family structure (Base group = Nuclear family)	0.15***	0.03	0.12***	0.15***	0.03	0.12***
	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)	(0.05)
BMI dummy (Base group = Normal weight)						
Underweight BMI	0.16**	−0.05	0.15**	0.15**	−0.05	0.15**
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Overweight BMI	0.02	0.05	0.06	0.02	0.05	0.06
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Area (Base group = Non-salinity)	0.08*	0.14***	0.11***			
	(0.04)	(0.04)	(0.04)			
Drinking water sources (Base group = Rainwater)	0.16***	0.15***	0.19***			
	(0.06)	(0.04)	(0.06)			
Area-wise drinking sources (Base group = NSG/P)						
NSR				0.004	−0.13	−0.07
				(0.12)	(0.09)	(0.13)
SR				−0.11*	−0.04	−0.09
				(0.07)	(0.04)	(0.06)
SG/P				0.10**	0.15***	0.13***
				(0.04)	(0.04)	(0.04)

***significant at the 1 percent level, **at the 5 percent level and *at the 10 percent level. Numbers in parentheses are standard errors.
NSG/P stands households who live in non-salinity area and drink ground/pond water,
NSR stands for households who live in non-salinity area and drink rainwater,
SR stands for households who live in salinity area and drink rainwater,
SG/P stands households who live in salinity area and drink ground/pond water.

[1] The logit regressions are computed with the natural logarithm of household income.

2.4 Discussion

In Bangladesh, groundwater is a primary source of drinking, and nearby 97 % of people depend on this source (Shamsudduha, 2013; Nahian et al., 2018). In the salinity areas, 61 % of households use pond water for drinking and 81 % use it for household purposes (Khan et al., 2011b). However, the water salinity level in coastal areas is reported to be increasing due to climate change & the associated anthropogenic activities (Khan et al., 2011a; Talukder et al., 2016; Rahman et al., 2019). The water salinity levels in both groundwater and surface water are < 600 parts per million (ppm) and $1000-1500$ ppm, which exceed the critical level according to the Bangladesh drinking water standard (Abedin and Shaw, 2013). In summary, coastal people currently use saline water to a wide variety of purposes, as a result, they are at risk of developing a number of serious health problems especially water-related diseases as shown in this research. Our analysis suggests that harvesting rainwater is an effective countermeasure to eliminate water-related diseases. Coastal people should be able to reserve rainwater at the family & community levels by using rain barrels or constructing large tanks. However, some support from the government, donor agencies and non-governmental organizations may be required to make such rainwater projects sustainable in practice.

Groundwater is contaminated in many areas of Bangladesh by arsenic pollution that creates many health problems in the affected areas. Past studies show that drinking arsenic contaminated water is linked with water-related diseases (Alam et al., 2002; Caldwell et al., 2003; Mondal et al., 2014). However, in the current study areas, arsenic concentration level in drinking water does not exceed the Bangladesh drinking water and world health organization standard level (Abedin and Shaw, 2013). Therefore, the arsenic problem shall not create any confounding effect in the detected association between salinity and water-related diseases. In future, the same type of studies can be implemented in the high arsenic affected areas, using rainwater or safe water to reduce the risk of health problems. A sustainable technology for harvesting and reserving rainwater in conjunction with sustainable water consumption practice can be effectively used to prevent high risk of water-related diseases and to achieve health related sustainable development goals (SDGs) by 2030.

Malnutrition is an important health indicator and a risk factor for disease. The nutritional status of coastal people is also reported to have decreased due to the impacts of soil and water salinity (Ara Parvin and Reazul Ahsan, 2013; Talukder et al., 2015; Szabo et al., 2016; Rahman et al., 2019). Approximately 49.1 % of children are moderately malnourished on weight for age (underweight) in the salinity areas (Alam et al., 2019). In Bangladesh, approximately 60 million subsistence farmers face a food security problem, and this problem is worsened in rural areas with elevated salinization (Rahman et al., 2019). As a consequence of salinity, rice production is predicted to decrease by 7.6 and 7.3 million by 2050 and 2080, respectively (Khan et al., 2011b). Our findings suggest that being in normal BMI or good nutritional status is crucial for people to be away from water-related diseases, and to this end, some tailor-made interventions are recommended to focus on different food security & nutritional programs for mitigating the risk of water-related diseases. The public food distribution and different government safety net programs can be expanded & redesigned to improve the food security status of coastal populations as well as to achieve SDGs.

2.5 Conclusions

We have systematically examined the quantitative impacts of salinity and some of its possible determinants on the likelihood of suffering from water-borne, water-washed and water-related diseases along with a new set of sociodemographic and anthropometric factors within a single analytical framework. The statistical analysis shows that the probabilities of being affected by water-borne, water-washed and water-related diseases are higher in the salinity areas than the non-salinity areas. Overall, our results suggest that the collection & preservation of rainwater and/or the community-based food & nutrition security programs shall be effective measures to get relief from water-related diseases and to maintain healthy lives among coastal populations, contributing to SDGs.

Chapter 3

Cooperation and cognition gaps for salinity: A field experiment of information provision in urban and rural areas of Bangladesh

3.1 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 and 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 and 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, this paper addresses people's cooperation, cognition and the gaps by conducting field experiments.

Past research examines people's cognition and cooperative behaviors 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). Lorenzoni et al. (2007) state that the degree of people's engagement with environmental activities relates to their cognition, such as knowledge, understanding and experience. 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. Arbuckle Jr et al. (2013) show that people who recognize the consequences of climate change are likely to support climate change mitigation actions. There are several researches that implement field surveys on how information about climate change affects people's cooperation through eliciting people's willingness to pay for resolving climatic problems, establishing the positive influence (Shwom et al., 2008; Johnson et al., 2011; Yang et al., 2014; Abbas et al., 2016). It is important to examine people's cognition about environmental problems to understand their cooperation for climate change and environmental problems.

Previous studies analyze people's prosociality and the relation with their proenvironmental activities. Neaman et al. (2018) examine the relationship between prosocial and proenvironmemtal behaviors among university students in Chile. They use two different scales in the questionnaire surveys to measure the prosocial and proenvironmemtal behaviors and find that these two behaviors are positively related to each other. Shahrier and Kotani (2016) demonstrate that prosociality is an important factor for inducing people to take some measures of collective disaster mitigation in their field research. Van Lange et al. (2007) empirically find that prosocial people donate more than so competitors and individualists, when donations aim at the poor and/or ill people. Shahrier et al. (2016) examine the relation between societies' types and social preferences of prosociality, establishing that people in rural societies are more prosocial than those in semiurban and urban societies. Literature classifies prosociality as a noncognitive factor, suggesting that it plays a major role in shaping people's behaviors and their societies (Heckman et al., 2006; Borghans et al., 2008; Kosse et al., 2020). Overall, prosociality shall be a crucial factor to understand people's cooperative behaviors to mitigate environmental problems.

A group of studies examine the effect of residential differences on environmental concerns and people's cooperation for climate change and environmental problems (Zahran et al., 2006; Shwom et al., 2008; Bel et al., 2014). 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. Rajapaksa et al. (2018) show that rural, urban and slam people have different proenvironmental behaviors to protect environment. In another study, Huddart-Kennedy et al. (2009) show that rural and urban people have different environmental concerns and rural people have a tendency to participate in environmentally supportive programs. These differences are noted to be due to the dependence of people's daily life on environmental and natural resources (Jones et al., 2003). Shwom et al. (2008) examine the effect of residential differences on climate change policy support, establishing an importance of such residential factors. Revi (2008) and Zang et al. (2015) claim that rural-urban difference is caused by rapid urbanization, welfare discrimination and risks to climate change. Residential or rural-urban 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 social and environmental problems separately, analyzing the potential impact on people's life and livelihood in relation to behaviors, cognition and perceptions (see, e.g., Arbuckle Jr et al., 2013, 2015; Islam et al., 2016; Alam et al., 2017a; Al-Amin et al., 2019; Rogers et al., 2019). However, the studies on how to resolve cooperation and cognition gaps of environmental problems among residential areas have been scarce and the issue remains unsolved. Given this gap in the literature, the present study examines cooperation and 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 from a total of 900 subjects in one urban and two rural areas of Bangladesh. The following research questions are posed: (i) Do perception of climate change and prosociality affect people's cooperation for reducing salinity problems? (ii) Does information provision about salinity through the lecture reduce cooperation gap for salinity problems by increasing people's cognition in urban and rural areas? To this end, answering these research questions could be helpful to reduce salinity problems by enhancing people's cooperation and cognition between urban and rural areas and to contribute to SDGs.

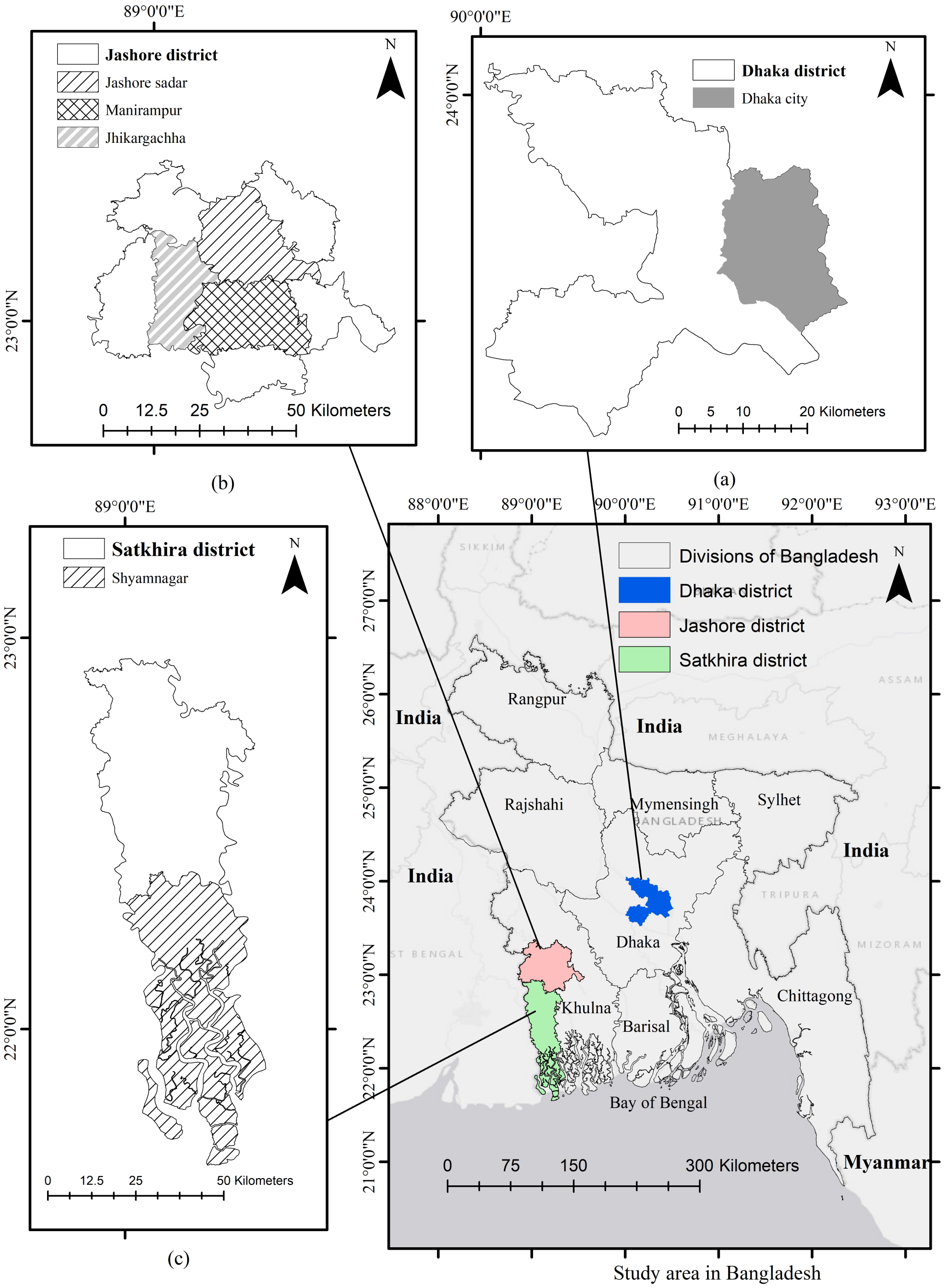
3.2 Methods

3.2.1 Survey area and sampling strategy

We conducted field experiments in the districts of Dhaka, Jashore and Satkhira in south-central and south-western Bangladesh. Figure 3.1 depicts the study areas where Dhaka is considered an urban area, while other two areas, Jashore and Satkhira are considered rural areas in this study. Dhaka is the capital city, and 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).

The field experiments were conducted between February 2019 and June 2019 and a total of 900 subjects was selected by the 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. The urban area, Dhaka, is a hectic megacity with the highest density of population in the world and number of slums. Therefore, collecting a list of residents from city offices within Dhaka city was not feasible. We conjecture that if we invite subjects by sending invitation letters based on usual household-based randomization procedure, the participation rate would be very low due to such environment. In this way, it is not possible to include subjects with low-income occupation due to their frequent movement within the city by utilizing usual household-based sampling procedures. Therefore, we implemented randomization and sampling based on occupations, collecting subjects through the channels of different organizations to increase the credibility of our experiments and to motivate subjects to participate. In this method, first, we calculated the percentage of each occupation in the total population based on some previous surveys conducted by the government agencies (Bangladesh Bureau of Statistics, 2018). Then, we randomly

Figure 3.1: Location of studied areas (districts) of Bangladesh: (a) Dhaka (urban), (b) Jashore and (c) Satkhira (rural). The map also shows the location of sub-districts in the selected districts: Dhaka city (Dhaka), Jashore sadar, Manirumpur and Jhikargachha (Jashore) and Shyamnagar (Satkhira).



selected organizations according to occupational categories and subjects from each of the organizations.

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 of urban and rural areas. Local supporting staffs and trained research assistants contacted and requested household head (husband or wife in a household) from each of the household to participate in our field experiments following the random sampling procedures specified in each type of urban and rural areas. The participation rate in field experiments was approximately 76 %. Our field experiments were conducted with real monetary payment for motivating subjects to provide their actual information and seriously participate in each game. The subjects who willingly participated in these field experiments provide their written consent signed at the beginning.

3.2.2 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 and it may occur even in the absence of human activities (see the appendix material A 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 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/himself and the receiver (see, e.g., Bolton et al., 1998; Engel, 2011). For example, Hirose et al. (2021) 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/he knows who is a receiver (ii) A well-known organization is a receiver that works on different adaptation and mitigation strategies of climate change. Different international organizations such as Intergovernmental Panel on Climate Change (IPCC), World Meteorological Organization (WMO), Adaptation Fund and United Nations Environment are providing necessary support to fight against salinity and climate change problems. 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.

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."[1] 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/he is asked to split the 150 BDT into two envelopes, "for yourself" or "for reducing salinity problems" as she/he wishes. Third, she/he is again asked to subdivide the money in the "for reducing salinity problems" envelope into two parts "for adaptation" and "for mitigation" by

[1]The BDT is the Bangladeshi currency in taka (1 USD $\approx$ 85 BDT).

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/his 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.

An experiment with the CD game is applied with and without information provision in each area 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 urban and rural 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 and 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., 2017b). The summary sheet of salinity intrusion contains the definition, causes, impacts and measures (adaptation and mitigation strategies) of salinity (see the appendix material B of summary lecture about salinity problems). 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.

The SVO game comprises 9 choice tasks, each of which represents the outcomes (equivalently, points or payoffs) for oneself and the unknown other as a pair. Each task has three options for herself/himself and the other and 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 (see the appendix material C for the instrument to measure SVO). In each task, there are three options, 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/he maximizes the joint benefit ($500 + 500 = 1000$). Finally, a choice of option (C) represents the individualistic person who maximizes her/his 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/he 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.

3.2.3 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 and 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 field experiments with questionnaire are used to collect necessary information which is divided into three factors (i) Cognitive and noncognitive factors: information provision about salinity through the lecture, perception of the cause of climate change and 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 3.1 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-squared 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

Table 3.1: 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.

