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Climate Change and Income Inequality: An Empirical Study in Coastal Bangladesh

Md. Nasif Ahsan
Assistant Professor, Economics Discipline, Khulna University, Bangladesh

Abstract: *Statistical data reveals that increase in natural catastrophes over the last two decades has been taken place due to climate change in most part of the world (Birkmann & von Teichman, 2010). Bangladesh, a South Asian LDC, has recently been reported as in the worst position of long-term climate risk (Germanwatch, 2010). Most of the devastating disasters, especially cyclones which are very likely to be the effects of climate change, hit the coastal belt of Bangladesh each year. Hence, huge infrastructural settings and entire socioeconomic structure are broken down. The most affected economic indicator in coastal belt is income. This study investigates the influence of disaster on income inequality. A spreadsheet computation of income inequality is used in this study to show the income inequality with econometric analysis. This study was conducted in three unions of Koyra Upazilla under Khulna district of Bangladesh from July 2009 to February in 2010.*

Introduction

The world is undergoing a broad set of global changes, like changes in population density, climate, resource use, land use, biodiversity, and urbanization and globalization processes. Climate change is one of the drivers of global change, which has over the years been received strong focus by scientists, policy-makers and leaders of the world (Vitousek, 1994). At present climate change is considered as emerging global threat that not only induces physical environmental impacts but also affects the social structures, economic factors and the overall development process (Birkmann & von Teichman, 2010). This emerging threat has introduced a new social community named *'Climate Refugee'* especially for the affected developing nations. The UN currently states that more refugees are displaced by environmental catastrophes than wars, and the number of the climate refugee is more than 25 million which is likely to become 50 million in coming decades (Myers, 2002). Out of those 25 million people about 10 million are from Africa who are directly affected by the climate change via droughts. The second largest group is from coastal areas of Asian countries, who are affected by natural disasters like cyclones, storm surges, floods, salinity and droughts (Anon, 2010).

The cumulative effects of climate change exacerbate food and water insecurity, loss of biodiversity and ecosystem, environmental degradation and human insecurity through social conflict, political conflict and violence in the affected developing countries (Adger & Kelly, 1999). Hence, the socioeconomic structures are undermined in these countries where the affected people are compelled to switch over occupations for livelihood. These are the people who can no longer ensure a secure livelihood in their origin of dwelling (Myers, 2002). Together with climate change effects, population pressure problem and hardcore poverty have induced a notable change in the whole economic structure of these countries. As a result, these countries are suffered from chronic socio-economic inequality and social instability (Barnett & Adger, 2007).

Since independence in 1971, Bangladesh has started her war against numerous socio-economic, political and socio-political problems with a view to escalating her status from bottom level LDC to top level LDC. Among a long list of existing problems like rapid population growth, poverty, illiteracy, gender disparity, low level of economic growth etc. income inequality takes the crucial role that actually undermines the sustainable development process of Bangladesh (Khan & Hossain, 1989). A decade ago the major causes behind income inequality were mostly socioeconomic ones, particularly in the coastal belt of Bangladesh. However, at present the most powerful determinant creating income inequality in coastal belt does not belong to socioeconomic aspects, rather to climatic factors in the form of natural disasters (Carter & Maluccio, 2003). Due to climate change, natural disasters are most frequent events in Bangladesh. Bangladesh often makes top news all over the world due to natural disaster, which usually means a huge death toll and massive destruction for one of the poorest nations in the world (Brammer, 1996). Recently, on November 15, 2007, thousands have died and millions were rendered homeless by super-cyclones named SIDR and AILA. It devastated southern and central Bangladesh. According to official sources, some 3,313 people were killed and 28,128 injured by the deadliest cyclone ever in the history of post-independence Bangladesh; and due to SIDR and AILA the estimated damage in terms of US dollar was 2,300 million (EM-DAT, 2010). However, the unofficial sources said that the total death will be between 5,000 and 10,000. Cyclone SIDR and AILA swept across 16 coastal districts with wind speeds of 240 km/h (150 mph). The winds whipped up waves three to five meters high. The cyclone flattened homes, uprooted trees, electricity, and telephone poles, washed away roads and bridges, destroyed crops, and killed livestock. The death toll would have been far worse if limited emergency plans had not been in place (Bilham & England, 2001). An early warning system enabled the evacuation of an estimated 3.2 million people to higher ground and safety. In contrast, during 1991, Cyclone Gorky claimed at least 138,000 lives and in 1970, Cyclone Bhola killed about half a million people

