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The Effects of Climate Change on Agriculture and Poverty in Coastal Bangladesh

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Abstract
Bangladesh which has a very high population density is one of the most vulnerable countries to climate change. The increasing risks from climate change, sea level rise, and natural and man-made hazards—such as cyclones, storm surge, flooding, land erosion, water logging, and salinity intrusion in soil and water have already adversely affected livelihoods of people living in environmentally fragile areas. This study identifies the relationship between the socio economic indicators of the study area and poverty induced landownership pattern. Thus seven unions in Koyra Upazila located in coastal areas in Bangladesh have been identified as the study area for this research activities. To make the outcomes useful, both qualitative and quantitative approaches of field investigations are done. Moreover, considering the possible effects of climate change in the coastal area, this study deals with the land ownership pattern and per capita consumption (which is a proxy for poverty).
Keywords: Climate change, agriculture, landownership, poverty, coastal Bangladesh

1 Introduction

The climate change is now global and so a significant environmental issue. The effects of this change are being experienced through irregular weather conditions. Bangladesh is vulnerable to climate change impacts in its coastal areas where extreme events are day by day increasing; more floods and droughts, high temperatures, heavy rains within a very short period of time, or low rainfalls. But, adaptations to such changes for Bangladesh are very important because its economy depends on its agricultural products, which often fail due to pest outbreaks, climate variation, price fluctuations, inappropriate land use or land tenure policies and food insecurity for rural people.

True, agriculture and climatic factors are interrelated. Climate change may increase the temperature, which will bring changes in rice farming activities and affect crops yields. In Bangladesh Noakhali, Bhola, Bagerhat, Potuakhali, Satkhira and southern portion (Koyra) of Khulna districts are the main affected coastal areas by the climate change. Although the coastal areas are much more fertile for agricultural production, these areas are relatively income-poor compared with the rest of the country. Moreover, climate change is a factor for sea level rise in the coastal regions of Bangladesh. This will cause an increase in salinity in water and soil in the coastal regions. Growth of standing crops like rice, jute, sugarcane etc. are being affected due to soil salinity, and this decreases crop produce in the coastal regions as well as makes the soil unsuitable for productive crops. This loss in agriculture would generate many economic and social problems, and force the import of food, which will require spending of hard currency. Average per capita gross domestic product (GDP) (at current market price) in the coastal zone was US$ 402 in 2008, compared to US$ 621 for the whole country on average. Thus, for a least developed country (LDC) like Bangladesh where the climate change takes a shape of natural disaster not only affects the socio-economic condition of coastal communities but also hinders obtaining an optimal GDP growth. Therefore, it is proved that climate change in the form of natural hazards poses a significant threat to Bangladesh.

1.2 Statement of the problem

Climate change and agriculture are interrelated. Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, carbon dioxide, glacial run-off, precipitation and the interaction of these elements. The Government of Bangladesh has already recognized coastal zone as potential areas of enormous production. But these areas are lagging behind in socio-economic development and vulnerable to different natural disasters and environmental degradation. So, coastal areas of Bangladesh are one of the most affected areas in the world due to the threats of climate change effects.

1.3 Study Objectives

This study is an investigation on changes in agricultural land use pattern due to effect of climate change. Identifying and understanding problems and policy direction, plans and programs depend on objectives of the study:

1. To identify the possible effects of climate change in coastal Bangladesh.
2. To figure out how climate change-induced poverty affects agricultural land ownership pattern.

2 Review of Literature

Juliano, J. (2010) evaluates the economic literature on the consequences of climate change on two strands: the production-function approach and the Ricardian approach. The first one is the most traditional. The consequences of the climate change are estimated from the association between agricultural productivity and climate measures like temperature, rainfall or greenhouse gases levels. He argues that these studies tend to overestimate the climate change damage, since they ignore the capacity of adaptations that farmers can make in response to worse climatic conditions, such as introduction of new crops, migration and occupational mobility. On the other hand, the Ricardian approach assumes that land prices represent the expected present value of all net profits farmers can get from land. Empirically, instead of studying yields of specific crops, the Ricardian approach examines how climate in different places affects the net rent or the value of farmland. He estimates the impact of climate change on agricultural productivity and poverty.