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

$$y_i^* = \beta_0 + \beta_1 I_i + \beta_2 P_i + \beta_3 S_i + \beta_4 A_i + \beta_5 I_i \times A_i + \boldsymbol{\beta}_6 \mathbf{Z}_i + \varepsilon_i \tag{3.1}$$

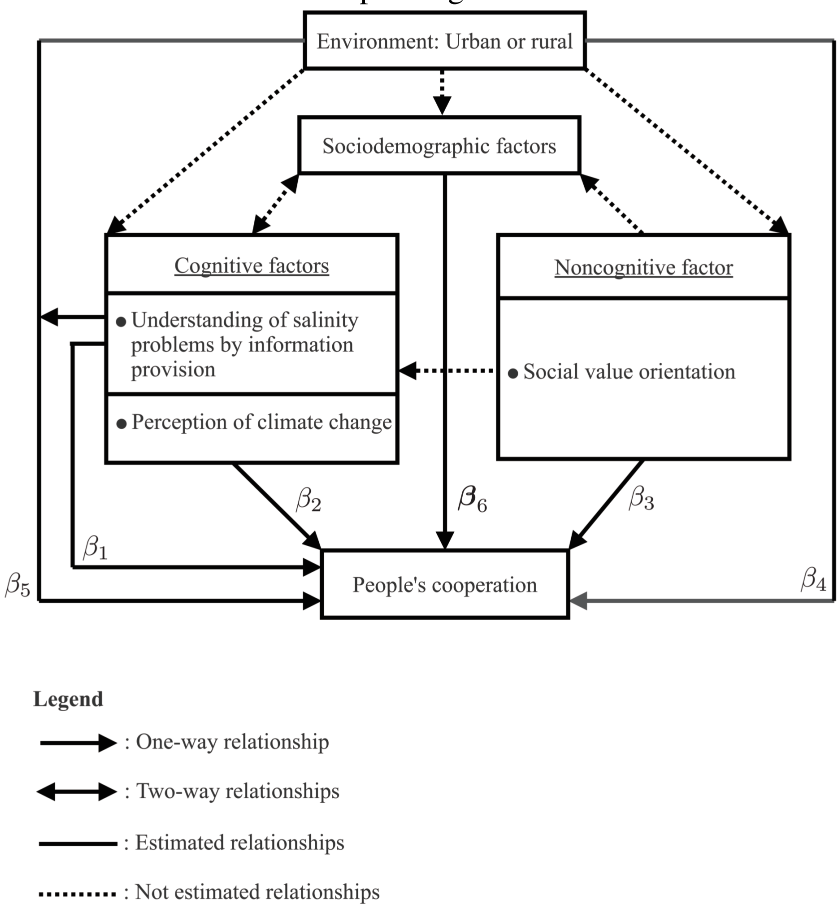
where y_i^* is a latent variable of the donation satisfying the relation $y_i = \max\{0, y_i^*\}$; I_i, P_i, S_i and A_i are dummy variables associated with information provision, perception of the cause of climate change, social value orientation and areas, respectively. Finally, $\mathbf{Z}_i$ is a vector of sociodemographic factors such as age, gender, education, occupation of the household head and household income (see table 3.1 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 $\boldsymbol{\beta}_6$ 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 (3.1) 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 TD, AD and MD as dependent variables for robustness check.

The conceptual framework in figure 3.2 visualizes the relationships among environment, cognitive, noncognitive factors and people's cooperation for reducing salinity problems along with some sociodemographic factors in urban and rural areas. The relationships among variables in figure 3.2 represented by plane arrows are tested in this research, however, some relationships showing by dashed arrows are described or proved by other research (see, e.g., Huddart-Kennedy et al., 2009; Shahrier et al., 2016; Al-Amin et al., 2019; Hirose et al., 2020; Timilsina et al., 2019). With the framework in mind, our focus is on estimating the coefficients β_1, β_2, β_3 and β_5 in figure 3.2. In this framework, a coefficient of each key variable, $\beta_j, j = 1, 2, 3, 5$, is considered to represent the effect of that variable on people's cooperation for reducing salinity problems, after the effects of all other key variables have been netted out (Wooldridge, 2010, 2019). Recall our research questions: "Do perception of climate change and prosociality affect people's cooperation for reducing salinity problems?" and "Does information provision about salinity through the lecture reduce cooperation gap for salinity problems by increasing people's cognition in urban and rural areas?" In this regard, the estimated coefficients of β_1, β_2, β_3 and β_5 in equation (3.1) are key parameters enabling us to answer the research questions. Specifically, the hypotheses of our research questions are posed as $H_0 : \beta_1 = 0$, $H_0' : \beta_2 = 0$, $H_0'' : \beta_3 = 0$ and $H_0''' : \beta_5 = 0$ and the alternatives are $H_1 : \beta_1 > 0$, $H_1' : \beta_2 > 0$, $H_1'' : \beta_3 > 0$ and $H_1''' : \beta_5 \neq 0$. The main objective of this framework is to represent how information provision, perception of climate change, prosociality as well as interaction between information provision $\times$ area affect people's cooperation. It is expected that subjects' cognition is influenced by the lecture about salinity problems so that subjects become cooperative for reducing salinity problems. However, the change in cooperation may differ across urban and rural areas in response to the information provision.

3.3 Results

Table 3.2 presents the summary statistics of the dependent variables with and without information provision for each of urban and rural areas. Without receiving information, urban subjects donate on an average 8.95, 5.18 and 3.77 BDT for each of total, adaptation and mitigation strategies of salinity, respectively. With receiving information, urban subjects donate on an average 20.29, 10.99 and 9.30 BDT for each of total, adaptation and mitigation strategies of salinity, respectively. On the other hand, the averages of total, adaptation and mitigation strategies of salinity of rural subjects are 19.79, 10.46 and 9.39 BDT without receiving information, while these averages are 22.27, 11.71 and 10.56 BDT with receiving information, respectively. Regardless of information provision, rural subjects donate more than urban subjects for each of total, adaptation and mitigation strategies of salinity. Table 3.2 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 of total, adaptation and mitigation strategies of salinity are higher in urban area than rural areas, potentially suggesting that urban subjects react more in response

Figure 3.2: A conceptual framework describing the relationships among environment, cognitive, noncognitive, sociodemographic factors and people's cooperation. β_1,β_2,β_3,β_4,β_5 and $\boldsymbol{\beta}_6$ are coefficients and a vector of coefficients for the corresponding factors.



to the information provision about salinity than rural subjects.

Table 3.3 summarizes the basic statistics of the major independent variables for 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 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 prosocial. This implies that prosociality among people is significantly higher in rural areas than urban area. In fact, a similar result is confirmed by several other studies, such as Shahrier et al. (2016, 2017) and Timilsina et al. (2019), demonstrating that prosocial people are more dominant in rural areas than 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 in table 3.3. With respect to gender, 25 % of urban subjects are female, while 56 % of rural subjects are female. This difference indicates that urban females are less interested to participate in field experiments than rural females. A possible reason for this is urban females are engaged in outside activities and they do not have enough time to participate in such activities. 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 and 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.

We apply a Mann-Whitney test to check the distributional differences for each of total, adapta-

Table 3.2: Summary statistics of the dependent variables (BDT)

	Area				Overall	p-value
	Urban		Rural			
	Without information provision	With information provision	Without information provision	With information provision		
Total donation (TD)						
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	0.01[3]
Min	0.00	0.00	0.00	0.00	0.00	
Max	50.00	150.00	150.00	150.00	150.00	
Adaptation donation (AD)						
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	0.01[3]
Min	0.00	0.00	0.00	0.00	0.00	
Max	50.00	50.00	150.00	100.00	150.00	
Mitigation donation (MD)						
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	0.01[3]
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.
[3] Mann-Whitney test is applied to check a distributional difference of the variables between urban and rural areas.

Table 3.3: Summary statistics of the independent variables

	Area		Overall	p-value
	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	0.06[3]
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	0.01[3]
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	0.14[4]
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	0.01[3]
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	0.01[3]
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	0.01[3]
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	0.01[4]
Min	3333.33	1333.33	1333.33	
Max	800000	76166.67	800000	
Sample size	300	600	900	

[1] Median in parentheses.
[2] SD stands for standard deviation.
[3] Chi-squared test is applied to examine whether or not the frequencies of the variables are independent of urban and rural areas.
[4] Mann-Whitney test is applied to check a distributional difference of the variables between urban and rural areas.

tion 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 3.2. 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-squared 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 3.4 present the regression results for total, adaptation and mitigation donations, respectively. We run different specifications for the regressions to check the robustness of our results after controlling sociodemographic, cognitive & non-cognitive and residential factors. We find that the main results in table 3.4 remain the same in all the models. Models 1-1, 2-1 and 3-1 report the estimated coefficients for independent variables in the tobit regression. Models 1-2, 2-2 and 3-2 present the estimated marginal probability (MP) 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 and 3-3 present the estimated marginal effect (ME) of each independent variable, indicating a change in the donation when the independent variable increases by one unit, holding other factors fixed. 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.

Some consistent tendencies are observed in models 1-1, 2-1 and 3-1 regarding information provision, perception of climate change, prosociality, area dummy and the interaction term between information provision and area dummy, however 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 3.4). 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 3.4. 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 and 7 % and donate 4.39, 2.67 and 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 3.4). 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 cooperative for salinity problems through the

Table 3.4: 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**
	(2.85)	(0.02)	(1.25)	(2.31)	(0.03)	(0.83)	(2.61)	(0.03)	(0.80)
Perception of climate change (r = Others)	5.01***	0.07***	3.76***	2.49*	0.05*	1.56*	2.98*	0.06*	1.63*
	(1.86)	(0.03)	(1.36)	(1.47)	(0.03)	(0.90)	(1.60)	(0.03)	(0.85)
Prosocial (r = Others)	7.14***	0.09***	5.56***	4.33***	0.09***	2.83***	3.94***	0.08***	2.27**
	(1.77)	(0.02)	(1.40)	(1.39)	(0.03)	(0.93)	(1.51)	(0.03)	(0.89)
Residential factor									
Area (r = Urban)	16.33***	0.14***	7.68***	9.60***	0.13***	3.95***	16.90***	0.26***	6.66***
	(3.01)	(0.03)	(1.74)	(2.42)	(0.04)	(1.15)	(2.69)	(0.04)	(1.02)
Information provision × Area	−11.91***			−6.36**			−8.11***		
	(3.47)			(2.77)			(3.09)		
Information provision × urban		0.21***	9.08***		0.18***	4.60***		0.17***	3.41***
		(0.04)	(1.89)		(0.05)	(1.26)		(0.05)	(1.03)
Information provision × rural		0.02	1.42		0.04	1.40		0.10	0.43
		(0.02)	(1.60)		(0.03)	(1.06)		(0.05)	(1.08)
Sociodemographic factors									
Age	−0.01	−0.0002	−0.01	−0.01	−0.0003	−0.01	0.03	0.001	0.02
	(0.08)	(0.001)	(0.06)	(0.06)	(0.001)	(0.04)	(0.07)	(0.001)	(0.04)
Gender (r = Male)	−1.87	−0.02	−1.43	−2.74*	−0.06*	−1.74*	1.11	0.02	0.62
	(1.93)	(0.03)	(1.47)	(1.52)	(0.03)	(0.96)	(1.65)	(0.03)	(0.93)
Education	−0.20	−0.003	−0.15	−0.16	−0.003	−0.10	−0.18	−0.004	−0.10
	(0.20)	(0.003)	(0.15)	(0.16)	(0.003)	(0.10)	(0.17)	(0.003)	(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*
	(1.99)	(0.03)	(1.47)	(1.56)	(0.03)	(0.96)	(1.67)	(0.03)	(0.89)
Household income[4]	1.04	0.01	0.80	−0.94	−0.02	−0.60	2.67**	0.05**	1.50**
	(1.41)	(0.02)	(1.08)	(1.12)	(0.02)	(0.72)	(1.23)	(0.03)	(0.69)

***significant at the 1 percent level, **at the 5 percent level and *at the 10 percent level. Numbers in parentheses are standard errors.
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.

channel of cognitive factors as described in figure 3.2.

Subjects with the perception of human-induced climate change are more likely to donate by 7, 5 and 6 % and donate 3.76, 1.56 and 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 3.4). 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 to donate by 9, 9 and 8 % and donate 5.56, 2.83 and 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 3.4). 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 to donate by 14, 13 and 26 % and donate 7.68, 3.95 and 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 3.4). 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 3.4). 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 × urban (rural)" row in MP and ME of table 3.4). The marginal probability (MP) of the interaction term, "information × 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 × 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.

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 and 17 % and donate 9.08, 4.60 and 3.41 BDT more for total, adaptation and mitigation than urban subjects who do not, respectively. Regarding rural 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 3.4 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 3.2.

Now, we are ready to provide the answers to our research questions, first research question is: "Do perception of climate change and prosociality affect people's cooperation for reducing salinity problems?" We set following hypotheses; $H_0' : \beta_2 = 0$ and $H_0'' : \beta_3 = 0$, while the alternatives are $H_1' : \beta_2 > 0$ and $H_1'' : \beta_3 > 0$ in the regression of equation (3.1). From the regression results, we consistently reject the null hypotheses and supporting alternative hypotheses with 1 % statistical significances. We can interpret the results that the perception of climate change and prosociality influence people's cooperation for reducing salinity problems. That means the answer of this research question is "yes," i.e., climate change perception and prosociality affect people's cooperation for reducing salinity problems. Another research question is: "Does information provision about salinity through the lecture reduce cooperation gap for salinity problems by increasing people's cognition in urban and rural areas?" The research question is expressed as the following hypotheses; the null hypotheses are $H_0 : \beta_1 = 0$ and $H_0''' : \beta_5 = 0$, while the alternatives are $H_1 : \beta_1 > 0$ and $H_1''' : \beta_5 \neq 0$ in the regression of equation (3.1). 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 gap between urban and rural areas is reduced by the treatment of information provision.

3.4 Discussion

Berenguer et al. (2005); Huddart-Kennedy et al. (2009); Shahrier et al. (2016, 2017); Rajapaksa et al. (2018) and Timilsina et al. (2021) 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 3.2, 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 3.2).

Urban people in Bangladesh are usually considered to have few experience and 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 cognitions related to climate change and salinity 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 likely to be detached from natural environment and climate. Systematically organizing such programs and education at national and global levels shall help to reduce cooperation and cognition gaps between urban and rural areas, contributing to SDGs. The lessons learned from this study are applicable to other low-lying developing countries or deltas that are highly vulnerable to salinity problems due to climate change and sea-level rise.

3.5 Conclusion

This paper has examined the effect of information provision on people's cooperation and cognition for reducing salinity problems in urban and rural areas. We hypothesize that information provision about salinity through the lecture is effective at reducing cooperation gap among people by influencing their cognition in urban and rural 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, prosociality, cognitive 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. The novel aspects of this study are (i) to consider cognitive and 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.

Chapter 4

Intrahousehold food intake inequality by family roles and age groups

4.1 Introduction

Nutritional deficiency is one of the severe problems around the globe, especially in developing countries. It is also reflected in the sustainable development goals (SDGs) that highlight the need for special attention to eradicate the malnutrition problem. Recently, intrahousehold food allocation is getting priority to researchers, policy planners and development practitioners because household food adequacy does not imply the nutritional adequacy of individuals (Akerele, 2011). Individual nutritional status largely depends on food allocation among household members (Akerele, 2011). Inequality in intrahousehold food intake is one of the major processes that exacerbate the nutritional deficiencies in certain subgroups of the population within households (Hadley et al., 2008; Akerele, 2011). Therefore, it is important to understand the dimensions of food intake inequality among household members and to identify the vulnerable subgroups of population at intrahousehold level. Such an understanding will support designing appropriate policies and enhancing equitable food intake within households for improving the nutritional status as well as contributing to SDGs. The present study addresses intrahousehold food intake inequality by subgrouping household members according to their family roles and age groups.