in Bangladesh (Nizamuddin, 2001). Both the frequency and the scale of natural disasters have increased in recent decades, especially the frequency of disasters does have adverse effect on developing countries like Bangladesh (Barkun, 1977). Despite increasing frequency, natural disasters have often been ignored by economists because of the difficulty regarding making generalized conclusions about their impacts. Disaster is mainly of two types and they are the natural disaster and the manmade disaster (Benson & Clay, 2004). It is quite difficult to calculate and make a conclusion on all disaster. In this paper, only a cyclone has been taken into account as natural disaster and it is the recent devastating super cyclone SIDR and AILA occurred on 15th November 2007 and 27th May 2009. As we have already mentioned that income inequality is one of the major problems in Bangladesh, which reveals the degree of disparity between high and low incomes. The degree of income inequality is often regarded as an important indication of the fairness of the society we live in. A high level of income inequality may be harmful to the level of social integration among the members. Inequality in income and other welfare indicators reflect underlying inequality in asset ownership pattern (Ferreira, Walton, International Bank for, & Development, 2005). The rise in income inequality in Bangladesh has attributed to the widening disparity in landholdings and education levels along with the rising income inequality between the urban and rural sectors (Deininger & Squire, 1996; Sen & Ali, 2005). Nowadays the natural disasters are highly responsible for creating income inequality in Bangladesh. Therefore, this paper focuses on the impact of disaster on income change in the study areas between pre and post SIDR-AILA period. The objectives of this study are i. to assess whether disaster (in form of climate change) affects the income or not and ii. to what extent disaster influences the factors that are directly related with income distribution.

Materials and Methods

The primary data were collected through questionnaire survey and observation method. Besides, a few secondary sources were also adopted. Collection of data was conducted in different units from the study area and after compilation of data; various outcomes of household factors are shown accordingly.

Impact Measuring Variables

A number of parameters were used while conducting this study to know the existing setup and overall socioeconomic status of the study area. These parameters are as follows:

Table 1: Parameters used to achieve the objectives

Objectives	Parameters
Identifying existing settlement pattern of study area	Housing materials, residence ownership pattern, housing condition, settlement distribution, topography, land use, physical infrastructure
To measure the income inequality	Income and expenditure of the family before and after SIDR and AILA, income source, income and asset loss during SIDR and AILA
To identify capacity of the people of study area against the cyclone, by assessing the human, social, financial, physical and natural assets of study area	Occupation pattern, income level, socioeconomic activities, social status, education level

Study Area

To investigate the impact of climate change effect on income distribution, the study area was chosen on the basis of intensity and frequency of climatic catastrophe in that particular area. One of the significant coastal cyclone-prone areas of Bangladesh is Koyra upzilla under Khulna district in Bangladesh. Moreover, Koyra is one of the most affected areas because of SIDR-AILA. This study was carried out in three unions namely Dakshin Bedkashi, Maharajpur and Maheshwarpur under Koyra Upazila in Khulna District, a southwestern coastal region of Bangladesh. To select the location of the study area, emphasis was given mainly on the mostly damaged part of Koyra upzilla comprising of three different locations as stated above. All the primary data for this study were collected from July 2009 to February 2010.

Sampling Unit and Sample Size Determination

For this study, stratified random sampling was adopted by targeting income differential among households, and then proportional random sampling was used to get the target group from different strata. In this study, each Household (HH) is considered as a unit. At the same time, sample size determination was also an important factor of this study. To avoid error it was essential to consider a very good proportion as sample size. Hence, a total of 324 households were taken as sample.

Results and Discussion

Socio-economic Condition Analysis

Population: In the study area total number of population is 7836, among them 49.72% is male and 50.28% is female. The total number of household is 1682 (BBS, 2009). The average member of the household is around 2.

