

How does climate change affect food security in the rural areas of Bangladesh?

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Abstract

This essay aims to show the impact of climate change on the rural livelihoods of Bangladesh. This is done by investigating the effects of climate change on the 3 dimensions of food security : food availability, food access and food utilization. For the concept of food availability : regression models are used to show the impacts of different climatic variables (rainfall, maximum and minimum temperature) on the Aman, Aus and Boro rice yields. Climatic variables have both positive and negative impacts on crop yields. The future climate change scenarios show decreasing yields of all the three rice varieties in the future. This poses a threat to food security by hindering supply. Food access is hindered by the impact of a climatic shock such as a flood on the prices of commodities of that region. The impact of climate change on food utilization is shown through a variety of diseases, which leads to a decrease in labor productivity as shown through a study in Satkhira . Population increase and climate change act to hinder food security. Rural poverty in the context of climate change and food insecurity is explained through a livelihood framework. As shown through a study, that poverty and crop reductions are linearly related, an increase in crop reduction leads to an increase in poverty. The conclusion focuses on the urban impacts of climate change and its impacts on food security. It also suggests adaptive measures that could be taken to combat the effects of climate change on food security.

Introduction

Climate Change is defined as an important change in the measures of climate which lasts for a long period of time. Climate change includes major changes in temperature, precipitation or wind patterns among other effects.¹ According to Shakeel et al. **food security** can be revealed through the quantity of food availability in a specific time period of a particular place for consumption of the population². Food Security at the domestic level refers to the availability in the country in terms of sufficient stocks to meet domestic demands either through the availability of the domestic supply or through imports.³ However the Food and Agriculture Organization provides a more robust definition to the definition of food security, it describes food security as “situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” .⁴

According to National Geographic, risk studies show that Bangladesh is one of the most vulnerable countries' to the impacts of climate change with the highest risks to populations, ecosystems and business environments.⁵ Situated in a subtropical region the climate of Bangladesh is characterized by moderate variations in rainfall, moderately warm temperatures and high humidity. Climatic models have predicted a 3.8% increase in rainfall by 20130 while an increase in temperature by 1.0 C by 20120. ⁶ Food insecurity is a growing problem in Bangladesh. Bangladesh's food insecure population is

¹ Basics." *EPA*. Environmental Protection Agency, n.d. Web. 06 Apr. 2014.

² Shakeel, Adnan. "A Regional Analysis of Food Security in Bundelkhand Region (Uttar Pradesh, India)." *Journal of Geography and Regional Planning* 5.9 (2012): n. pag. Print

³ Sharma, Dev, and A. N. Sharma. *Food Security in India: Performance, Challenge and Policies*. N.p.: OXFAM, 2010. PDF.

⁴ "Bangladesh, India Most Threatened by Climate Change, Risk Study Finds." *News Watch*. N.p., n.d. Web. 07 Apr. 2014.

⁵ "Bangladesh, India Most Threatened by Climate Change, Risk Study Finds." *News Watch*. N.p., n.d. Web. 07 Apr. 2014.

⁶ Roy, Kumar, Masudur Rahman, and Uthpal Kumar. *Future Climate Change and Moisture Stress: Impact on Crop Agriculture in South-Western Bangladesh*. N.p.: Climate Change and Development Perspective, Sept. 2009. PDF.

estimated to be nearly 45% of the country's population and nearly one quarter of the population is severely food insecure⁷. This paper only focuses on rural livelihoods of Bangladesh. 80% of Bangladesh's population lives in rural areas where 54% are engaged in agriculture. High levels of poverty, vulnerability to natural disasters, low agricultural productivity are few of the defining characteristics of the rural households⁸. This paper aims to analyze the relationship between climate change and food security through explaining the impact of climate change on the multiple dimensions of food security : food availability, food access, and food utilization. Furthermore it also analyzes the concepts of climate change and poverty amidst the two critical variables : population growth and poverty, which are crucial for Bangladesh's rural areas.