Literature analyzes intrahousehold adequacy in food intake with respect to gender, focusing on specific-age groups (Harris-Fry et al., 2017, 2018; Madjdian, 2018; Fadare et al., 2019; Sassi et al., 2019). Hossain et al. (2021) establish sex bias in food intake, showing that calorie and protein consumptions are higher for sons than daughters among empowered women's households in Bangladesh. Aurino (2017) demonstrates that boys are more advantaged in terms of intrahousehold food allocation than girls, particularly for children and adolescents in India. Similarly, Akerele (2011) presents that adult males consume more calories than others in Nigeria. Harris-Fry et al. (2018) find that male household heads have higher dietary adequacy and they consume higher animal-source foods than household women in Nepal. Singh (2019) assesses intrahousehold food discrimination in India, finding that gender has a significant effect on child nutrition. However, Finaret et al. (2018) examine dietary patterns of children within households in Nepal and demonstrate that there are not sex biases but age biases in intrahousehold food allocation. Overall, these studies establish gender discrimination in intrahousehold food intake by focusing on certain age groups.

Another group of research examines food intake patterns and dietary practices in relation to sociodemographic characteristics by questionnaire surveys at individual and/or household levels. Fernández-Alvira et al. (2013) assess the relationship between parental education and children food intake behaviors in Europe and show that parental education has an effect on healthy dietary practices. Rabbani (2014) compares dietary diversity of poor and non-poor households in Bangladesh by using secondary data and concludes that dietary diversity in poor families is lower than that in non-poor families. Bose and Dey (2007) examine household dietary patterns in rural and urban areas of Bangladesh and find that households suffer from food poverty not by cereals but by pulses, livestock and horticulture commodities in both areas. Ponce et al. (2006) find that the urban poor have higher dietary diversity than the rural poor in Mexico. Jayawardena et al. (2013) and Keino et al. (2014) estimate individual dietary diversity and its relation with sociodemographic factors in Sri Lanka and Kenya, respectively, reporting that age, gender, area of residence, education and ethnicity are highly correlated with the diversity. Overall, these studies suggest that sociodemographic characteristics are important determinants for explaining food intake patterns and diversity practices, regardless of the countries.

Most of the prior studies have examined food intake practices and patterns based on gender and specific-age cohorts by selecting a subgroup of the population at household level. However, there are few researches to address food intake inequality at individual level in intrahousehold settings. Given the scarcity of literature, we analyze dietary diversity scores (DDSs) of all members per household along with sociodemographic factors in a single framework, hypothesizing that there exists an inequality of dietary diversity by their family roles (fathers, mothers, sons, daughters and grandparents) and age groups (children, adults and elderly). Specifically, we seek to answer the following open research questions: (i) How do household members have dietary diversity by their roles and/or age groups, depending on poverty level and areas of residence? (ii) Who are the vulnerable food intake subgroups within households? To this end, we conduct questionnaire surveys, collecting sociodemographic information and dietary data using a 24-hours recall method of 3248 subjects in 811 households from one urban and two rural areas in Bangladesh.

4.2 Methods

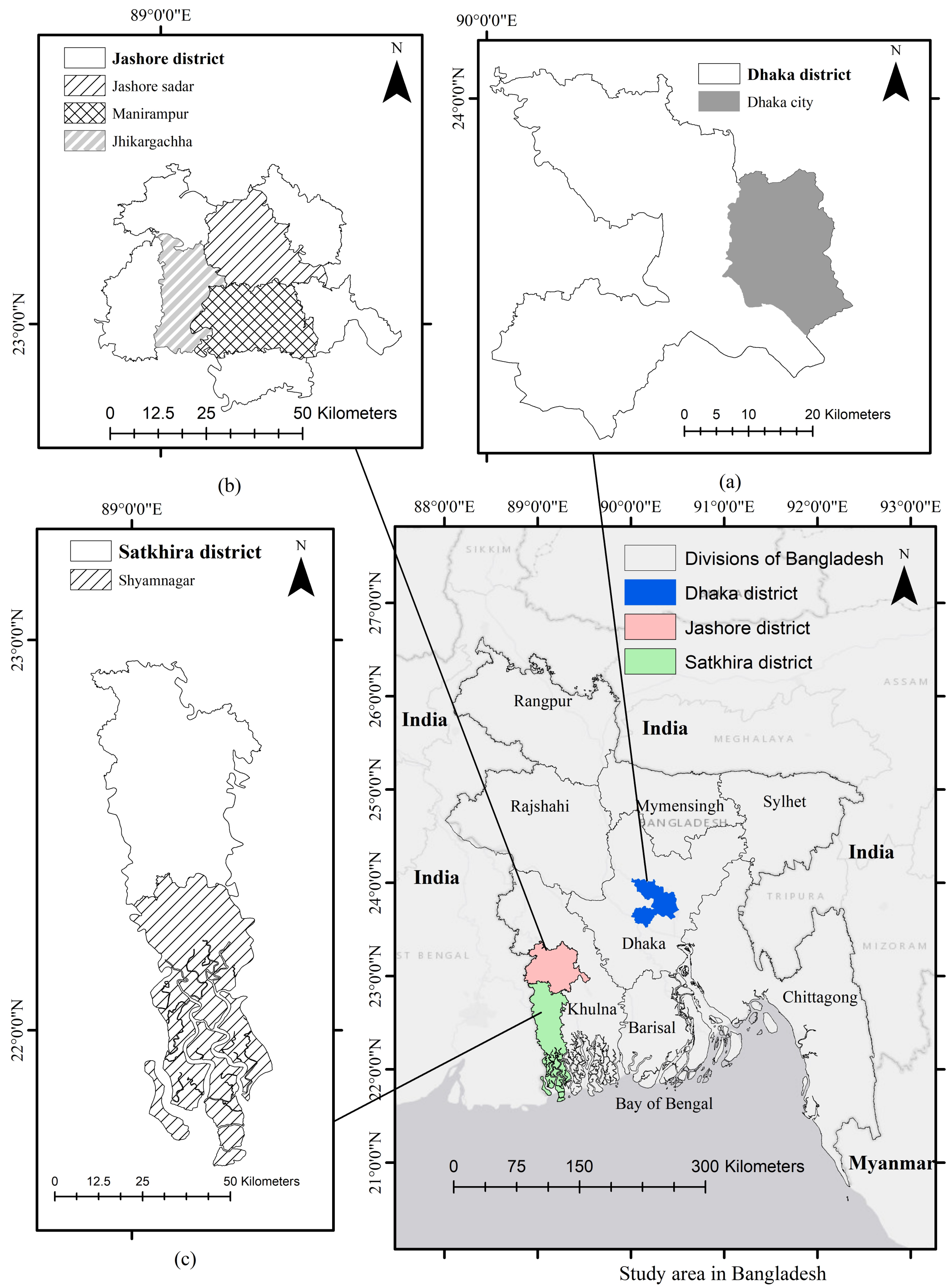
4.2.1 Survey areas, sample and sampling strategy

A cross sectional design was applied to collect data from multiple members of household with a predefined questionnaire in three districts: Dhaka, Jashore and Satkhira of Bangladesh during the period between February 2019 to June 2019 (see figure 4.1). Dhaka district is an urban and high densely populated area, while Jashore and Satkhira districts are rural and less densely populated areas in Bangladesh. The current study randomly identified 900 households, among them 300 from Dhaka, 300 from Jashore and 300 from Satkhira districts. However, 874 households provided all information contained in the questionnaire, while 26 households have missing observations in urban and rural areas. We excluded the households and the associated members with such missing observations for our analysis. In total 811 households, 219 from urban and 592 from rural areas were selected for the final analysis. Among the selected households, in total 3248 (94 %) subjects participated in the surveys. The number of subjects per household ranges from 2 to 9, with a median of 4. Data of children aged between 2 to 10 years were collected from their mothers.[1]

Data collection procedures follow a hierarchical nature where subjects are nested into households. In urban area, we applied an occupation based randomization technique for precisely representing the population. We are interested to include all social classes of people from low-income to high-income

[1]Pregnant women and children aged below 2 years are not considered subjects from the beginning of our surveys.

Figure 4.1: Location of study areas in Bangladesh



groups. The occupation-based randomization technique allows us to include all income categories of households even those who reside in slam areas (Shahrier et al., 2017; Asma et al., 2021). In this technique, first, we computed the proportion of each occupation on the basis of previous reports conducted by governmental authorities in Bangladesh (Bangladesh Bureau of Statistics, 2018). Second, we proportionally identified the required number of households from randomly selected organizations based on each occupation. In rural areas, the list of households who reside in Jashore and Satkhira districts was collected in cooperation with local non-governmental organizations (NGOs). By using this list and random number generator, we selected the required number of households from each rural area. Trained research staff contacted the selected households and obtained sociodemographic & dietary intake information through conducting our survey questionnaires.[2] The participated household head (a husband or wife in a household) provided a written consent form at the beginning.

4.2.2 Key variables

Dietary diversity is concerned with the number of food groups consumed by a person in a given period of time (Sibhatu et al., 2015; Aurino, 2017; Koppmair et al., 2017). For measuring a dietary diversity score (DDS) per subject, data on food items are categorized into 9 food groups by following the food and agriculture organization (FAO) guidelines (Food and Agriculture Organization, 2011): (i) starchy staples, (ii) dark green leafy vegetables, (iii) other vitamin A rich fruits & vegetables, (iv) other fruits & vegetables, (v) organ meat, (vi) meat & fish, (vii) eggs, (viii) legumes, nuts & seed and (ix) milk & milk products. A dummy variable is created for each food group assigning the values of 0 and 1. If a subject consumes any item from a particular food group, then the subject is assigned a value of 1, otherwise 0. A set of 9 food groups is used to calculate DDS through adding the number of food groups consumed by each subject in a period of past 24 hours. The maximum value of DDS is 9 and the minimum value is 0. We follow a 15 g minimum quantity to any of the food group when calculating DDS (Arimond et al., 2010; Food and Agriculture Organization, 2011). The diversity calculation with

[2]Research staff was carefully trained about how to conduct the surveys.

the 9 food groups adopted by FAO is established to perform well in developing countries to reflect micronutrient adequacy at individual level (Leroy et al., 2015; Ali et al., 2019). Therefore, in this study, the DDS is used as a measurement of dietary diversity per subject.

Each household member's nuclear role within a household was asked for confirmation and the data were recorded. Chan and Sobal (2011) apply the same procedure to identify the role of each household member within a household. In the present study, five types of family roles such as fathers, mothers, sons, daughters and grandparents were identified based on each household member's self-reported specific role as well as another reconfirmation from other members in the household. A husband or a wife is a household head and their family roles are categorized as fathers or mothers, respectively. Young and adult children are usually the roles of sons and daughters within households. Household members who reported their family role as grandparents are basically grandfathers and grandmothers.

The present study estimates poverty in both urban and rural areas based on the cost of basic need (CBN) method (Household Income and Expenditure Survey, 2017). The CBN method represents the level of per capita expenditure of a household to meet the basic needs of its members including both food and non-food allowances.[3] Specifically, in this method, the poverty line indicates the minimum average level of per capita expenditure below which a household cannot meet their basic food and non-food needs. The CBN approach is known as an official methodology for estimating poverty in Bangladesh where a household under absolute poverty is the one whose per capita expenditure is below the upper poverty line. The estimated upper poverty lines are 2929 and 2019 BDT in the selected urban and rural areas, respectively (Household Income and Expenditure Survey, 2017). In this study, a household is defined to be poor if per capita monthly expenditure (food and non-food) is less than the national estimated upper poverty line, otherwise non-poor.

During the questionnaire surveys, information was collected on age, areas of residence, father education, mother education, total household earners, occupation of the household head, religion, family structure and household eating practice. Some literature finds that the relationship between age and

[3]Non-food allowance includes expenditures of fuel & lightning, transport & travel, clothing, health, housing, education, recreation and leisure (Household Income and Expenditure Survey, 2017).

DDS is not linear (Humphries et al., 2017; Finaret et al., 2018). Therefore, the age of the subjects is categorized into three groups: children (below 16 years old), adults (between 16 to 60 years old) and elderly (above 60 years old), and we create the separate dummy variables to accommodate the possible nonlinearity in the analysis, following past literature (Islam and Nath, 2012; Mohajan, 2014; Barikdar et al., 2016). Table 4.1 represents the descriptions of all variables used in this study.

4.2.3 Statistical analysis

We compute and interpret the descriptive statistics, such as mean, median and standard deviation of the dependent and independent variables. We apply some statistical analyses, such as chi-squared and Mann-Whitney tests, to compare the differences of the key variables by urban and rural areas. A Wilcoxon matched-pairs singed-rank test is implemented to assess the paired differences of DDS between fathers and others household members (mothers, sons, daughters and grandparents). To quantitatively identify the inequality of DDS among household members based on their family roles and age groups, we employ an ordinary Poisson regression (zero-truncated Poisson regression) in our analysis due to the positive and count values of DDS (Cameron and Trivedi, 2013; Wooldridge, 2019). The ordinary Poisson regression can be specified as follows:

$$\ln(\mu_i) = \beta_0 + \boldsymbol{\alpha}\mathbf{F}_i + \boldsymbol{\beta}\mathbf{A}_i + \boldsymbol{\gamma}\mathbf{X}_i + \varepsilon_i \tag{4.1}$$

where μ_i is the expected value of DDS for ith subject, $\mathbf{F}_i$, $\mathbf{A}_i$ and $\mathbf{X}_i$ are the vectors of family role dummies, age group dummies and sociodemographic variables, respectively, and ε_i is an error term. The β_0 is the parameter associated with the intercept, while $\boldsymbol{\alpha} = (\alpha_1, \alpha_2, \ldots, \alpha_5)$, $\boldsymbol{\beta} = (\beta_1, \beta_2)$ and $\boldsymbol{\gamma} = (\gamma_1, \gamma_2, \ldots, \gamma_9)$ are the vectors of the parameters associated with $\mathbf{F}_i$, $\mathbf{A}_i$ and $\mathbf{X}_i$, respectively. In this research, we are interested to estimate the coefficients of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ in equation (4.1). We can interpret the coefficients of explanatory variables in Poisson regression in the following way. Suppose, an estimated coefficient of each sociodemographic variable, $\hat{\gamma}_j, j = 1, 2, \ldots, 9$, is considered to represent the marginal effect of that variable on DDS after the effects of the other variables are netted out. The

Table 4.1: Definitions of variables

Variables	Description
Dependent variable	
Dietary diversity score (DDS)	Dietary diversity score is defined as a count variable that takes values from 0 to 9 based on the number of food groups consumed over a 24-hours period.
Independent variables	
Family role dummy variables (Base group = Fathers)	
Mothers	Fathers 0 and Mothers 1.
Sons	Fathers 0 and Sons 1.
Daughters	Fathers 0 and Daughters 1.
Grandparents	Fathers 0 and Grandparents 1.
Age group dummy variables (Base group = Adults)	
Children	Adults 0 and Children 1.
Elderly	Adults 0 and Elderly 1.
Sociodemographic variables	
Father education	Years of schooling 0 to 14 (0 = No schooling and refused group [1], 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).
Mother education	Years of schooling 0 to 14 (0 = No schooling and refused group [1], 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).
Household poverty	Non-poor 0 and Poor 1.
Area	Urban 0 and Rural 1.
Total household earners	Numbers.
Occupation of the household head	Non-agriculture 0 and Agriculture 1.
Religion	Non-Muslim 0 and Muslim 1.
Family structure	Nuclear family 0 and Extended family 1.
Household eating practices	Takes the value 1 when household members eat together, otherwise 0.

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

marginal effect of a continuous explanatory variable, such as father education, is derived from a formula $\hat{\gamma}_1 \times 100$ to be a percentage change in the expected value of DDS when one year increase in father education. If a dummy explanatory variable, such as household poverty (poor $= 1$ and non-poor $= 0$), is calculated by $[\exp(\hat{\gamma}_3 - 1)] \times 100$ being interpreted as a percentage change in the expected value of DDS when the household poverty increases from 0 to 1 (see, e.g., Wooldridge, 2019).