Table 2: Demographic features of the study area

Total households	Population		
	Male	**Female**	**Total**
1682	4896	3740	8636

Source: BBS, 2009

Age-sex structure: The major age group of the population is 0-9 and 18-34 years (1795 and 1713 respectively). Age Sex distribution of the people of the study is shown in Table 3.

Table 3: Age-Sex structure of survey area

Total		0-9 yrs		10-17 yrs		18-34 yrs		35-59 yrs		60 & Over	
M	F	M	F	M	F	M	F	M	F	M	F
4896	3740	882	913	875	838	985	944	623	697	531	548

*M=Male; F=Female
Source: BBS, 2009

Educational status: The literacy rate of the study area is not satisfactory enough. More than 38.27% people are illiterate in the surveyed area and only 8.64% people are graduate. A significant portion of people has completed their secondary education and it is 27.16%.

Toilet facility: In the study area, condition of toilet facility is not hygienic as because most of the peoples rely in unhygienic practices as the super cyclone SIDR and AILA have destroyed almost all the sanitation facility in the surveyed area. Only 34.56% of total households have the sanitary toilet facility. Around 61.72% people have no access of sanitary latrine (Table 4).

Table 4: Existing toilet facility in the study area

Households	Sanitary	Non-sanitary	No toilet
324	112	200	12

Source: BBS, 2009.

Drinking water: Table 5 shows that only 22.22% people are using the Deep Tube well water for drinking purpose whereas most of people are using pond water as their main source of drinking which is 62.96%.

Table 5: Drinking water supply system in the study area

Total respondent	Source of drinking water			
	Deep Tube Well	Tube Well	Pond	River
324	72	48	204	Nil

Source: BBS, 2009.

Housing: The people in the surveyed area are mainly poor and they are using kucca residence for their living. Around 73% households are living in kucca house. Only 19.20% households are living in semi-pucca house and 7.81% households in pucca house.

Income expenditure pattern: Before SIDR-AILA monthly average income of the low income group was Tk. 5347; whereas for middle and higher income deciles, it was Tk. 11572 and Tk. 22311 respectively. A decrease of average monthly income is found after SIDR-AILA and for lower income deciles it is now Tk. 4035; for middle income deciles it is now Tk. 9723, for higher income deciles it rises to Tk. 23656. The expenditure pattern of the surveyed households has been changed due to SIDR and AILA. Normally the people spent more on food compared to other items. Before SIDR and AILA, 64% of the total expenditure was made to food for all income groups. Again, only 10% of the total expenditure was made to educational purpose. The people had very little scope for recreation and they spent only 3% of total expenditure on this purpose. However, after SIDR and AILA, expenditure on food declined to 58%. On the contrary, the expenditure on health increased to 10% since people become more affected with diseases during post SIDR and AILA period. Moreover, expenditure on education decreased by 1% after SIDR and AILA.

Loss During SIDR and AILA

The super cyclone SIDR and AILA affected socioeconomic condition of the people of the study area. The loss was too severe to explain. These catastrophes destroyed houses, trees and washed away animals, crops, net etc. in this study total loss during SIDR and AILA is divided into income loss and asset loss. This study found that the mentioned cyclones hit the poor people badly in the study area.

Income loss during SIDR and AILA: Among the income losses, there are five categories; occupation, rent, livestock, crops and business. From the field survey

it was found that among the income loss, 76% belongs to crop-damage; then 17% loss belongs to the business.

Asset loss during SIDR and AILA: SIDR and AILA were responsible for huge asset damage. Among the total loss, 32% loss was related to house-destruction and 20% for *gher*-overflow. Generally, the people of the study area are engaged in fishing and they lost their fishing-kits due to SIDR and AILA; the percentage of this group is 13.

Statistical Analysis

Correlation between income before and after SIDR-AILA: Correlation is conducted between incomes before and after SIDR-AILA and the result is 0.850. It shows that there exists a significant high degree of positive correlation between income before and after SIDR-AILA (Table 6).