Ahsan (2010) explained that most of the devastating disasters, especially cyclones which are the effects of climate change, hits the coastal belt of Bangladesh each year. He investigated the nature and extent of relationship between vulnerability and important socioeconomic parameters of *Koyra* (Southern Area of Bangladesh) in this study. He also examined how vulnerability and poverty are related to each other and investigated relationships of social capital, literacy, household-size and vulnerability (both domain-wise and aggregate) with poverty, and with land ownership. Ericksen, et al. (1994) have shown socioeconomic implications for Bangladesh related to climate change. They basically focused on climate-society interaction, vulnerable in transition, population, settlement and climate change, migration, employment and climate change, health care and education. Kumar, et al. (2007) reviews this report to provide an understanding of the present situation exposed by the cyclone Aila. This study is expected to provide an account of socio-economic and environmental scenario of the affected people and their present livelihood condition in the affected regions after one year of Aila ravage with a key focus on Shyamnagar, Koyra and Dacope Upazilas of Satkhira and Khulna Districts.

Sikder (2010) studied on long-term climatic and crop productivity data, regional climatic scenarios and impact analysis of different aspects of climate change on agriculture. The study reveals that the crop yield would be negatively impacted by rise in temperature, erratic rainfall, flooding, droughts, salinity, etc. but, of them, water logging and drainage congestion are the major problems. Islam (2006) expresses different land use patterns in different times with the changes of climate. It affects on the coastal area of Bangladesh. Drainage congestion inside and heavy siltation outside the polders made the southwestern area unsuitable both for agriculture, and, human habitation. Crop land and mangroves were transformed to shrimp farming. This creates social conflicts.

Hossain (2010) has analyzed available data to assess impacts of global warming induced sea level rise on loss of soil and land resources and their implications on food security of Bangladesh. The loss of land mass and degradation of soil and land resources will adversely affect national food production and thereby food security. Sea level rise impacts are really high for Bangladesh, though the country plays insignificant role in green house gas emission.

There is a worldwide consensus among climate scientists that global average temperature has risen about 1°F (0.4°C-0.8°C) in the past 140 years. The assessments are done by the US National Academy of Sciences and the United Nations' IPCC find that most of the warming of the past 50 years is likely due to the accumulation of greenhouse gases. The Figure 1 shows the increase in the earth's surface temperature from 1860. The foremost evidence for worldwide climate change has been global warming. For the Northern Hemisphere temperatures during the second half of the 20th century were higher than during any other 50-year period in the last 500 years and probably in the last 1,300 years. In addition, eleven of the last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature which began in 1850.

The fourth assessment of the IPCC states that the impacts of human-induced climate change are likely to be felt in poor countries and poor communities first. The IPCC highlights the following as being particularly vulnerable: 01. Small Island Developing States (SIDS) 02. Africa 03. Mega-deltas (particularly in Asia) 04.The Polar Regions. In future, a warming climate will influence the normal range of weather patterns for major regions of the globe (IPCC, 2001a).

The projections of sea-level rise for the 21st century are shown in figure 2.2. For the TAR (Third Assessment Report of IPCC), the projections are for 2100 compared with 1990 levels. For the AR4 (Fourth Assessment

Report of IPCC), the projections are for the 2090 to 2100 decade (shown as the bars plotted at 2095) compared with 1980 to 2000 averages (approximately equal to the 1990 values). The TAR projections are indicated by the shaded regions and the curved lines are the upper and lower limits. The AR4 projections are the bars plotted at 2095. The inset shows sea level observed with satellite altimeters from 1993 to 2006(orange) and observed with coastal sea-level measurements from 1990 to 2001 (blue).

While most of these papers are written about the impacts of climate change on Bangladesh, this paper is an investigation to explore how agricultural land is decreased. Side by side poverty in the selected areas of Koyra in coastal Bangladesh is increases on account of possible effects of climate change. The literatures assessments done by the IPCC have figured out the possibilities of climate change and its related aftermath on coastal Bangladesh. The poverty will be measured as proxy variable consumption expenditure. Again it is tried to explore the effects of climate change on agricultural land ownership pattern of the Koyra region.

3 Methodology of the study

This study is based on both the primary and secondary data and information. published materials, books, journals and different organization reports are the main sources of secondary information. A structured interview schedule was prepared to collect the required information and data. Moreover, questionnaire survey and face to face interview were done for collecting field level data and information. The collected data were analyzed by using the statistical software-Excel, SPSS and STATA. Random sampling has been considered in selecting the study population. Since the study area consists of seven unions (Koyra, Amadi, Bagali, Dakshin Bedkashi, Maharajpur, Maheswaripur, and Uttar Bedkashi), we collected data from all of these unions. We randomly picked six households from each union. Hence, a total of 420 households were randomly chosen from the whole study area. The study followed both the qualitative and quantitative approaches. This is a quantitative analysis because this will apply the statistical tools like OLS and Heckman Two stage Model in analyzing the variables and their relationship. The main aim of this study is how climate change affects agricultural land ownership pattern and poverty in coastal Bangladesh and analyzes it by helping primary and secondary sources of data. This study has been completed in an analytical and descriptive way.