The subjects are nested (or clustered) in (by) households, and thus, the ordinary Poisson regression model is customized to consider the cluster-specific effect in the model. The simplest modification is called the two-level random intercept Poisson regression model in which the intercept captures the cluster-specific effect from the other covariates (Goldstein, 2011). The multilevel model provides efficient estimates and captures the unobserved variation in the model (Alom et al., 2012; Imam et al., 2018). Moreover, the multilevel modeling is employed to differentiate the individual and household levels characteristics for the relationship between independent and dependent variables (Chan and Sobal, 2011). The two-level random intercept Poisson regression model considering subjects at level 1 and households at level 2 can be written as follows:

$$\ln(\mu_{ik}) = \beta_0 + \boldsymbol{\alpha}\mathbf{F}_{ik} + \boldsymbol{\beta}\mathbf{A}_{ik} + \boldsymbol{\gamma}\mathbf{X}_{ik} + \varepsilon_{0k} + \varepsilon_{ik} \tag{4.2}$$

where μ_{ik} is the expected value of DDS for ith subject living in kth cluster (household). $\mathbf{F}_{ik}$, $\mathbf{A}_{ik}$ and $\mathbf{X}_{ik}$ are the vectors of family role dummies, age group dummies and sociodemographic variables, respectively for ith subject in kth cluster (household). The regression coefficient β_0 is the intercept, while the coefficients $\boldsymbol{\alpha} = (\alpha_1, \alpha_2, \ldots, \alpha_5)$, $\boldsymbol{\beta} = (\beta_1, \beta_2)$ and $\boldsymbol{\gamma} = (\gamma_1, \gamma_2, \ldots, \gamma_9)$ are the vectors of the parameters associated with $\mathbf{F}_{ik}$, $\mathbf{A}_{ik}$ and $\mathbf{X}_{ik}$, respectively. The ε_{0k} is a cluster-specific random component that assumes to be independently and normally distributed and ε_{ik} is an error term. The interpretation of the regression coefficients in a two-level random intercept Poisson regression remains the same as an ordinary Poisson regression model but the intercept interpretation is different (Rabe-Hesketh and Skrondal, 2008). The cluster-specific random component can capture the unobserved variation in the model that is not explained by the explanatory variables. If the cluster-specific effect is significant in the model, then we conclude that subjects from different households with the same set of values and levels of the independent variables will show different DDS.

4.3 Results

Table 4.2 summarizes the descriptive statistics, such as mean, median and standard deviation of dietary diversity score (DDS) and food group consumption by the family roles. The mean DDS for the overall sample is 4.88 (see the "overall" column in table 4.2). The mean DDS is consistent with some previous studies and they find that the DDS is relatively low at all ages of people in Bangladesh as compared to the world average, varying between 4.00 and 5.00 in average (median) values (Bose and Dey, 2007; Rabbani, 2014; Ali et al., 2019; Islam et al., 2020). However, it is identified that grandparents have a lower DDS than other household members (see table 4.2). Food groups, such as starchy staples, dark green leafy vegetables, other vitamin A rich fruits & vegetables and meat & fish are mostly consumed, while consumption of animal sources of foods, such as organ meat, eggs, milk & milk products, consumption of other fruits & vegetables and legumes, nuts & seeds are relatively low consumed by subjects, irrespective of the family roles. Overall, the DDS and food group consumption among household members vary by their family roles.

Table 4.3 presents the summary statistics of the key dependent and independent variables for urban and rural areas. A major difference is observed in the mean DDS in urban and rural areas. Urban subjects (5.61) have significantly higher dietary diversity than rural subjects (4.63). Considering family role dummies, the differences exist in the percentages of grandparents between urban (3 %) and rural areas (6 %). Based on age groups, the percentages of children and elderly (22 % and 5 %) are higher in rural areas than urban area (17 % and 3 %). There are variations in father and mother educations between urban and rural areas. The median of father education (mother education) in urban area is 12 (11) years of schooling, while this median is 7 (7) years of schooling in rural areas. Regarding the household poverty, 17 % overall subjects are considered poor people and a largest variation is found in the percentages of poor people living in urban and rural areas. In urban area, 5 % subjects are

Table 4.2: Summary statistics of the dependent variable by family roles

	Family roles					Overall
	Fathers	Mothers	Sons	Daughters	Grandparents	
Dietary diversity score (DDS)						
Average (Median) [1]	5.00 (5.00)	4.92 (5.00)	4.93 (5.00)	4.74 (5.00)	4.44 (4.00)	4.88 (5.00)
SD [2]	1.62	1.60	1.54	1.50	1.48	1.57
Starchy staples						
Average (Median)	0.99 (1.00)	0.99 (1.00)	0.99 (1.00)	0.99 (1.00)	0.98 (1.00)	0.99 (1.00)
SD	0.06	0.04	0.04	0.07	0.11	0.06
Dark green leafy vegetables						
Average (Median)	0.72 (1.00)	0.71 (1.00)	0.69 (1.00)	0.65 (1.00)	0.68 (1.00)	0.69 (1.00)
SD	0.45	0.45	0.46	0.48	0.47	0.46
Other vitamin A rich fruits & vegetables						
Average (Median)	0.78 (1.00)	0.78 (1.00)	0.77 (1.00)	0.73 (1.00)	0.77 (1.00)	0.77 (1.00)
SD	0.42	0.41	0.42	0.44	0.42	0.42
Other fruits & vegetables						
Average (Median)	0.30 (0.00)	0.28 (0.00)	0.30 (0.00)	0.29 (0.00)	0.18 (0.00)	0.29 (0.00)
SD	0.46	0.45	0.46	0.45	0.38	0.45
Organ meat						
Average (Median)	0.35 (0.00)	0.35 (0.00)	0.34 (0.00)	0.31 (0.00)	0.30 (0.00)	0.34 (0.00)
SD	0.48	0.48	0.47	0.46	0.46	0.47
Meat & fish						
Average (Median)	0.71 (1.00)	0.70 (1.00)	0.71 (1.00)	0.65 (1.00)	0.71 (1.00)	0.69 (1.00)
SD	0.45	0.46	0.45	0.48	0.45	0.46
Eggs						
Average (Median)	0.39 (0.00)	0.37 (0.00)	0.36 (0.00)	0.41 (0.00)	0.29 (0.00)	0.38 (0.00)
SD	0.49	0.48	0.48	0.49	0.46	0.48
Legumes, nuts & seeds						
Average (Median)	0.52 (1.00)	0.51 (1.00)	0.52 (1.00)	0.47 (0.00)	0.42 (0.00)	0.50 (1.00)
SD	0.50	0.50	0.50	0.50	0.49	0.50
Milk & milk products						
Average (Median)	0.23 (0.00)	0.22 (0.00)	0.25 (0.00)	0.23 (0.00)	0.10 (0.00)	0.23 (0.00)
SD	0.42	0.41	0.43	0.42	0.31	0.42
Sample size	798	802	799	686	163	3248

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

living below the poverty line, while this percentage is 21 % in rural areas. According to the national estimation, the percentages of poor people in the selected urban and rural areas are 8.45 % and 22.75 %, respectively (Household Income and Expenditure Survey, 2017).

The number of total household earners is 1 as a median in both urban and rural areas in table 4.3. Regarding the occupation, all urban household heads are engaged with non-agricultural activities, while 41 % rural household heads are engaged in agricultural activities. Table 4.3 also shows that 90 % of urban subjects are Muslim, while 87 % of the subjects are Muslim in rural areas. The main family structure of the overall sample in both areas (urban and rural) is the nuclear family, however, the percentage of the extended family is relatively higher (30 %) in rural areas than urban area (19 %). In terms of household eating practices, 68 % (85 %) of urban subjects (rural subjects) have a practice to eat together with their family members. In summary, rural areas have lower dietary diversity but higher number of grandparents, children and elderly than urban area. Most of the sociodemographic variables, such as poverty, education, earners, occupation, religion, family structure and eating practices vary between urban and rural areas.

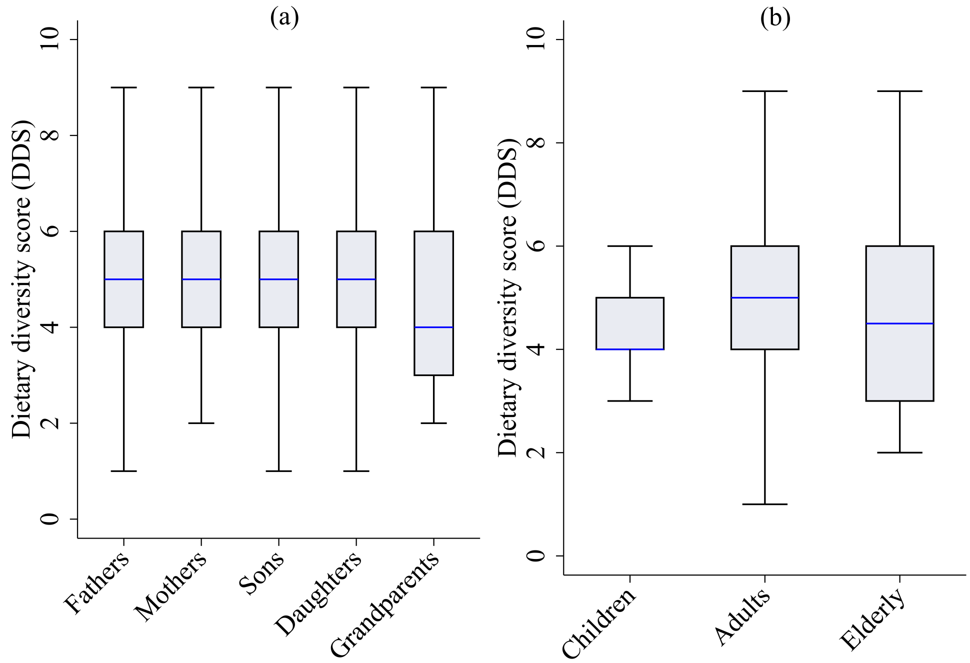
Figure 4.2 (a) shows the boxplots of dietary diversity scores (DDSs) of household members by their family roles and figure 4.2 (b) presents the boxplots of DDSs by their age groups. In figure 4.2 (a), the DDS distribution in grandparents is lower than those in fathers with respect to the medians. We apply a Wilcoxon matched-pairs singed-rank test to compare the distributional differences of fathers' DDS with other household members' DDS. A null hypothesis is that the distributions of DDS between fathers and mothers pairs are the same. The following pairs are tested: (i) fathers' DDS *vs* mothers' DDS (ii) fathers' DDS *vs* sons' DDS (iii) fathers' DDS *vs* daughters' DDS and (iv) fathers' DDS *vs* grandparents' DDS. We find that all cases (i) ($Z = 3.36, p = 0.01$), (ii) ($Z = 2.07, p < 0.04$), (iii) ($Z = 1.64, p < 0.10$) and (iv) ($Z = 4.96, p < 0.01$) reject the null hypotheses. In figure 4.2 (b), it can be seen that the DDS distributions in children and elderly are lower than those in adults with respect to the medians. We run a Mann-Whitney test with a null hypothesis that the DDS distributions between children and adults are the same. The following pairs are considered: (i) children' DDS vs adults' DDS (ii) elderly' DDS vs adults' DDS. We reject the case (i) ($Z = -4.61, p = 0.01$), implying that there is a

Table 4.3: Summary statistics of the dependent and independent variables by areas

		Area		Overall	p-value
		Urban	Rural		
Dietary diversity score					
	Average (Median)[1]	5.61 (6.00)	4.63 (4.00)	4.88 (5.00)	
	SD[2]	1.78	1.40	1.57	0.01[3]
Family role dummies (Base group = Fathers)					
Mothers					
	Average (Median)	0.26 (0.00)	0.24 (0.00)	0.25 (0.00)	
	SD	0.44	0.43	0.43	0.27[4]
Sons					
	Average (Median)	0.26 (0.00)	0.24 (0.00)	0.25 (0.00)	
	SD	0.44	0.43	0.43	0.48[4]
Daughters					
	Average (Median)	0.19 (0.00)	0.22 (0.00)	0.21 (0.00)	
	SD	0.40	0.41	0.41	0.18[4]
Grandparents					
	Average (Median)	0.03 (0.00)	0.06 (0.00)	0.05 (0.00)	
	SD	0.17	0.23	0.22	0.01[4]
Age group dummies (Base group = Adults)					
Children					
	Average (Median)	0.17 (0.00)	0.22 (0.00)	0.21 (0.00)	
	SD	0.38	0.41	0.41	0.01[4]
Elderly					
	Average (Median)	0.03 (0.00)	0.05 (0.00)	0.04 (0.00)	
	SD	0.16	0.21	0.20	0.02[4]
Father education					
	Average (Median)	10.55 (12.00)	6.04 (7.00)	7.19 (8.00)	
	SD	3.96	4.47	4.77	0.01[4]
Mother education					
	Average (Median)	9.60 (11.00)	5.99 (7.00)	6.91 (8.00)	
	SD	4.11	4.01	4.33	0.01[4]
Household poverty (Base group = Non-poor)					
	Average (Median)	0.05 (0.00)	0.22 (0.00)	0.17 (0.00)	
	SD	0.22	0.41	0.38	0.01[4]
Total household earners					
	Average (Median)	1.51 (1.00)	1.40 (1.00)	1.42 (1.00)	
	SD	0.66	0.63	0.64	0.01[3]
Occupation of the household head (Base group = Non-agriculture)					
	Average (Median)	0.00 (0.00)	0.41 (0.00)	0.30 (0.00)	
	SD	0.00	0.49	0.46	0.01[4]
Religion (Base group = Non-Muslim)					
	Average (Median)	0.90 (1.00)	0.87 (1.00)	0.88 (1.00)	
	SD	0.30	0.34	0.33	0.01[4]
Family structure (Base group = Nuclear family)					
	Average (Median)	0.19 (0.00)	0.30 (0.00)	0.27 (0.00)	
	SD	0.40	0.46	0.44	0.01[4]
Household eating practices (Base group = Others)					
	Average (Median)	0.68 (1.00)	0.85 (1.00)	0.80 (1.00)	
	SD	0.47	0.36	0.40	0.01[4]
Sample size		831	2417	3248	

[1] Median in parentheses.
[2] SD stands for standard deviation.
[3] Mann-Whitney test is applied to check a distributional difference of the variable between urban and rural areas.
[4] Chi-square test is applied to examine whether or not the frequencies of the variables are independent of urban and rural areas.

Figure 4.2: Boxplots of dietary diversity scores (DDSs) by (a) family roles and (b) age groups



distributional difference of DDS between children and adults. However, case (ii) ($Z = 1.59, p = 0.11$) does not reject.

The descriptive statistics, tests and diagrams suggest that the DDS varies among household members by their family roles and/or age groups. We run ordinary and two-level random intercept Poisson regressions to further characterize the relationships of DDS with the family role and age group dummies after controlling sociodemographic variables. Table 4.4 reports the estimated coefficients of the explanatory variables on DDS in the ordinary and two-level random intercept Poisson regressions with several model specifications, respectively. At first, we include the family role dummies with fathers as the base group in Model 1-1 (Model 2-1) in the ordinary Poisson regression (the two-level random intercept Poisson regression). Then, we exclude the family role dummies and include the age group dummies with adults as the base group in Model 1-2 (Model 2-2) in the ordinary Poisson regression (the two-level random intercept Poisson regression). Finally, we include all the independent variables, such as family role dummies, age group dummies and sociodemographic variables in Model 1-3 (Model 2-3) in the ordinary Poisson regression (the two-level random intercept Poisson regression), in addition to the base group specifications of Models 1-1 and 1-2 (Models 2-1 and 2-2) in table 4.4.

Sociodemographic variables, such as father education, mother education, household poverty, area and total household earners, are identified to be statistically and economically significant in Model 1-3 (Model 2-3) in the ordinary Poisson regression (the two-level random intercept Poisson regression) (see table 4.4). The effects of father and mother educations are generally demonstrated to be positive on their household nutrition. In terms of the father education, the ordinary Poisson regression (the two-level random intercept Poisson regression) in Model 1-3 (Model 2-3) finds that the expected DDS increases by 0.7 % (0.7 %) per one-category increase in schooling. In case of the mother education, the expected DDS increases by 1 % (1 %) per one-category increase in schooling (see table 4.4). The results suggest that education is one of the important factors to improve dietary diversity at households, being consistent with Huq and Tasnim (2008); Yen and Tan (2012); Jayawardena et al. (2013) and Fadare et al. (2019). Overall, we corroborate that there is a positive relationship between education and healthy food practices in intrahousehold settings.