Table 6: Correlation between income before and after SIDR and AILA

	Income before SIDR & AILA	**Income after SIDR & AILA**
Income before SIDR & AILA	1.000	0.850**
Income after SIDR & AILA	0.850**	1.000

**Correlation is significant at the 0.01 level (2-tailed) (N = 324)
Source: Field Survey 2009-10

Partial correlation between income before and after SIDR and AILA*:* Partial correlation has been conducted between the income before and after SIDR-AILA and in this case the family size is considered as control variable. The result is shown Table 7.

Table 7: Partial correlation between income before and after SIDR-AILA

Control variable		**Income before SIDR and AILA**	**Income after SIDR and AILA**
Family size	Income before SIDR and AILA	1.000	0.846*
	Income after SIDR and AILA	0.846*	1.000

* Correlation is significant at the 0.05 level (2-Tailed) (N = 324)
Source: Field survey 2009-10

The result shows that considering the family-size as a control variable, there exists a significantly high degree of positive correlation between income before and after SIDR-AILA and it is 0.846.

Correlation between family size and income before SIDR-AILA: The correlation between family size and income before SIDR and AILA is conducted

and the result (0.277) shows that there is very low degree of significant correlation between family size and income before SIDR and AILA (Table 8).

Table 8: Correlation between family size and income before SIDR-AILA

	Family size	Income before SIDR and AILA
Family size	1	0.277*
Income before SIDR and AILA	0.277*	1

*Correlation is significant at the 0.05 level (2-tailed) (N = 324)
Source: Field survey 2009-10

Correlation between family size and income after SIDR-AILA: The correlation between family size and income after SIDR and AILA is 0.191, which shows very low degree of positive correlation. The result is not significant (Table 9).

Table 9: Correlation between family size and income after SIDR and AILA

	Family Size	Income after SIDR and AILA
Family Size	1.000	0.191
Income after SIDR and AILA	0.191	1.000

*(2-tailed) (N = 321)
Source: Field Survey 2009-10

Partial Correlation between income before and after SIDR and AILA: Partial correlation is conducted between income before and after SIDR-AILA, where year of education is considered as a control variable. The result is 0.851, which shows high degree of significant positive correlation (Table 10).

Table 10: Partial correlation between income before and after SIDR and AILA

Control Variables		Income before SIDR and AILA	Income after SIDR and AILA
Year of education	Income before SIDR and AILA	1.000	0.851*
	Income after SIDR and AILA	0.851*	1.000

*Correlation is significant at the 0.05 level (2-tailed) (N = 324)
Source: Field survey 2009-10

Pre and post SIDR-AILA income regression model analysis: In the pre SIDR and AILA income regression model, the relationship of income before SIDR and AILA is explained with year of education and size of the family. The R^2 for this model is 0.83 which means that 83% of the model is explained.

To explain the model we can write as,

$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$ …… (i)

Where, y = Income in pre SIDR and AILA period, α= Constant, ε= Error term, β_1= Coefficient of Year of education, x_1= Year of education, β_2 = Coefficient of family size and x_2= Family size

The following table (Table 11) shows coefficients of different independent variables. This table shows that all the independent variables are positively correlated with the dependent variable. However, only 'year of education' under this model is significant.

Table 11: Model summary of the pre and post SIDR-AILA income

Model name	Dependent variable	R^2	Co-efficient	Independent variable	P-value
Model for income before SID-AILA	Income before SIDR and AILA	0.83	1372.31	Year of education	0.011*
			135.31	Family size	0.487
Model for income after SIDRA-AILA	Income after SIDR and AILA	0.57	1168.46	Year of education	0.073*
			302.5	Family Size	0.203

* Significant at 5% level

Again in the post SIDR-AILA regression model, the relationship of income after SIDR and AILA is also explained with year of education and size of the family. The R^2 for this model is 0.57 which means that 57% of the model is explained.

To explain the model we can write as,

$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$ …… (ii)

Where, y = Income in post SIDR and AILA period, α= Constant, ε= Error term, β_1= Coefficient of Year of education, x_1= Year of education, β_2 = Coefficient of family size and x_2= Family size

Table 11 shows the coefficients of different independent variables. This table shows that all the independent variables are positively correlated with the dependent variable but in this case year of education, one of the independent variables is significant.