3.1 Selection of the study area

It can be mentioned that *Koyra* Upazila which is a significant disaster-prone coastal area unlike other areas due to possible effects of climate change in Bangladesh is primarily selected as a study area because of super cyclones AILA and SIDR that shook it within the span of last four years.

3.2 Determination of sample size

Sample size determination is an important factor of any research. Since the study area consists of seven unions, we collected data from all of these unions. We randomly picked six households from each union. Hence, a total of 420 households were randomly chosen from the whole study area. During data collection, once we picked a household for questionnaire survey, the very next one was chosen after ten households. We assumed that the number of households chosen from each union would reflect the real status of the concerned union.

3.3 Data Collection

Data are an essential factor for any research work that are collected for the research, which will be collected by the questionnaire survey and books, journals and Internet sources. For this research a household survey was designed which contained both structured and semi-structured questions. This was done to have qualitative information next to the outcomes from the statistical analysis based on the structured questions. The survey looked into the land use pattern and poverty due to climate change. To link their relation, questions were asked concerning their expenditure asset portfolio. The semi-structured questions focused on the perceived problems of the respondents to reduce their climatic shocks.

4 Population in the study area

The Koyra town has a population of 8636; male 47.95%, female 52.05%. The density of population is 861 per sq km. Literacy rate among the town people is 31.3 %. It has one dakbungalow. The total population of this Upazila is 192534; of which male is 95993 and female is 96541. Males constitute 49.68% of the population, and females 50.32%. This Upazila's eighteen up population is 80,830 (Banglapedia, 2011)

4.1 Identification of the respondents

Age structure and sex composition of a society are fundamental demographic data when examining population characteristics. The number of family members (per household) living in Koyra Upazila ranged between one and sixteen. In most households the range of respondents' age varies from 20-40 years which is about 52.86%. Accordingly, the average family size in the study area is found to be 4.8 persons per household. The population distribution of the study area has reflected a medium age population pattern, i.e. that the proportion of the people in medium age groups is much higher than the proportion of the people in older age groups and younger age groups. In the study area the minimum schooling year is 1 year and the maximum schooling year is 20 years.

The mean schooling year is 4.58 which are near to 5. From the survey it is found that out of 420 households, 134 households' average schooling year is >5 year which is considered as standard level in Bangladesh HDI (Human Development Index) trend. A total number of 420 respondents 391 are married, 15 are never married, 6 are divorced and 8 are widowers.

Most of the respondents live below poverty line. They engage themselves in different types of works to maintain their subsistence level. They are Farmers, Govt. employees, Fishers, Private Job holders, Daily labors, Honey-collectors, Traders, Wood-cutters and others. Most of them are directly or indirectly related with agriculture. Some persons are unemployed. Now let us see the tabulated value of profession of the respondents. most of the respondents are day laborers i. e. 21.7%. 20.7% are farmers, 14.5% engaged in fishing, 14.3% engaged in trade and 1.9% is wood cutters. Some persons are engaged in both govt. service and private jobs i. e. 2.4% in govt. service and 3.8% in private job. And 7.9% are engaged in other professions and only 54 people out of 420 i.e. 12.9% are unemployed. Of the unemployed, 24 respondents are males who are disabled to work and 30 are females who are housewives. In the study area, no female respondent is engaged in private job sector. The average income was 65227.32 TK/yr in 2008 and in 2009 it was 34190.09. So from this survey it is found that in 2008 the household income was twice the amount of 2009. The average hectare of land is 99.90. And maximum is 1320 hectares and minimum is 1 hectare. But only 1 respondent enjoys 1320 hectares of land and 3 persons each have 1 hectare of land.

5 Analysis and Discussion

The first section will discuss the descriptive statistics and in the second section the results of the Heckman two-stage approach will be discussed. The descriptive statistics of the survey data will be discussed by comparing and characterizing the households that are affected and not affected by the climate change.

In the study area the total land size may be changed due to possible effects of climate change because it is one of the factors responsible for reducing land size. It appears from the table 3 which shows the comparative analysis of land pattern before and after Aila. In 2008 the average land size is 157.02 hectare and in 2009 it is 99.89 hectare. Land is used for different purposes. In 2008, 159 respondents used their land for cultivation *i. e* they are the agricultural land owner and in 2009 this quantity is decreasing.