The regression results of household poverty in Model 1-3 (Model 2-3) find that the expected DDS of poor is 15 % (15 %) lower than non-poor, holding other factors fixed. Household poverty is a dummy variable, therefore, we use the following formula to calculate the marginal effect of household poverty: $\exp(0.14) - 1 \approx 0.15 = 15\,\%$. The results indicate that poor people have lower dietary diversity than non-poor, being consistent with the past literature. Rabbani (2014) reports that poor families' foods are not diversified compared to non-poor families. Likewise, the results of area dummy in Model 1-3 (Model 2-3) can be interpreted. The expected DDS of rural subjects is calculated to be 12 % (12 %) lower than that of urban subjects (the marginal effect of the area dummy $= \exp(0.11) - 1 \approx 0.12 = 12\,\%$). The results demonstrate that dietary diversity of urban subjects is higher than that in rural subjects, being in line in literature. For instance, Bose and Dey (2007) show that consumption of non-cereal foods in urban areas is diversified as compared to rural areas. The number of total household earners has an effect on DDS, i.e., the ordinary Poisson regression (the two-level random intercept Poisson regression) in Model 1-3 (Model 2-3) estimates a 5 % (5 %) increase in the expected DDS per one-earner increase within the household. Bashir et al. (2010) also demonstrate the same result in a

Table 4.4: Regression coefficients of the independent variables on DDS in the ordinary Poisson and two-level random intercept Poisson regressions

	Ordinary Poisson regression			Two-level random intercept Poisson regression		
	Model 1-1	Model 1-2	Model 1-3	Model 2-1	Model 2-2	Model 2-3
Family role dummies (Base group = Fathers)						
Mothers	−0.02		−0.01	−0.02		−0.01
	(0.02)		(0.02)	(0.02)		(0.02)
Sons	−0.01		0.03	−0.02		0.01
	(0.02)		(0.03)	(0.02)		(0.03)
Daughters	−0.05**		0.01	−0.04*		0.003
	(0.02)		(0.03)	(0.02)		(0.03)
Grandfathers	−0.13**		−0.17**	−0.12*		−0.15**
	(0.06)		(0.07)	(0.06)		(0.07)
Grandmothers	−0.11**		−0.13**	−0.10**		−0.12**
	(0.05)		(0.06)	(0.05)		(0.06)
Age group dummies (Base group = Adults)						
Children		−0.07***	−0.08***		−0.05**	−0.06**
		(0.02)	(0.02)		(0.02)	(0.03)
Elderly		−0.04	0.07		−0.04	0.05
		(0.04)	(0.05)		(0.04)	(0.05)
Sociodemographic variables						
Father education			0.007***			0.007***
			(0.002)			(0.003)
Mother education			0.01***			0.01***
			(0.003)			(0.003)
Household poverty (Base group = Non-poor)			−0.14***			−0.14***
			(0.02)			(0.03)
Area (Base group = Urban)			−0.11***			−0.11***
			(0.02)			(0.03)
Total household earners			0.05***			0.05***
			(0.01)			(0.02)
Occupation of the household head (Base group = Non-agriculture)			0.03			0.03
			(0.02)			(0.02)
Religion (Base group = Non-Muslim)			−0.001			0.003
			(0.02)			(0.02)
Family structure (Base group = Nuclear family)			0.01			0.01
			(0.02)			(0.02)
Household eating practices (Base group = Others)			0.02			0.02
			(0.02)			(0.03)
Observations	3248	3248	3248	3248	3248	3248
Groups: Household	-	-	-	811	811	811
Random effect (SD[1]) : Household	-	-	-	0.20***	0.20***	0.16***
Likelihood-Ratio/Wald χ^2	12.51**	14.04***	258.02***	7.98	6.58**	172.80***
AIC[2]	12686.37	12678.85	12464.45	12511.65	12507.10	12384.42

***significant at the 1 percent level, **at the 5 percent level and *at the 10 percent level. Numbers in parentheses are standard errors.

[1] SD stands for standard deviation.

[2] AIC stands for Akaike information criterion.

survey study, finding that the likelihood of being secured in food intake is likely to increase in a number of earners per household.

Models 1-3 and 2-3 examine the effects of family role and age group dummies on DDS in table 4.4, more precisely, controlling for other sociodemographic variables. The regression results of family role (age group) dummies in Model 1-3 (Model 2-3) do not differ from that of Model 1-1 (Model 2-1), confirming the consistency and robustness of our results. Family role and age group dummies are identified to be important determinants of DDS in both the ordinary and two-level random-intercept Poisson regressions, with 5 % statistical and economic significance. The ordinary Poisson regression (the two-level random intercept Poisson regression) estimation in Model 1-3 (Model 2-3) reveals that the expected DDS of grandfathers and grandmothers are 19 % and 14 % (16 % and 13 %) lower than those of fathers. The marginal effects of family role dummies are calculated by using the formula: $[\exp(\hat{\alpha}_j - 1)] \times 100$, $\hat{\alpha}_j$ is the estimated regression coefficient of the dummy variable. For example, $\exp(0.17) - 1 \approx 0.19 = 19\,\%$. Likewise, the results of age group dummies in Model 1-3 (Model 2-3) can be interpreted. The expected DDS of children is calculated to be 8 % (6 %) lower than those of adults. The marginal effects of the age group dummies are calculated by using the earlier mentioned formula (i.e., $\exp(0.08) - 1 \approx 0.08 = 8\,\%$). Consistent with the summary statistics, both regression estimations confirm that the inequality in food intake among household members and identify that grandparents and children are the vulnerable food intake subgroups within households.

In table 4.4, we notice that father and mother educations are important to uniformly raise the standard of dietary diversity for their household, however, they do not resolve the inequality. We do not find any interaction effect between family roles and father or mother educations. However, the cluster-specific effect is observed and significant in Models 2-1, 2-2 and 2-3 in the two-level random intercept Poisson regressions, meaning that subjects from different households with the same set of values and levels of the independent variables will show different DDS (see table 4.4). The magnitude of the cluster-specific effect is greater than the effects of some of the important explanatory variables in the models. For instance, the standard deviation of the random cluster-specific effect in Model 2-3 is 0.16, indicating one standard deviation change in the cluster-specific effect has a greater effect on DDS than household poverty ($\gamma_3 = -0.14$). In such a situation, the cluster-specific effect needs proper investigation for appropriate policy intervention. For example, household-specific characteristics, such as food practices, frequencies of the main meals, nutritionally balanced foods and father & mother nutritional awarenesses, could be given priority for the improvement of household dietary diversity practices.

Now, it is time to provide the answers to the following open research questions: (i) How do household members have different dietary diversity by their roles and/or age groups, depending on poverty level and areas of residence? The summary statistics, tests and diagram suggest that household members do not have equal dietary diversity by their family roles and/or age groups. The regression results further accomplish that household members have different DDSs after controlling for sociodemographic variables. Overall, it can be concluded that household members have different dietary diversity, confirming an existence of intrahousehold food intake inequality, irrespective of poverty level and areas of residence. Another research question is: (ii) Who are the vulnerable food intake subgroups within households? The regression results consistently show that grandparents (children) have lower dietary diversity than those of fathers (adults). This indicates that grandparents and children are the vulnerable subgroups in case of nutritional adequacy within households.

4.4 Discussion

Inequality in intrahousehold food intake is a major concern that promotes nutrient deficiencies and perpetuates the malnutrition problem (Hadley et al., 2008; Akerele, 2011). Literature argues that family roles influence how people perceive and behave toward food and nutritional outcomes in a certain way (Chan and Sobal, 2011; Madjdian and Bras, 2016; Humphries et al., 2017). However, it is currently unknown about whether or not intrahousehold food intake inequality exists by the family roles and/or age groups. This research confirms intrahousehold food intake inequality and finds that grandparents and children are the vulnerable food intake subgroups within households. Now, it is time to answer "why do household members have significantly different food intakes?" We make the following two arguments to explain intrahousehold food intake inequality in Bangladesh. One is the "contribution rule" and another one is the "lack of mothers' nutritional knowledge."

Intrahousehold food intake inequality can be explained by using the "contribution rule." It describes a situation where household members who have contribution to the family are more likely to be favored for food and nutrition than others (Harris-Fry et al., 2017). For example, Blum et al. (2019) indicate that adult males and boys are more favoured for food and nutrition than others because they are expected to provide money and care for their parents in current and old age. Again, Harris-Fry et al. (2018) document that family invests more nutritious food to the economically productive members resulting in higher incomes. According to the "contribution rule," it is considered that household heads and adults are favored in terms of food and nutrition, because they are the main sources of financial support and security to the household in the present and future time. On the other hand, grandparents and children are not favored, because they are considered to have no contribution to the household. We argue that the "contribution rule" implicitly remains as part of food cultures in Bangladesh, being applicable to explain an existence of intrahousehold food intake inequality. At the same time, we note that household members should have equal dietary diversity and receive a certain share of available foods in a well-balanced manner for the betterment of health in theory (Dos-Santos, 2020).

A household woman, i.e, a mother, is the sole decision-maker of preparation, serving and allocation of food in Bangladesh. For allocating meals, mothers often underestimate calories and nutritional requirements of household members. In reality, it is very difficult to measure the relative size of dietary needs for every household member, especially for children and older people. Moreover, there are many misconceptions regarding nutritional knowledge. For example, one statement regarding nutrition is that children consume nearly one-fourth as much food as they require at adult life (Finaret et al., 2018). This type of perception may create difficulty to ensure equitable food intake within households. Food allocation among household members is also related to mothers' knowledge, attitudes and practice (Angeles-Agdeppa et al., 2019). Several studies document that mothers' nutritional knowledge is positively related to receive a good nutritious diet to the family members (Moore et al., 2009; Halder and Kejriwal, 2016; Hirvonen et al., 2017). If this is the case, we conjecture that lack of mothers' nutritional knowledge shall be responsible for intrahousehold food intake inequality. Therefore, it is recommended to specifically examine how mothers' nutritional awareness is related to intrahousehold food intake and take good nutritional care of household members.

The study has several implications in the field of research and policy formulation regardless of the developed and developing countries. Previous studies examine the levels and patterns of malnutrition. However, they often fail to take into account family roles and age effects on intrahousehold food intake. As a result, policymakers might have been misguided to take appropriate policies for eliminating the malnutrition problem. National health and nutrition policies always focus on the underprivileged population for improving nutritional status. Although females are reported to be disadvantaged in food allocation (Ndiku et al., 2011; Madjdian and Bras, 2016; Harris-Fry et al., 2018; Hossain et al., 2021), this study does not find any gender difference in dietary diversity. The reason may be that the government of Bangladesh takes many actions regarding gender gap and inequality. We confirm that grandparents and children are the vulnerable groups in terms of food intake within households, therefore, it is necessary to focus on improving their dietary diversity. Father and mother educations have effects to uniformly raise dietary diversity for household members, but they do not resolve the intrahousehold inequality. Systematically organizing awareness programs of diversity practices at household level shall be necessary for the resolution of intrahousehold food intake inequality with a target of fathers and mothers for the betterment of nutritional and health status as well as contributing to SDGs.

4.5 Conclusion

We have examined dietary diversity scores (DDSs) of household members with a focus on their family roles (fathers, mothers, sons, daughters and grandparents) and age groups (children, adults and elderly). Whereas theory suggests that members in a household should have equal dietary diversity by receiving a certain share of available foods, this research hypothesizes that they do not to do so by their roles and/or age groups. We conduct questionnaire surveys, collecting sociodemographic information and dietary data using a 24-hour recall method of 3248 subjects in 811 households from one urban and two rural areas in Bangladesh. The study has three major findings: (i) Poor and rural people have lower dietary diversity than non-poor and urban people, respectively. (ii) Grandparents (children) have lower dietary diversity than do fathers (adults), confirming an existence of intrahousehold food intake inequality by the roles and/or age groups, irrespective of poverty level and areas of residence. (iii) Father and mother educations are crucial determinants to uniformly raise the standard of dietary diversity for their household, however, they do not resolve the inequality. Overall, we suggest that specific awareness and education programs of dietary diversity shall be necessary for resolving the inequality with a target group of fathers and mothers for the betterment of nutrition and health at household level, contributing to SDGs.

Chapter 5

Conclusion

With ongoing climate change and urbanization, it is necessary to understand people's economic and health behaviors at household level for the betterment of health and sustainable societies. Therefore, in the first study of this thesis, we conduct questionnaire surveys with 527 households: 273 subjects from the non-salinity and 254 subjects from the salinity rural coastal areas of Bangladesh. We empirically characterize the effects of salinity on human health by segregating water-borne, water-washed and water-related diseases. The statistical analysis shows that the probabilities of being affected by water-borne, water-washed and water-related diseases are higher in the salinity areas than the non-salinity areas. To counter these risks, we find that consuming rainwater as a drinking water and/or being in normal BMI are quite effective. Our results suggest that the long-term reservation of rainwater and addressing community-based food security & nutrition programs shall be effective countermeasures to reduce the risk of health problems in the coastal population and to sustain their lives even under the threat of salinity.

In the second study, we examine the effect of information provision on people's cooperation and cognition for reducing salinity problems in urban and rural areas. We pose the following research questions: (i) Do perception of climate change and prosociality affect people's cooperation for reducing salinity problems? (ii) Does information provision about salinity through the lecture reduce cooperation gap for salinity problems by increasing people's cognition in urban and rural areas? Therefore, we design and institute a field experiment to examine the effect of information provision on people's cooperation for reducing salinity problems from a total of 900 subjects in one urban and two rural areas of 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 regression 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 sustainable development goals through affecting people's cognition.

In the third study, we analyze dietary diversity scores (DDSs) of all members per household along with sociodemographic factors in a single framework, hypothesizing that there exists an inequality of dietary diversity by their family roles (fathers, mothers, sons, daughters and grandparents) and age groups (children, adults and elderly). We conduct questionnaire surveys, collecting sociodemographic information and dietary data using a 24-hour recall method of 3248 subjects in 811 households from one urban and two rural areas in Bangladesh. The statistical analysis demonstrates three major findings. First, poor and rural people have lower dietary diversity than non-poor and urban people, respectively. Second, grandparents (children) have lower dietary diversity than do fathers (adults), confirming an existence of intrahousehold food intake inequality by the roles and/or age groups, irrespective of poverty level and areas of residence. Third, father and mother educations are crucial determinants to uniformly raise the standard of dietary diversity for their household, however, they do not resolve the inequality. Overall, it is suggested that awareness programs of dietary diversity shall be necessary with a target group of fathers and mothers for the betterment of intrahousehold inequality and health at household level, contributing to SDGs.

Finally, we note some limitations of our study and suggest some possible research in the future. In the second chapter, we examine the association between water-related diseases and coastal salinity. The following limitations can be listed. First, there may be additional environmental determinants of water-related diseases such as cleanliness and/or sanitation at the community and city levels. Second, we did not consider the variation of sodium consumption in individual food intake, although it could possibly affect individual health risks. Third, we only conducted cross-sectional analysis, implying that the seasonality of salinity levels is not explicitly considered.[1] We could not take into account the above factors in our questionnaire surveys because of several constraints we faced with respect to time, subjects and budgets. In the future, more detailed data collection and cross effects analysis should be made regarding anthropometric & environmental factors, per person sodium intake and seasonality with panel data structures. By doing so, the relationship between health risks and salinity shall be fully characterized. These caveats notwithstanding, it is our belief that the findings of this study are robust enough and become the first important step that quantitatively clarifies health risks of salinity associated with climate change.

Third chapter 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, future research should apply the information provision treatment to other types of climate change, environmental and poverty problems where exist gaps between urban and rural areas in developed and other developing countries. Through this paper, we cannot draw any conclusion on socio-technical transitions to sustainability, because this study neither addresses a temporal 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 researches, such as social experiments of information provision, will be able to address this issue by observing such changes in people's behaviors and cognitive factors along with the socio-technical transitions in both urban and rural areas. However, it is known that directly measuring cognitive abilities is a very difficult task. Therefore, some caution shall be necessary to conduct such research. In this study, information provision is random, however, other variables such as perception of the cause of climate change and SVO might not be random. Therefore, future research could use balancing test to confirm about it before using them in the model. 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.