Pre and post SIDR-AILA labor income regression model analysis: In the pre SIDR-AILA labor income regression model, the relationship of labor income before SIDR and AILA is explained with income from service, agriculture, fishing, business and day labor. The R^2 for this model is 0.912 which means that 91.2% of the model is explained.

To explain the model we can write as,

$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \varepsilon$... (iii)

Where, y = Labor income in pre SIDR and AILA period, α= Constant, ε= Error term, β_1= Coefficient of service, x_1= Labor income from service, β_2 = Coefficient of agriculture, x_2= Labor income from agriculture, β_3= Coefficient of fishing, x_3= Labor income fishing, β_4= Coefficient of business, x_4= Labor income from business, β_5= Coefficient of day labor, x_5= Labor income from day labor.

The following table (Table 12) shows the value of coefficients of different independent variables. This table shows that all the independent variables are positively correlated with the dependent variable. Besides, all independent variables under this model are significant.

Table 12: Model summary of the pre and post SIDR and AILA labor income

Model name	Dependent variable	R^2	Co-efficient	Independent variable	P-value
Pre SIDR-AILA labor income	Labor income before SIDR and AILA	0.912	0.935	Service	0.004
			1.069	Agriculture	0.000
			1.002	Fishing	0.000
			0.954	Business	0.000
			0.537	Day Labor	0.000
Post SIDR-AILA labor income	Labor income after SIDR and AILA	0.966	0.949	Service	0.001
			1.049	Agriculture	0.000
			0.893	Fishing	0.000
			0.957	Business	0.000
			0.868	Day Labor	0.000

Similarly, in the post SIDR-AILA period labor income regression model, the relationship of labor income after SIDR-AILA is explained with income from service, agriculture, fishing, business and day labor. The R^2 for this model is 0.966 which means that 96.6% of the model is explained.

To explain the model we can write as, $y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \varepsilon$…….(iv)

Where, y = Labor income in post SIDR-AILA period, α= Constant, ε= Error term, β_1= Coefficient of service, x_1= Labor income from service, β_2 = Coefficient of agriculture, x_2= Labor income from agriculture, β_3= Coefficient

of fishing, x_3= Labor income fishing, β_4= Coefficient of business, x_4= Labor income from business, β_5= Coefficient of day labor, x_5= Labor income from day labor.

Table 12 shows the coefficients of different independent variable. This table shows that all the independent variables are positively correlated significantly with the dependent variable.

Income Inequality Measurement

The concept of inequality is distinct from that of poverty and fairness. Income inequality metrics or income distribution metrics are used here to measure the income inequality of the most affected unions due to climate change effects in Koyra upzilla. The most common metrics used to measure inequality are the Gini Index (also known as Gini Coefficient), the Theil Index, and the Hoover Index. In this study, Gini Index is used to measure the income inequality of the study area. The Gini Index is the most frequently used inequality index. The reason for its popularity is that it is easy to understand how to compute the Gini Index as a ratio of two areas in Lorenz curve diagrams. To measure the income inequality, Gini Coefficient has been used. The spreadsheet computation of Gini Coefficient is presented in Table 13. And from this table, the income inequality of the study area is measured.

According to the spreadsheet, the income of the people in the surveyed area has divided into three categories. They are: i. Group one (0 to less than Tk. 8000 per month), ii. Group two (8001 to less than Tk. 15000 per month) and iii. Group Three (Tk. 15001 and above per month). Each of the range or group has the same number of member and in this research, it is 108 and the total sample is 324.

Calculation of Income Inequality through Gini Index and Major Findings

The result of the Gini Index shows that income inequality prevails in the study area and pre SIDR-AILA period, the value of Gini Coefficient was 0.29. The range of the Gini Index is between 0 and 1 (0% and 100%), where 0 indicates perfect equality and 1 (100%) indicates maximum inequality. So, the value shows that there exists income inequality in pre SIDR-AILA period and it increased after SIDR-AILA period, which is 0.40. Hence, it can be said that climate change effects induced an increase in income inequality.