In the last 5 years, 62 households lost their land in the study area. The total quantity of damaged land is 36911.58 hectares. Most of the people depend on agriculture, so loss of land is a great threat to their livelihood. Such loss is responsible for decreasing expenditure. Hence, it can be concluded that they live below poverty line.

The independent variable is consumption expenditures which are used as a proxy of poverty. From analyzing the primary data it is found that in 2009 only 84 respondents out of 420 do not live below poverty line. It is estimated by using our expenditure data from primary survey analysis. So it can be easily said that due to climate change most of the households live below poverty line because this area is coastal one. So after Aila the expenditure decreased than the previous year. Data show that possible effect of climate change on agricultural land pattern because the indicators of climate change salinity, flood, landslides hamper agricultural land size and we analyze its consequence in terms of poverty. Changes in agricultural land affect the living standard of the poor and consequently, rural poverty. In absolute terms, the poverty variation induced by climate change is much less extreme when we allow households to adjust both in terms of occupations and sectors as well as in terms of migration.

Now we would like to continue with figuring out the nature and extent of relationship between agricultural land ownership pattern and the situation of poverty at *Koyra*. Hence, in this case we conduct econometric analysis. With a view to identifying the relationship pattern between agricultural land ownership pattern and poverty we ran a number of econometric models. But before we proceed to the operation with econometric models, let us have a look at the variables used in the model.

The dependent variable is the total land owned by, which is considered to be affected by climate change. This variable indicates how much land was owned by the household in 2009. The values were taken in hectares for the entire household. We have used the following independent variables with short explanation that we used in models. Variable 'household size' refers to the total number of members in a household. 'Education' refers to household's average aggregate academic schooling year. It is the number obtained by summing up of formal schooling years of all members in a household and then dividing it with the number of total household members. This variable is considered as a proxy for capacity of households. The variable 'Duration with community' refers to the number of years the respondent household living with the current community. Along with the above-mentioned dependent and independent variables, we used the following two independent variables for constructing correlation and regression.

We applied a Heckman Two Stage Model for dependent variable 'land ownership' in order to find out if there is any sample selection bias. This model consists of two steps that are addressed by two different equations: a selection equation and a conditional equation. The first probit equation is a selection process for the households

having land-ownership or not. In the second equation the effects of independent variables on 'land ownership' are examined.

The Heckman two-stage approach is based on the assumption that the selection equation and the conditional equation are related to each other through their error terms. When there is no relation between the error terms there is no need to perform a Heckman two stage approach as there is no sample selection bias and an OLS regression will give unbiased estimators. For such a model, the bottom line in STATA output gives a value for 'lambda' with associated p-value. Since the data is missing mainly on the dependent variable, a nonrandom sample selection exists in this case. There is a possibility that due to some common pattern, the respondents did not provide any data. If that has happened, bias could always occur in OLS in estimating the population model. As a result, we use here the Heckman model.

Our model is

$$land\ ownership = \beta_0 + \beta_1 lnpce + \beta_2 hh\_size + u_1 \quad \ldots\ldots\ldots\ldots \text{(i)}$$

$$land\ ownership = \gamma_0 + \gamma_1 lnpce + \gamma_2 edulevel + \gamma_3 duringwithcomty + \gamma_4 hh\_size + \gamma_5 asst2008 + u_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

6 Results

Using landownership as a dependent variable in Heckman regression, we find $lnpce$ and the constant term are significant. We also find positive relationship for $lnpce$ and hh_size with $landownership$. Considering the absolute values of the coefficients, the result shows that $lnpce$ is the most influential between the two variables.

We will explore the relationship between the landownership pattern and the per capita consumption expenditure. In this model we are going to have the dependent variable in its original metric and the independent variable log-transformed. In this particular model we take log with per capita consumption expenditure and the coefficients on per capita consumption expenditure and represent the estimated marginal effects of the regressors in the underlying regression equation. So, an increase in the household size by one member increases land ownership by 6.30 hectares and an increase in the household consumption expenditure by one percent increases land ownership by 0.613 hectares. In Heckman model the p value of lambda is 19%. So there is no correlation between the error terms of the two equation i and ii. However, since the lambda term is not significant, we cannot come to any such conclusion and hence we conducted OLS which would provide an unbiased result.

We present the usual OLS regression. From the OLS we consider the independent variables are per capita expenditure, education level, during with the community, household size and asset 2008 and the dependent variable is land ownership of the respondents. In this analysis the model is significant in case of asset 2008 for dependent variable land ownership. From the regression we get per capita expenditure, education level, during with the community and asset 2008 is positive. We also found significant positive relationship per capita expenditure, education level, duration with the community and asset 2008 with land ownership whereas it is significantly negative for household size.