The fourth chapter uses a 24-hour recall method to calculate DDSs, while multiple dietary recalls

[1]However, our data were collected during February-March, well approximating the representative scenarios of salinity effects in Bangladesh.

including both weekdays and weekends may be considered an alternative way to have a good picture of the habitual food intake for household members. Second, applying a 24-hour recall method may suffer from reporting and recall biases. However, several studies mention that the DDS by using a 24-hour recall method is reliable enough to measure individual nutrient adequacy without being significantly biased (Food and Agriculture Organization, 2011; Headey and Ecker, 2013). Third, there may be additional determinants of DDSs, such as nutritional knowledge, awareness, health and disease-related variables that are not included in this study. We could not collect the data due to several constraints we face with respect to time, subjects and budgets. However, we collected information on household size but we did not use it because of the multicollinearity problem with family structure. More detailed data about multiple dietary recalls, nutrition, health and disease-related characteristics should be considered in the future studies, enabling us to have panel data to fully characterize intrahousehold food intake inequality. These caveats notwithstanding, it is our belief that the findings of our study are robust enough and become the first important step that quantitatively identifies intrahousehold food intake inequality including all household members by the family roles and/or age groups.

The findings of our study are robust enough and become the first step that quantitatively analyzes people's economic and health behaviors at household level under climate change and urbanization. These caveats notwithstanding, it is our belief that this research is an important first step in understanding people's economic and health behaviors in developing countries for the betterment of health and sustainable of societies.

NOMENCLATURE

AD Adaptation donation

BDT Bangladesh taka

BMI Body mass index

CD Climate donation

CBN Cost of basic need

dS/m DeciSiemens per metre

DDS Dietary diversity score

EC Electrical conductivity

FAO Food and agriculture organization

MD Mitigation donation

ME Marginal effect

MP Marginal probability

NGOs Non-governmental organizations

ppm Parts per million

SD Standard deviation

SDGs Sustainable development goals

SRDI Soil Resources Development Institute

SVO Social value orientation

TD Total donation

BIBLIOGRAPHY

Abbas, A., Amjath-Babu, T., Kächele, H., and Müller, K. (2016). Participatory adaptation to climate extremes: An assessment of households' willingness to contribute labor for flood risk mitigation in Pakistan. *Journal of water and climate change*, 7:621–636.

Abedin, M. and Shaw, R. (2013). Safe water adaptability for salinity, arsenic and drought risks in southwest of Bangladesh. *Risk, hazards and crisis in public policy*, 4:62–82.

Aburto, N., Ziolkovska, A., Hooper, L., Elliott, P., Cappuccio, F., and Meerpohl, J. (2013). Effect of lower sodium intake on health: Systematic review and meta-analyses. *British medical journal*, 346:1–20.

Acquah, H. and Onumah, E. (2011). Farmers perception and adaptation to climate change: An estimation of willingness to pay. *Agris on-line papers in economics and informatics*, 3:31–39.

Ahmad, H. (2019). Bangladesh coastal zone management status and future trends. *Journal of coastal zone management*, 22:1–7.

Aitken, C., Chapman, R., and McClure, J. (2011). Climate change, powerlessness and the commons dilemma: Assessing New Zealanders' preparedness to act. *Global environmemtal change*, 21:752–760.

Akerele, D. (2011). Intra-household food distribution patterns and calorie inadequacy in south-western Nigeria. *International journal of consumer studies*, 35:545–551.

Al-Amin, A., Akhter, T., Islam, A., Jahan, H., Hossain, M., Prodhan, M., Mainuddin, M., and Kirby, M. (2019). An intra-household analysis of farmers' perceptions of and adaptation to climate change impacts: Empirical evidence from drought prone zones of Bangladesh. *Climatic change*, 156:545–565.

Alam, G., Alam, K., and Mushtaq, S. (2017a). Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. *Climate risk management*, 17:52–63.

Alam, M., Allinson, G., Stagnitti, F., Tanaka, A., and Westbrooke, M. (2002). Arsenic contamination in Bangladesh groundwater: A major environmental and social disaster. *International journal of environmental health research*, 12:235–253.

Alam, M., Carpenter-Boggs, L., Mitra, S., Haque, M., Halsey, J., Rokonuzzaman, M., Saha, B., and Moniruzzaman, M. (2017b). Effect of salinity intrusion on food crops, livestock, and fish species at Kalapara coastal belt in Bangladesh. *Journal of food quality*, 2017:2045157.

Alam, M., Miah, M., and Hossain, S. (2019). Prevalence of moderate acute malnutrition and associate factors among under-five children in some selected areas of Satkhira district, Bangladesh. *Research & reviews: Journal of food science and technology*, 8:33–41.

Alam, M. and Murray, L. (2005). *Facing up to climate change in South Asia*. International Institute for Environment and Development, IEED.

Ali, N., Tahsina, T., Hoque, D., Hasan, M., Iqbal, A., Huda, T., and Arifeen, S. (2019). Association of food security and other socio-economic factors with dietary diversity and nutritional statuses of children aged 6-59 months in rural Bangladesh. *PLoS ONE*, 14:e0221929.

Alom, J., Quddus, M., and Islam, M. (2012). Nutritional status of under-five children in Bangladesh: A multilevel analysis. *Journal of biosocial science*, 44:525–535.

American Association for the Advancement of Science (2016). Rise of the city. *Science*, 352:906–907.

Angeles-Agdeppa, I., Monville-Oro, E., Gonsalves, J., and Capanzana, M. (2019). Integrated school based nutrition programme improved the knowledge of mother and school children. *Maternal and child nutrition*, 15:e12794.

Ara Parvin, G. and Reazul Ahsan, S. (2013). Impacts of climate change on food security of rural poor women in Bangladesh. *Management of environmental quality: An international journal*, 24:802–814.

Arbuckle Jr, J., Morton, L., and Hobbs, J. (2015). Understanding farmer perspectives on climate change adaptation and mitigation: The roles of trust in sources of climate information, climate change beliefs, and perceived risk. *Environment and behavior*, 47:205–234.

Arbuckle Jr, J., Prokopy, L., Haigh, T., Hobbs, J., Knoot, T., Knutson, C., Loy, A., Mase, A., McGuire, J., and Morton, W. (2013). Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the midwestern United States. *Climatic change*, 117:943–950.

Arimond, M., Wiesmann, D., Becquey, E., Carriquiry, A., Daniels, M., Deitchler, M., Fanou-Fogny, N., Joseph, M., Kennedy, G., Martin-Prevel, Y., and Torheim, L. (2010). Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings. *Journal of nutrition*, 140:2059S–2069S.

Asma, K. and Kotani, K. (2019). Salinity and water-related disease risk in coastal Bangladesh. Research Institute for Future Design, Kochi University of Technology, Working paper SDES-2019-9.

Asma, K., Shahrier, S., and Kotani, K. (2021). Cooperation and cognition gaps for salinity: A field experiment of information provision in urban and rural areas of Bangladesh. *Journal of cleaner production*, 311:127562.

Aurino, E. (2017). Do boys eat better than girls in India? Longitudinal evidence on dietary diversity and food consumption disparities among children and adolescents. *Economics and human biology*, 25:99–111.

Bangladesh Bureau of Statistics (2018). District statistics. Technical report, Bangladesh Bureau of Statistics.

Barikdar, A., Ahmed, T., and Lasker, S. (2016). The situation of the elderly in Bangladesh. *Bangladesh journal of bioethics*, 7:27–36.

Bashir, M., Naeem, M., and Niazi, S. (2010). Rural and peri-urban food security: A case of district Faisalabad of Pakistan. *World applied sciences journal*, 9:403–411.

Bel, G., Fageda, X., and Mur, M. (2014). Does cooperation reduce service delivery costs? Evidence from residential solid waste services. *Journal of public administration research and theory*, 24:85–107.

Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W., and Courchamp, F. (2012). Impacts of climate change on the future of biodiversity. *Ecology letters*, 15:365–377.

Berenguer, J., Corraliza, J., and Martin, R. (2005). Rural-urban differences in environmental concern, attitudes, and actions. *European journal of psychological assessment*, 21:128–138.

Berk, R. and Fovell, R. (1999). Public perceptions of climate change: A 'willingness to pay' assessment. *Climatic change*, 41:413–446.

Berk, R. and Schulman, D. (1995). Public perceptions of global warming. *Climatic change*, 29:1–33.

Bhunia, R. and Ghosh, S. (2011). Waterborne cholera outbreak following cyclone Aila in Sundarban area of West Bengal, India, 2009. *Transactions of the royal society of tropical medicine and hygiene*, 105:214–219.

Blum, L., Khan, R., Sultana, M., Soltana, N., Siddiqua, Y., Khondker, R., Sultana, S., and Tumilowicz, A. (2019). Using a gender lens to understand eating behaviours of adolescent females living in low-income households in Bangladesh. *Maternal and child nutrition*, 15:e12841.

Bolton, G., Katok, E., and Zwick, R. (1998). Dictator game giving: Rules of fairness versus acts of kindness. *International journal of game theory*, 27:269–299.

Borghans, L., Duckworth, A., Heckman, J., and Bas, T. (2008). The economics and psychology of personality traits. *Journal of human resources*, 43:972–1059.

Bose, M. and Dey, M. (2007). Food and nutritional security in Bangladesh: Going beyond carbohydrate counts. *Agricultural economics research review*, 20:203–225.

Botzen, W., Aerts, J., and van den Bergh, J. (2009). Willingness of homeowners to mitigate climate risk through insurance. *Ecological economics*, 68:2265–2277.

Boutelle, K., Birnbaum, A., Lytle, L., Murray, D., and Story, M. (2003). Associations between perceived family meal environment and parent intake of fruit, vegetables, and fat. *Journal of nutrition education and behavior*, 35:24–29.

Brammer, H. (2010). After the Bangladesh flood action plan: Looking to the future. *Environmental hazards*, 9:118–130.

Brammer, H. (2014). Bangladesh's dynamic coastal regions and sea-level rise. *Climate risk management*, 1:51–62.

Braun, M. and Saroar, M. (2012). Participatory action research on climate risk management, Bangladesh. Technical report, World Fish.

Caldwell, B., Caldwell, J., Mitra, S., and Smith, W. (2003). Tubewells and arsenic in Bangladesh: Challenging a public health success story. *International journal of population geography*, 9:23–38.

Cameron, A. and Trivedi, P. (2013). *Regression analysis of count data*, volume 53. Cambridge university press.

Carloni, A. (1981). Sex disparities in the distribution of food within rural households. *Food and nutrition*, 7:3–12.

Chan, J. and Sobal, J. (2011). Family meals and body weight. Analysis of multiple family members in family units. *Appetite*, 57:517–524.

Chaudhury, R. (1988). Adequacy of child dietary intake relative to that of other family members. *Food and nutrition bulletin*, 10:26–34.

Chen, Y., Feng, S., Heckman, J., and Kautz, T. (2020). Sensitivity of self-reported noncognitive skills to survey administration conditions. *Proceedings of the national academy of sciences of the United States of America*, 117:931–935.

Cotruvo, J., Dufour, A., Rees, G., Bartram, J., Carr, R., Cliver, D., Craun, G., Fayer, R., and Gannon, V. (2004). *Waterborne zoonoses*. IWA publishing.

Deryugina, T. and Shurchkov, O. (2016). The effect of information provision on public consensus about climate change. *PLoS ONE*, 11:e0151469.

Dos-Santos, L. (2020). Equitable food distribution and sustainable development. In Leal, F., Walter, A., Azul, A., Brandli, L., Özuyar, G., and Wall, T., editors, *Zero hunger. Encyclopedia of the UN sustainable development goals*, pages 1–9. Springer International Publishing.

Elahi, K. (2016). *Climate change and health impacts in Bangladesh*. In Climate Change and Human Health Scenario in South and Southeast Asia. Springer.

Engel, C. (2011). Dictator games: A meta study. *Experimental economics*, 14:583–610.

Engle, P. and Nieves, I. (1993). Intra-household food distribution among Guatemalan families in a supplementary feeding program: Behavior patterns. *Social science and medicine*, 36:1605–1612.

Fadare, O., Mavrotas, G., Akerele, D., and Oyeyemi, M. (2019). Micronutrient-rich food consumption, intra-household food allocation and child stunting in rural Nigeria. *Public health nutrition*, 22:444–454.

Fernández-Alvira, J., Mouratidou, T., Bammann, K., Hebestreit, A., Barba, G., Sieri, S., Reisch, L., Eiben, G., Hadjigeorgiou, C., Kovacs, E., Huybrechts, I., and Moreno, L. (2013). Parental education and frequency of food consumption in European children: The IDEFICS study. *Public health nutrition*, 16:487–498.

Finaret, A., Miller, L., Joshi, N., Mahato, S., Lohani, M., Drozdowsky, J., and Rogers, B. (2018). Longitudinal analysis of the intrahousehold distribution of foods in rural Nepal: Relative variability of child dietary quality across age and sex cohorts. *Food policy*, 79:101–110.

Fischer, A. and Charnley, S. (2012). Risk and cooperation: Managing hazardous fuel in mixed ownership landscapes. *Environmental management*, 49:1192–1207.

Food and Agriculture Organization (2011). Guidelines for measuring household and individual dietary diversity. Technical report, Food and Agriculture Organization.

Fujii, H., Iwata, K., and Managi, S. (2017). How do urban characteristics affect climate change mitigation policies? *Journal of cleaner production*, 168:271–278.

Fulkerson, J., Neumark-Sztainer, D., and Story, M. (2006). Adolescent and parent views of family meals. *Journal of American dietetic association*, 106:526–532.

Gittelsohn, J. (1991). Opening the box: Intrahousehold food allocation in rural Nepal. *Social science and medicine*, 33:1141–1154.

Goff, S., Waring, T., and Noblet, C. (2017). Does pricing nature reduce monetary support for conservation? Evidence from donation behavior in an online experiment. *Ecological economics*, 141:119–126.

Goldstein, H. (2011). *Multilevel statistical models*. John Wiley and Sons.

Guterres, A. (2008). Climate change, natural disasters and human displacement: A UNHCR perspective. Technical report, United Nations High Commissioner for Refugees, Geneva.

Habiba, U., Abedin, M., Shaw, R., and Hassan, A. (2013). Salinity-induced livelihood stress in coastal region of Bangladesh. In Abedin, M. A., Habiba, U., and Shaw, R., editors, *Water insecurity: A social dilemma (Community, environment and disaster risk management)*, volume 13, chapter 7, pages 139–165. Emerald Group Publishing Limited.

Hadley, C., Lindstrom, D., Tessema, F., and Belachew, T. (2008). Gender bias in the food insecurity experience of Ethiopian adolescents. *Social science and medicine*, 66:427–438.

Halder, S. and Kejriwal, S. (2016). Nutritional awareness of mothers in relation to nutritional status of the preschool children. *Early child development and care*, 186:1366–1377.

Harris-Fry, H., Paudel, P., Shrestha, N., Harrisson, T., Beard, B., Jha, S., Shrestha, B., Manandhar, D., Costello, A., Cortina-Borja, M., and Saville, N. (2018). Status and determinants of intra-household food allocation in rural Nepal. *European journal of clinical nutrition*, 72:1524–1536.

Harris-Fry, H., Shrestha, N., Costello, A., and Saville, N. (2017). Determinants of intra-household food allocation between adults in south Asia–A systematic review. *International journal for equity in health*, 16:1–21.

Hasan, M., Shamsuddin, M., and Hossain, A. (2013). Salinity status in groundwater: A study of selected upazilas of southwestern coastal region in Bangladesh. *Global science and technology journal*, 1:112–122.

He, F., Li, J., and MacGregor, G. (2013). Effect of longer term modest salt reduction on blood pressure: Cochrane systematic review and meta-analysis of randomised trials. *British medical journal*, 346:1–15.

Headey, D. and Ecker, O. (2013). Rethinking the measurement of food security: From first principles to best practice. *Food security*, 5:327–343.

Heckman, J., Stixrud, J., and Urzua, S. (2006). The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior. *Journal of labor economics*, 24:411–482.

Hirose, J., Kotani, K., and Nakagawa, Y. (2020). Is climate change induced by human? The impact of the gap in perceptions on the cooperation. Research Institute for Future Design, Kochi University of Technology, Working paper SDES-2020-2.

Hirose, J., Kotani, K., and Nakagawa, Y. (2021). Is climate change induced by humans? The impact of the gap in perceptions on cooperation. *Economics of disasters and climate change*, 5:391–413.

Hirvonen, K., Hoddinott, J., Minten, B., and Stifel, D. (2017). Children's diets, nutrition knowledge, and access to markets. *World development*, 95:303–315.

Hossain, M., Asadullah, M., and Kambhampati, U. (2021). Women's empowerment and gender-differentiated food allocation in Bangladesh. *Review of economics of the household*, 19:739–767.