Table 13: Spreadsheet computations of income inequality matrix

Group	Members per group	Income per group	Income per individual	Relative deviation	Accumulated income	Gini
1	A_1	E_1	$\bar{E}_1 = E_1/A_1$	$D_1 = E_1/\Sigma E - A_1/\Sigma A$	$K_1 = E_1$	$G_1 = (2 * K_1 - E_1) * A_1$
2	A_2	E_2	$\bar{E}_2 = E_2/A_2$	$D_2 = E_2/\Sigma E - A_2/\Sigma A$	$K_2 = E_2 + K_1$	$G_2 = (2 * K_2 - E_2) * A_2$
3	A_3	E_3	$\bar{E}_3 = E_3/A_3$	$D_3 = E_3/\Sigma E - A_3/\Sigma A$	$K_3 = E_3 + K_2$	$G_3 = (2 * K_3 - E_3) * A_3$
Totals	ΣA	ΣE	$\bar{E} = \Sigma E/\Sigma A$			ΣG
Inequality measures						Gini = $1 - \Sigma G/\Sigma A/\Sigma E$

Sources: (Anon, 2009; Wikipedia, 2009).

Table 14: Gini coefficient before and after SIDR-AILA

Before SIDR and AILA	**Gini per Group** Gini for Group 1, $G_1=(2*K_1-E_1)*A_1 = 62373564$ Gini for Group 2, $G_2=(2*K_2-E_2)*A_2 = 259725528$ Gini for Group 3, $G_3=(2*K_3-E_3)*A_3 = 654940728$ So, $\Sigma A=324$; $\Sigma E=4236933$; $\Sigma G=977039820$	**Income Inequality of the study area** Gini = 1 – [{ΣG/ΣA}/ΣE] = 1- [{977039820/324}/4236933] = 1- 0.71 = 0.29
After SIDR and AILA	**Gini per Group** Gini for Group 1, $G_1=(2*K_1-E_1)*A_1 = 151867080$ Gini for Group 2, $G_2=(2*K_2-E_2)*A_2 = 109904080$ Gini for Group 3, $G_3=(2*K_3-E_3)*A_3 = 351517920$ So, $\Sigma A=324$; $\Sigma E=3175920$; $\Sigma G=613289080$	**Income Inequality of the study area** Gini = 1 – [{ΣG/ΣA}/ΣE] = 1- [{613289080/324}/3175920] = 1- 0.60 = 0.40

Conclusion

No one can get rid of the destructive impact of climatic catastrophes. However, the damage by these catastrophes is enormous as well as hard to estimate. This study found that higher income group have huge amount capital and assets in the form of cultivable land, livestock, gher etc. and therefore, this group is less likely to be affected once any disaster takes place. Again, the lower income group people have negligible portion of assets depending on which they are to survive. Due to disaster, these groups of people lose all their assets and they have started living below the subsistence level. Income inequality is one of the major reasons for the backwardness of the country and it also prevails in the study area. The analysis of the study shows that before SIDR-AILA the value of Gini Coefficient was 0.29 and after SIDR-AILA it is now 0.40. The result is alarming for the country because poor people are the main victim of the consequences of climate change. Another point which needs to be taken into consideration is that after SIDR-AILA, the lower income group people have become more vulnerable and they are being exploited by the higher class people. Different social *'pressure groups'* have been found as positive catalyst for the higher income group who actually took part in exploiting the marginal people in the coastal societies. Hence, disparity between the above-mentioned two groups is being broadened day by day at present.

It is very difficult to model the socioeconomic effects due to climate change in terms of climatic catastrophes. Despite these difficulties, modeling the effects of disasters, even with region specific models, remains an important task. In this study it was not possible to consider all the major factors that might be the determinants for the consequence of climatic catastrophes. However, the factors or parameters those were considered in the econometric models indicate that the consecutive climatic shocks had enhanced the socioeconomic disparity in the coastal communities of Koyra in terms of income inequality, asset and non-economic infrastructure. Therefore, if the government would like to lessen the mentioned disparity then some realistic policy approaches need to be adopted by focusing on specific issues such as employment generation, education, human resource development through trainings etc. Only then it might be possible to find a way-out how the disaster affected poor can recover the shocks and what mitigation and alleviation strategies might have been successful in various unions of Koyra.

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