However, there is sample selection bias. There is heteroscedasticity in the OLS model. We apply an analytical test to see heteroscedasticity problem in the model. Therefore, we present heteroscedasticity corrected standard errors using an extra interaction variable which is found by multiplying the two independent variables per capita expenditure and education level. Due to existence of heteroscadasticity problem, we reconstruct the three regression model by using three different weights. In the first column the analytical weight is 1/ $(int\_pce\_edu)^{1/2}$, in the second it is 1/ $(int\_pce\_edu)^2$ to in the three it is 1/ $(int\_pce\_edu)^{1/3}$.

It explores asst2008 and land ownership is positively related to each other. Due to 1 unit increase in the asst2008, land ownership will be increased by 0.00083 hectare. On the other hand, the relationship between land ownership and per capita consumption expenditure and education level is positive. As 1% increase in per capita consumption expenditure results in 50 units increase and vice versa and when education level is increased by 1 unit land ownership also increased by 74 units. It is found that household size and interaction variable (consumption variable multiplied by education level) are negatively related with landownership. That means 1 unit increase in household size and interaction variable (consumption variable multiplied by education level) land ownership decreased by 6 and 12 units respectively. 11% of variation of the land ownership will be explained by education level, per capita expenditure, household size; Heteroscedasticity corrected OLS results differ from previous OLS results. Here four variables *i.e*, per capita expenditure, education level, asset 2008, and interaction variable (consumption variable multiplied by education level) are significant. This table satisfies both economic and statistical interpretation.

In case of any climatic shock these households were more likely to be vulnerable through exacerbating of their poverty level because such shock is related to higher expenditure. From empirical result it is found that an

uneven distribution of land ownership exists in Koyra Upazila. Different possible effects of climate change are responsible to decrease agricultural landownership. So it can be said that in the study area the total land size is changed due to possible effects of various climatic hazards. As the study area is located in the coastal belt of Bangladesh, the different climatic situation hampers the people's livelihood pattern *i. e* their expenditure decreases and that is why most of them live below poverty line and their land size is also decreased.

7 Conclusion

Bangladesh's coast is the worst victim to natural disasters. The coastal areas of Bangladesh have already been facing salinity problem which is expected to be exacerbated by climate change and sea level rise. Climate change impacts are already adding significant stress to physical and environmental resources of the people, their human ability, and economic activities. In this paper the pattern of agricultural land ownership and poverty in the study area Koyra due to the possible effects of climate change has been projected. One of the significant results from this study shows positive relation between consumption expenditure (measurement of poverty) and land ownership. Hence, land ownership becomes a crucial factor for capacity of the households while facing challenges of both poverty and vulnerability. It is found during field survey that after transferring of land ownership, some households migrate to nearby urban area while some stay in the same union. Hence, these households are self-selected to stay in the same union and even after selling their lands. So these empirical study-findings conclude that possible effects of climate change worsen poverty as well as socio-economic situation in coastal Bangladesh.

8. Recommendations

Firstly, we must try to find out ways to maximize economic growth along the affected coastal Bangladesh. Secondly, to identify the aftermath of global warming and take possible steps of how to counter it so that the harmful consequences of climate change can be lessened in the coastal areas. Thirdly, the Government may set up a center/cell under the control of its relevant Ministry and take policies to deal with climate change affectations especially in the affected areas. Fourthly, measures should be taken to give protection to the coastal-belt dwellers vulnerable to oft-occurred natural hazards so that they may be saved from constant loss and poverty. Fifthly, a framework can be developed for constant assessment of climate change scenarios, its impacts for mitigation. Sixthly, relevant sectors (local, Govt. NGOs and other Agencies) can study climate change impacts and take possible adaptation measures for the livelihoods groups in terms of their regional basis acuteness of troubles. Seventhly, various agencies may come forward to train the people who can face challenges of climate change affectation. Eighthly, it is to be ensured that all productive land in the coastal belt can be properly utilized to ameliorate poverty situation. Ninthly, regular research, projects, field study, and subsequent evaluation are essentially required to address coastal climate change issue. Tenthly, as the coastal areas are relatively vulnerable to different hazards on account of climate change, the physical infrastructure in such places is to be developed keeping in contemplation the effects caused by the climate change. Eleventh, Climate change is no doubt an enemy and as such poses threats which are to be dealt with by all thoughtful appropriate measures and meaningful programs even by changing livelihood patterns across the coastal Bangladesh.

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