Household Income and Expenditure Survey (2017). Description of the official methodology used for poverty estimation in Bangladesh for 2016/17. Technical report, The World Bank.

Huddart-Kennedy, E., Beckley, T., McFarlane, B., and Nadeau, S. (2009). Rural-urban differences in environmental concern in Canada. *Rural sociology*, 74:309–329.

Humphries, D., Dearden, K., Crookston, B., Woldehanna, T., Penny, M., and Behrman, J. (2017). Household food group expenditure patterns are associated with child anthropometry at ages 5, 8 and 12 years in Ethiopia, India, Peru and Vietnam. *Economics and human biology*, 26:30–41.

Hunter, P., MacDonald, A., and Carter, R. (2010). Water supply and health. *PLoS medicine*, 7:e1000361.

Huq, M. and Tasnim, T. (2008). Maternal education and child healthcare in Bangladesh. *Maternal and child health journal*, 12:43–51.

Huq, N., Hugé, J., Boon, E., and Gain, A. (2015). Climate change impacts in agricultural communities in rural areas of coastal Bangladesh: A tale of many stories. *Sustainability*, 7:8437–8460.

Imam, M., Islam, M., and Hossain, M. (2018). Factors affecting poverty in rural Bangladesh: An analysis using multilevel modelling. *Journal of Bangladesh agricultural university*, 16:123–130.

Islam, M., Kotani, K., and Managi, S. (2016). Climate perception and flood mitigation cooperation: A Bangladesh case study. *Economic analysis and policy*, 49:117–133.

Islam, M. and Nath, D. (2012). A future journey to the elderly support in Bangladesh. *Journal of anthropology*, 2012:6.

Islam, M., Rahman, S., Tarafder, C., Rahman, M., Rahman, A., and Ekström, E. (2020). Exploring rural adolescents' dietary diversity and its socioeconomic correlates: A cross-sectional study from Matlab, Bangladesh. *Nutrients*, 12:2212–2230.

Jabed, M., Paul, A., and Nath, T. (2020). Peoples' perception of the water salinity impacts on human health: A case study in south-eastern coastal region of Bangladesh. *Exposure and health*, 12:41–50.

Jardine, A., Speldewinde, P., Carver, S., and Weinstein, P. (2007). Dryland salinity and ecosystem distress syndrome: Human health implications. *EcoHealth*, 4:10–17.

Jayawardena, R., Byrne, N., Soares, M., Katulanda, P., Yadav, B., and Hills, A. (2013). High dietary diversity is associated with obesity in Sri Lankan adults: An evaluation of three dietary scores. *BMC public health*, 13:314.

Jevrejeva, S., Jackson, L., Grinsted, A., Lincke, D., and Marzeion, B. (2018). Flood damage costs under the sea level rise with warming of 1.5°C and 2°C. *Environmental research letters*, 13:074014.

Johnson, D., Halvorsen, K., and Solomen, B. (2011). Upper midwestern US consumers and ethanol: Knowledge, beliefs and consumption. *Biomass and bioenergy*, 35:1454–1464.

Jones, R., Fly, M., Talley, J., and Cordell, H. (2003). Green migration into rural America: The new frontier of environmentalism? *Society and natural resources*, 16:221–238.

Keino, S., Plasqui, G., and Borne, B. (2014). Household food insecurity access: A predictor of overweight and underweight among Kenyan women. *Agriculture and food security*, 3:2.

Khan, A., Ireson, A., Kovats, S., Mojumder, S., Khusru, A., Rahman, A., and Vineis, P. (2011a). Drinking water salinity and maternal health in coastal Bangladesh: Implications of climate change. *Environmental health perspectives*, 119:1328–1332.

Khan, A., Scheelbeek, P., Shilpi, A., Chan, Q., Mojumder, S., Rahman, A., Haines, A., and Vineis, P. (2014). Salinity in drinking water and the risk of (pre) eclampsia and gestational hypertension in coastal Bangladesh: A case-control study. *PLoS ONE*, 9:e108715.

Khan, A., Xun, W., Ahsan, H., and Vineis, P. (2011b). Climate change, sea-level rise, & health impacts in Bangladesh. *Environment: Science and policy for sustainable development*, 53:18–33.

Khanom, T. (2016). Effect of salinity on food security in the context of interior coast of Bangladesh. *Ocean and coastal management*, 130:205–212.

Kok, M. and De Coninck, H. (2007). Widening the scope of policies to address climate change: Directions for mainstreaming. *Environmental science and policy*, 10:587–599.

Kollmuss, A. and Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental education research*, 8:239–260.

Koppmair, S., Kassie, M., and Qaim, M. (2017). Farm production, market access and dietary diversity in Malawi. *Public health nutrition*, 20:325–335.

Kosse, F., Deckers, T., Pinger, P., Schildberg-Hörisch, H., and Falk, A. (2020). The formation of prosociality: Causal evidence on the role of social environment. *Journal of political economy*, 128:434–467.

Kragt, M., Gibson, F., Maseyk, F., and Wilson, K. (2016). Public willingness to pay for carbon farming and its co-benefits. *Ecological economics*, 126:125–131.

Lam, Y., Surkan, P., Winch, P., and Nizame, F. (2018). Freshwater access in high salinity regions: Impacts and adaptation insights from the Ganges river delta. *Journal of global health reports*, 2:e2018007.

Leroy, J., Ruel, M., Frongillo, E., Harris, J., and Ballard, T. (2015). Measuring the food access dimension of food security: A critical review and mapping of indicators. *Food and nutrition bulletin*, 36:167–195.

Lorenzoni, I., Nicholson-Cole, S., and Whitmarsh, L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global environmemtal change*, 17:445–459.

Luo, W., Zhai, F., Jin, S., and Ge, K. (2001). Intrahousehold food distribution: A case study of eight provinces in China. *Asia Pacific journal of clinical nutrition*, 10:19–28.

Madjdian, D. (2018). Gender, intra-household food allocation and social change in two Himalayan communities in Nepal. In Niehof, A., Gartaula, H., and Quetulio-Navarra, M., editors, *Diversity and change in food wellbeing: Cases from southeast Asia and Nepal*, chapter 8, pages 153–175. Wageningen Academic Publishers.

Madjdian, D. and Bras, H. (2016). Family, gender, and women's nutritional status: A comparison between two Himalayan communities in Nepal. *Economic history of developing regions*, 31:198–223.

Mahmuduzzaman, M., Ahmed, U., Nuruzzaman, A., and Ahmed, S. (2014). Causes of salinity intrusion in coastal belt of Bangladesh. *International journal of plant research*, 4:8–13.

Mallick, B., Rahaman, K., and Vogt, J. (2011). Coastal livelihood and physical infrastructure in Bangladesh after cyclone Aila. *Mitigation and adaptation strategies for global change*, 16:629–648.

McCaffrey, M. and Buhr, S. (2008). Clarifying climate confusion: Addressing systemic holes, cognitive gaps, and misconceptions through climate literacy. *Physical Geography*, 29:512–528.

Mcleod, E., Poulter, B., Hinkel, J., Reyes, E., and Salm, R. (2010). Sea-level rise impact models and environmental conservation: A review of models and their applications. *Ocean and coastal management*, 53:507–517.

Messer, E. (1997). Intra-household allocation of food and health care: Current findings and understandings-introduction. *Social science and medicine*, 44:1675–1684.

Mohajan, H. (2014). Child rights in Bangladesh. *Journal of social welfare and human rights*, 2:207–238.

Mondal, D., Ganguli, B., Roy, S., Halder, B., Banerjee, N., Banerjee, M., Samanta, M., Giri, A., and Polya, D. (2014). Diarrhoeal health risks attributable to water-borne-pathogens in arsenic-mitigated drinking water in West Bengal are largely independent of the microbiological quality of the supplied water. *Water*, 6:1100–1117.

Moore, J., Pawloski, L., Rodriguez, C., Lumbi, L., and Ailinger, R. (2009). The effect of a nutrition education program on the nutritional knowledge, hemoglobin levels, and nutritional status of Nicaraguan adolescent girls. *Public health nursing*, 26:144–152.

Müller, D., Wilck, N., Haase, S., Kleinewietfeld, M., and Linker, R. (2019). Sodium in the microenvironment regulates immune responses and tissue homeostasis. *Nature reviews immunology*, 19:243–254.

Nahian, M., Ahmed, A., Lázár, A., Hutton, C., Salehin, M., and Streatfield, P. (2018). Drinking water salinity associated health crisis in coastal Bangladesh. *Elementa: Science of the anthropocene*, 6:1–14.

Ndiku, M., Jaceldo-Siegl, K., Singh, P., and Sabate, J. (2011). Gender inequality in food intake and nutritional status of children under 5 years old in rural eastern Kenya. *European journal of clinical nutrition*, 65:26–31.

Neaman, A., Otto, S., and Vinokur, E. (2018). Toward an integrated approach to environmental and prosocial education. *Sustainability*, 10:583.

Nelson, M. (1986). The distribution of nutrient intake within families. *British journal of nutrition*, 55:267–277.

Ortega-Egea, J., García-de Frutos, N., and Antolín-López, R. (2014). Why do some people do "more" to mitigate climate change than others? Exploring heterogeneity in psycho-social associations. *PLoS ONE*, 9:e106645.

Paul, A. and Jabed, M. (2018). Salinity has made our life terrible: A qualitative investigation of human sufferings in the Chittagong coast. *Oriental geographer*, 59:1–18.

Paul, B., Rahman, M., and Rakshit, B. (2011). Post-cyclone Sidr illness patterns in coastal Bangladesh: An empirical study. *Natural hazards*, 56:841–852.

Ponce, X., Ramirez, E., and Delisle, H. (2006). A more diversified diet among Mexican men may also be more atherogenic. *Journal of nutrition*, 136:2921–2927.

Rabbani, A. (2014). Household food security in Bangladesh: Going beyond poverty measures. *Bangladesh development studies*, 37:103–125.

Rabe-Hesketh, S. and Skrondal, A. (2008). *Multilevel and longitudinal modeling using Stata*. STATA Press.

Rahman, A., Iqbal, Z., Bunn, J., Lovel, H., and Harrington, R. (2004). Impact of maternal depression on infant nutritional status and illness: A cohort study. *Archives of general psychiatry*, 61:946–952.

Rahman, M., Penny, G., Mondal, M., Zaman, M., Kryston, A., Salehin, M., Nahar, Q., Islam, M., Bolster, D., Tank, J., and Müller, M. (2019). Salinization in large river deltas: Drivers, impacts and socio-hydrological feedbacks. *Water security*, 6:100024.

Rajapaksa, D., Islam, M., and Managi, S. (2018). Pro-environmental behavior: The role of public perception in infrastructure and the social factors for sustainable development. *Sustainability*, 10:937.

Rakib, M., Sasaki, J., Matsuda, H., and Fukunaga, M. (2019). Severe salinity contamination in drinking water and associated human health hazards increase migration risk in the southwestern coastal part of Bangladesh. *Journal of environmental management*, 15:238–248.

Ramasamy, R. and Surendran, S. (2012). Global climate change and its potential impact on disease transmission by salinity-tolerant mosquito vectors in coastal zones. *Frontiers in physiology*, 3:1–14.

Rasheed, S., Siddique, A., Sharmin, T., Hasan, A., Hanifi, S., Iqbal, M., and Bhuiya, A. (2016). Salt intake and health risk in climate change vulnerable coastal Bangladesh: What role do beliefs and practices play? *PLoS ONE*, 11:1–15.

Revi, A. (2008). Climate change risk: An adaptation and mitigation agenda for Indian cities. *Environment and urbanization*, 20:207–229.

Rindermann, H. (2008). Relevance of education and intelligence at the national level for the economic welfare of people. *Intelligence*, 36:127–142.

Ritchie, S. and Tucker-Drob, E. (2018). How much does education improve intelligence? A meta-analysis. *Psychological science*, 29:1358–1369.

Rizvi, N. (1983). Effects of food policy on intrahousehold food distribution in Bangladesh. *Food and nutrition bulletin*, 5:1–6.

Rogers, R., Ma, D., Nguyen, T., and Nguyen, N. (2019). Early childhood education and cognitive outcomes in adolescence: A longitudinal study from Vietnam. *Education economics*, 27:658–669.

Rosenzweig, C., Solecki, W., Hammer, S., and Mehrotra, S. (2010). Cities lead the way in climate change action. *Nature*, 467:909–911.

Saha, S. (2017). Cyclone, salinity intrusion, adaptation and coping measures in coastal Bangladesh. *Space and culture, India*, 5:12–24.

Sarker, A., Sultana, M., Mahumud, R., Sheikh, N., Van Der Meer, R., and Morton, A. (2016). Prevalence and health care-seeking behavior for childhood diarrheal disease in Bangladesh. *Global pediatric health*, 3:1–12.

Sassi, S., Abassi, M., Traissac, P., Gharbia, H., Gartner, A., Delpeuch, F., and Ati, J. (2019). Intra-household double burden of malnutrition in a north African nutrition transition context: Magnitude and associated factors of child anaemia with mother excess adiposity. *Public health nutrition*, 22:44–54.

Scheelbeek, P., Chowdhury, M., Haines, A., Alam, D., Hoque, M., Butler, A., Khan, A., Mojumder, S., Blangiardo, M., Elliott, P., and Vineis, P. (2017). Drinking water salinity and raised blood pressure: Evidence from a cohort study in coastal Bangladesh. *Environmental health perspectives*, 125:057007–8.

Schellnhuber, H., Hare, B., Serdeczny, O., Schaeffer, M., Adams, S., Baarsch, F., Schwan, S., Coumou, D., Robinson, A., Vieweg, M., Piontek, F., Donner, R., Runge, J., Rehfeld, K., Rogelj, J., Perette, M., Menon, A., Schleussner, C.-F., Bondeau, A., Svirejeva-Hopkins, A., Schewe, J., Frieler, K., Warszawski, L., and Rocha, M. (2013). *Turn down the heat: Climate extremes, regional impacts, and the case for resilience.* International Bank for Reconstruction and Development, World Bank.

Semenza, J., Hall, D., Wilson, D., Bontempo, B., Sailor, D., and George, L. (2008). Public perception of climate change: Voluntary mitigation and barriers to behavior change. *American journal of preventive medicine*, 35:479–487.

Shahen, M., Shahrier, S., and Kotani, K. (2019). Happiness, generativity and social preferences in a developing country: A possibility of future design. *Sustainability*, 11:5256.

Shahrier, S. and Kotani, K. (2016). Labor donation or money donation? Pro-sociality on prevention of natural disasters in a case of cyclone Aila, Bangladesh. *Singapore economic review*, 61:1640007.

Shahrier, S., Kotani, K., and Kakinaka, M. (2016). Social value orientation and capitalism in societies. *PLoS ONE*, 11:e0165067.

Shahrier, S., Kotani, K., and Saijo, T. (2017). Intergenerational sustainability dilemma and the degree of capitalism in societies: A field experiment. *Sustainability science*, 12:957–967.

Shammi, M., Rahman, M., Bondad, S., and Bodrud-Doza, M. (2019). Impacts of salinity intrusion in community health: A review of experiences on drinking water sodium from coastal areas of Bangladesh. In *Healthcare*, volume 7, page 50. Multidisciplinary Digital Publishing Institute.

Shamsudduha, M. (2013). *Groundwater-fed irrigation and drinking water supply in Bangladesh: Challenges and opportunities*. Citeseer.

Shoyama, K., Managi, S., and Yamagata, Y. (2013). Public preferences for biodiversity conservation and climate change mitigation: A choice experiment using ecosystem services indicators. *Land use policy*, 34:282–293.

Shwom, R., Dan, A., and Dietz, T. (2008). The effects of information and state of residence on climate change policy preferences. *Climatic change*, 90:343–358.

Sibhatu, K., Krishna, V., and Qaim, M. (2015). Production diversity and dietary diversity in smallholder farm households. *Proceedings of the national academy of sciences of the United States of America*, 112:10657–10662.

Singh, N. (2019). Gender, intra-household discrimination and cash transfer schemes: The case of Indian Punjab. *Economies*, 7:75.

Skea, J. and Nishioka, S. (2008). Policies and practices for a low-carbon society. *Climate policy*, 8:S5–S16.

Soil Resources Development Institute (2010). Soil salinity reports 2010 of Bangladesh. Technical report, Soil Resources Development Institute.

Spence, A., Leygue, C., Bedwell, B., and O'Malley, C. (2014). Engaging with energy reduction: Does a climate change frame have the potential for achieving broader sustainable behaviour? *Journal of environmental psychology*, 38:17–28.

Szabo, S., Hossain, M., Adger, W., Matthews, Z., Ahmed, S., Lázár, A., and Ahmad, S. (2016). Soil salinity, household wealth and food insecurity in tropical deltas: Evidence from south-west coast of Bangladesh. *Sustainability science*, 11:411–421.

Talukder, M., Rutherford, S., and Chu, C. (2015). Salinization of drinking water in the context of climate change and sea level rise: A public health priority for coastal Bangladesh. *International journal of climate change: Impacts & responses*, 8:21–32.

Talukder, M., Rutherford, S., Chu, C., Hieu Nguyen, T., and Phung, D. (2017). Association between salinity and hospital admission for hypertension: An ecological case-control study in the Mekong delta region in Vietnam. *Journal of public health*, 40:75–81.

Talukder, M., Rutherford, S., Phung, D., Islam, M., and Chu, C. (2016). The effect of drinking water salinity on blood pressure in young adults of coastal Bangladesh. *Environmental pollution*, 214:248–254.

Therborn, G. (2004). *Between sex and power: Family in the world 1900-2000*. Routledge.

Timilsina, R., Kotani, K., and Kamijo, Y. (2017). Sustainability of common pool resources. *PLoS ONE*, 12:e0170981.

Timilsina, R., Kotani, K., and Kamijo, Y. (2019). Generativity and social value orientation between rural and urban societies in a developing country. *Futures*, 105:124–132.

Timilsina, R., Kotani, K., Nakagawa, Y., and Saijo, T. (2021). Concerns for future generations in societies: A deliberative analysis of the intergenerational sustainability dilemma. *Journal of behavioral and experimental economics*, 90:101628.

UNICEF and WHO (2015). *Progress on sanitation and drinking water-2015 update and MDG assessment*. In Progress on sanitation and drinking water–2015 update and MDG assessment. UNICEF, New York and WHO, Geneva. United States of America.

Van Lange, P., Bekkers, R., Schuyt, T., and Vugt, M. V. (2007). From games to giving: Social value orientation predicts donations to noble causes. *Basic and applied social psychology*, 29:375–384.

Vineis, P., Chan, Q., and Khan, A. (2011). Climate change impacts on water salinity and health. *Journal of epidemiology and global health*, 1:5–10.

Warner, K., Van der Geest, K., Huq, S., Harmeling, S., Kusters, K., de Sherbinin, A., and Kreft, S. (2012). Evidence from the frontlines of climate change: Loss and damage to communities despite coping and adaptation. Technical report, United Nations University-Institute for Environment and Human Security (UNU-EHS).

Weber, E. and Stern, P. (2011). Public understanding of climate change in the United States. *American psychologist*, 66:315–328.

Wheeler, E. (1991). Intra-household food and nutrient allocation. *Nutrition research reviews*, 4:69–81.

White, G., Bradley, D., and White, A. (2002). Drawers of water: Domestic water use in East Africa. *Bulletin of the world health organization*, 80:63–73.

Wooldridge, J. (2010). *Econometric analysis of cross section and panel data*. MIT Press.

Wooldridge, J. (2019). *Introductory econometrics*. South-Western College Publishing.

Yang, J., Zou, L., Lin, T., Wu, Y., and Wang, H. (2014). Public willingness to pay for CO_2 mitigation and the determinants under climate change: A case study of Suzhou, China. *Journal of environmental management*, 146:1–8.

Yen, S. and Tan, A. (2012). Who are eating and not eating fruits and vegetables in Malaysia? *International journal of public health*, 57:945–951.

Zahran, S., Brody, S., Grover, H., and Vedlitz, A. (2006). Climate change vulnerability and policy support. *Society and natural resources*, 19:771–789.

Zang, B., Lv, P., and Warren, C. (2015). Housing prices, rural–urban migrants' settlement decisions and their regional differences in China. *Habitat international*, 50:149–159.

APPENDICES

Appendix A

An instruction summary used for collecting the data associated with the perception of climate change

Read the following two statements and look at the associated picture carefully. Choose among 1, 2, 3 and 4.

Statement 1

There is a widespread concern in the climate research community that human activities are changing the climate through the release of greenhouse gases, particularly CO_2, into the atmosphere. This release will lead to adverse effect to many societies, especially if it involves threshold crossing and abrupt climate change (see figure 1).

Statement 2

Human-induced climate change may not have as great an impact on nature, and natural resources as might multi-decadal natural climate variability. Comparing present resources only with those simulated under future climate change may exaggerate the importance of human-induced climate change by ignoring the impacts of natural variability: the estimated climate change impacts may occur even in the absence of human-induced climate change (see figure 2).

1. I agree with statement 1, 2. I agree with statement 2, 3. Both statements are persuasive and I cannot answer and 4. I do not understand the statements and cannot answer.

Figure 1: Human-induced climate change

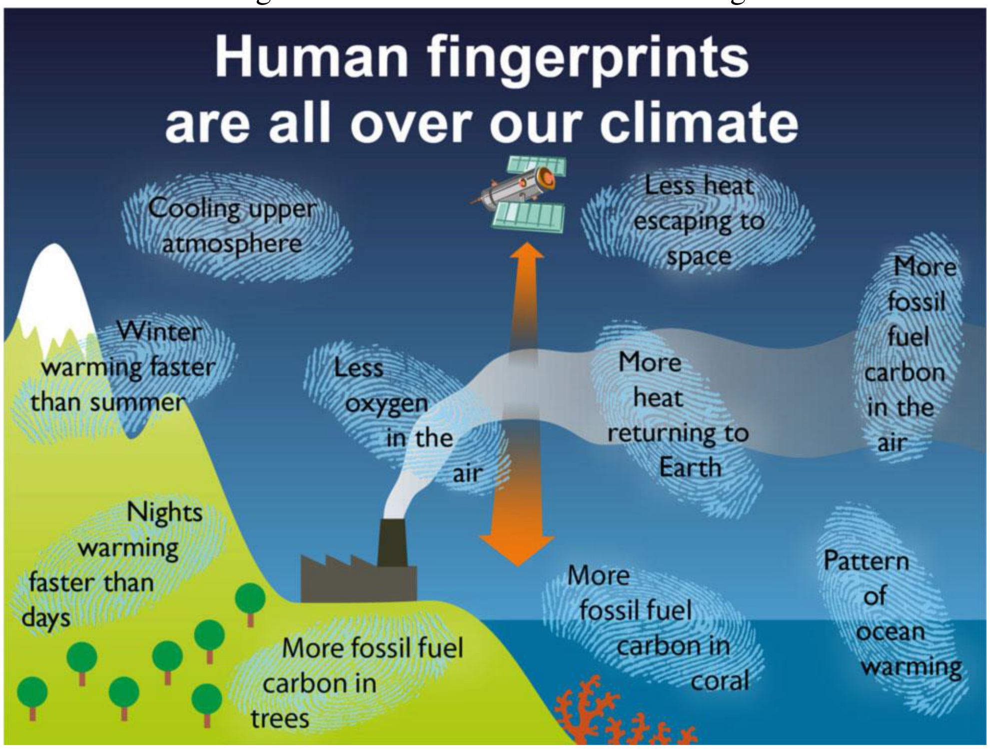
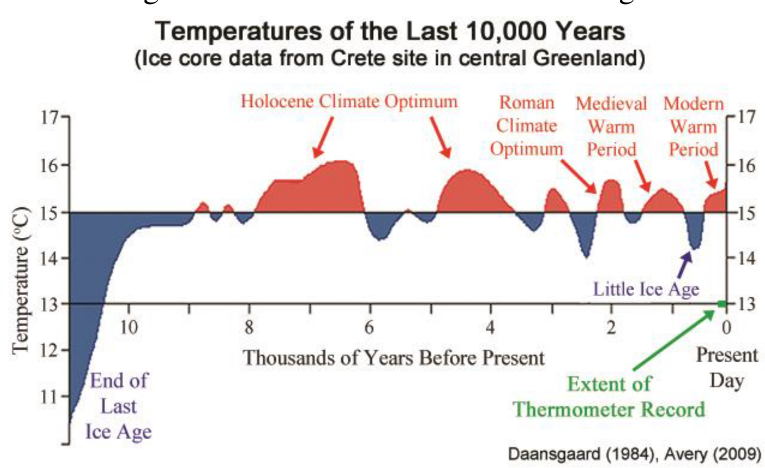


Figure 2: Nature- induced climate change



Appendix B

A Summary: Lecture about salinity problems (by English translation)

Objective of the lecture: 1. To understand the salinity with its causes, impacts and different measures

Instructor: 1st author of this research

Duration: 30 minutes per lecture

Outline of the lecture: Definition, cause, impact and measure of salinity

Each item of topics 1, 2 and 3 is fully described and explained by the 1st author with native language of Bengali with some visual presentation, graphs and the associated data.

1. Definition of salinity: Define salinity and describe why it is important to know in Bangladesh context. (Salinity is the measure of concentration of dissolved salts in soil and water. Bangladesh belongs to one of the seaside countries where the adverse impact of saltwater intrusion is significant. Salinity is one of the major concerns in coastal regions of Bangladesh. From 1973 to 2009, salinity areas in Bangladesh expanded by 27 and the water salinity levels in both surface and groundwater in the salinity areas are < 600 parts per million (ppm) and $1000 - 1500$ ppm, which exceed the critical level according to the Bangladesh drinking water standard.)

2. Causes of the salinity: Discuss nature induced salinity (e.g. sea-level rise, reduced dry season and tidal flooding) and human induced salinity (e.g. Farakka barrage, expansion of shrimp cultivation, excessive use of ground water and faulty management of coastal polders).

3. Impacts of salinity: Give a real scenario about the impacts of salinity on agriculture, fisheries, livestock, soli, water, ecosystem, health, industry and environment.

4. Different measures of salinity: The following different adaptation and mitigation strategies are discussed in detail.

Mitigation strategies of salinity: 1. Construction of embankment across the bank of sea, 2. Provision of sluice gate on the embankment, 3. Leveling of land, 4. Harvesting of rainwater for irrigation. 5. Cultivation of salinity tolerant cultivars, 6. Introduction of crop in rabi (winter) season, 7. Fallowing of lands, 8. Application of potash fertilizer and 9. Reduction of groundwater level.

Adaptation strategies of salinity: 1. Adjusting with the ecological, social, or economic systems to actual or expected climatic impacts. 2. Changing the traditional cropping patterns, 3. Introduction of fast growing and improved varieties fish across the coastal belt, 4. Plantation of the correct varieties of vegetables and 5. Introduction of salt tolerant rice variety.

Place of the lecture: In rural areas, the experiments were implemented at district primary or secondary schools. In urban area, experiments were mainly conducted at universities and colleges. We conducted field experiments on a daily basis in rural areas whenever we successfully collected a sufficient number of subjects. On the other hand, in urban area, field 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.

Appendix C

An instrument to measure social value orientation (SVO)

In this task, we ask you to imagine that you have been randomly paired with another person, whom we will refer to simply as the "other." This other person is someone you do not know at this moment and you will never know in the future. Both you and the "other" person will be making choices by circling either the letter A, B, or C. Your own choices will produce points for both yourself and the "other" person. Likewise, the other's choice will produce points for him/her and for you. Every point has value: the more points you receive, the better for you, and the more points the "other" receives, the better for him/her (see figure 3).

Here's an example of how this task works: In this example, if you choose A you would receive 500 points and the other would receive 100 points; if you chose B, you would receive 500 points and the other 500; and if you chose C, you would receive 550 points and the other 330. So, you see that your choice influences both the number of points you receive and the number of points the other receives. Before you begin making choices, please keep in mind that there are no right or wrong answers—choose the option that you, for whatever reason, prefer most (see figure 3).

After playing this game, your choice will be randomly paired with another respondent's choice in our experiment. Both you and your pair will be paid by a certain amount of money based on the point you get, and your pair gets. The more point you get; the more money you will earn. (For calculating the actual payment, a predetermined exchange rate will be applied. From this game, you can earn at maximum BDT 150.)

Figure 3: Social value orientation

	A	B	C
You get	500	500	550
Other gets	100	500	330

For each of the nine choice situations, circle A, B, or C, depending on which column you prefer most:

1.

	A	B	C
You get	480	540	480
Other gets	80	280	480

2.

	A	B	C
You get	560	500	500
Other gets	300	500	100

3.

	A	B	C
You get	520	520	580
Other gets	520	120	320

4.

	A	B	C
You get	500	560	490
Other gets	100	300	490

5.

	A	B	C
You get	560	500	490
Other gets	300	500	90

6.

	A	B	C
You get	500	500	570
Other gets	500	100	300

7.

	A	B	C
You get	510	560	510
Other gets	510	300	110

8.

	A	B	C
You get	550	500	500
Other gets	300	100	500

9.

	A	B	C
You get	480	490	540
Other gets	100	490	300

ACKNOWLEDGEMENTS

First of all, I would like to express my heartiest gratitude to the merciful Almighty ALLAH, who enabled me to pursue my education and to complete my dissertation for the Ph.D.

I feel immense proud to express my heartfelt respect, sincere gratitude, deepest appreciation to my supervisor Prof. Koji Kotani for his scholastic guidance, steadfast cooperation, insightful comments, invaluable suggestions throughout the research work and encouragement to complete my Ph.D. dissertation. His deepest knowledge, philosophical thinking, excellent research ability motivated me to think about quality research and inspired me to publish two papers during my Ph.D. I received an infinite amount of advice and supports from him whenever I require it. I really appreciate his kindness support for my academic life. His philosophy regarding family life also inspired me to learn about how to make a balance between research and family life. Research philosophy that I learned from my supervisor would influence me to do quality research throughout my life.

I would like to take an opportunity to express my cordial respect and the deepest sense of gratitude to Prof. Makoto Kakinaka, Prof. Hiroaki Miyamoto, Prof. Kenta Tanaka, Prof. Yoshinori Nakagawa and Prof. Yuki Yanai for their kind cooperation, helpful comments, guidance and encouragement. I sincerely acknowledge the support and cooperation from the faculty members and staff of Kochi University Technology. I gratefully acknowledge to the SSP program for providing me financial support to conduct my research and study throughout the Ph.D. program. I am also grateful to the Japanese Society of the Promotion of the Science as the Grant-in-Aid for Scientific Research and Kochi University of Technology for supporting me in my study.

I owe heartfelt gratitude and thanks to Moinul Islam for his technical support on preparing the picture files for maps. I express my thanks to all the research assistants, especially Abdur Rahman Oli, Tuhin Rana, Sumi Khatun, Md. Faruk Hossain and Md. Abdul Alim who helped me to conduct the experiment. I feel proud in expressing my gratefulness to Shibly Shahrier for his supports and guidelines in conducting experiment in Bangladesh and providing valuable comments during the publication process in my paper. I express my deepest sense of gratitude to all of my friends, especially Raja Rajendra

Timilsina, Jingchao Zhang, Yayan Hernuryadin, Mostafa Shahen, Pankaj Koirala, Kostya Ovsiannikov, Arpana Pandit and Le Thi Huyen for their supports, inspiration, valuable suggestions and cooperation. I am really grateful to my friend, Ayat Alazab, for spending with me and continuous mental supports. I am indeed very grateful to my professors and colleagues in Bangladesh for their cordial cooperation and inspiration over the period of research. I deeply acknowledge the Bangladesh Agricultural University for providing me the study leave to continue my Ph.D. in abroad.

I am pretty much grateful to my family members, especially my parents Md. Rofiqul Islam and Mst. Amena Khatun for their love, prayers and encouragement. Last but not least, I am truly grateful to my husband, Md. Faruk Hossain, for his care, love, prayer and inspiration. I want to provide my special thanks to my children, Fatiha Jahan Farisha and Aylan Farabi, for their unconditional love and scarifies. The acknowledgement would not be completed without giving thanks to everyone who helped me during my Ph.D. journey.

I would

like to dedicate this research to

my beloved parents, my loving husband

and the future generations.