Climate change and Food Production and Food availability

Food availability depends on the supply of food through the three criterions production, distribution and exchange of food. The production of adequate crops, fisheries, livestock, domestic production, and reliable import capacity are all important components to determine food security. Climate change affects food production directly through altering agro-ecological conditions thus affecting the supply side aspect of food.⁹ and indirectly by affecting growth and distribution of incomes which further causes demand for agricultural produce to change.¹⁰ Anthropogenic greenhouse emissions causes changes in temperature and precipitation which further affects land suitability and crop yields¹¹. Different crop yields react to different climate change variables differently. A case study by Md Abdur Rashid Sarker will be used to show the impacts of climate change on three main rice varieties of Bangladesh : Aman, Boro and Aus. The results are shown in Table 1. The mean yield is the highest for Boro, while the lowest maximum and minimum temperatures compared to aman and aus. Furthermore in Boro is three times

⁷ Food Security at a Glance." — *Bangladesh*. N.p., n.d. Web. 06 Apr. 2014

⁸ "Bangladesh: Priorities for Agriculture and Rural Development." *Agriculture* -. N.p., n.d. Web. 06 Apr. 2014.

⁹ Weber, Eberhard. "Climate and Environmental Change and Food Security." *The Journal of Pacific Studies* (2012): 99-110. Web. 6 Apr. 2014.

¹⁰ Schmidhuber, Josef. "Global Food Security under Climate Change." *Proceedings of the National Academy of Sciences of the United States of America* 104.50 (2007): n. pag. JSTOR. Web. 05 Apr. 2014.

¹¹ *Climate Change 2007: Synthesis Report*. N.p.: An Assessment of the Intergovernmental Panel on Climate Change, 2007. PDF.

lower than that for Aman and four times lower than that for Boro. The climatic variables (maximum temperature, minimum temperature and rainfall) are used as independent variables and are regressed on the output yields of Aus, Aman and Boro in tables 2,3, 4 respectively. 37%, 29% and 29% of the variability in crop yields can be explained due to the climatic variables as shown by the R^2 value. As shown in table 2, for AUS models, the maximum temperature and rainfall are both significant climatic variable. The minimum temperature is not highly significant but negative effects crop yields (negative coefficient). As shown in table 3 at 10%,5% and 1% level of significances maximum temperature, minimum temperature and rainfall respectively are all climatically significant variables. The minimum temperature has a negative impact on crop yield. Table 4 shows that maximum temperature and minimum temperature are both significant at 5% and 1% significance levels respectively. Maximum temperature effects the boro yields negatively. Rainfall is not relevant because Boro is grown under completely irrigated conditions.¹² As the link between climate change and rice crop yield has been established, it is important to decode the importance of rice for the food security of Bangladesh¹³ Thus decreasing yields of rice varieties due to climatic variables pose an extreme threat on the supply of rice and thus food security of individuals. However this study disregards regional differences between climatic variations in different zones rather it provides an aggregate time series data study on the impacts of climatic variables on crop yields. Yu¹⁴, further expanded on the implications of different scenarios climate change scenarios on the yields of Aus, Aman and Boro in the 2030s and 2050s (A2 scenarios pose high levels of carbon dioxide emissions, B1 poses lower but still rising amounts of emissions). The results of this DCGE model is shown in table 5, under different climate change scenarios. The Aus and Aman rice yields are decreasing, however the negative impact on boro rice yield seem to

¹² Sarker, Abdur Rashid. *Impacts of Climate Change on Rice Production and Farmers' Adaptation in Bangladesh*. N.p.: University of Queensland, 2012. PDF.

¹³ S. S. Dipti, S. T. Hossain ., M. N. Bari ., and K. A. Kabir . "Physicochemical and Cooking Properties of Some Fine Rice Varieties." *Pakistan Journal of Nutrition* 1.4 (2002): 188-90. Print.

¹⁴ Thurlow, James, Paul Dorosh, and Winston Yu. "A Stochastic Simulation Approach to Estimating the Economic Impacts of Climate Change in Bangladesh." *Review of Development Economics* 16.3 (2012): 412-28. Print.

be the greatest. Even though Boro was initially seen as having the highest yields (table 1), it will lose its capacity to compensate for the yield losses of Aman and Aus which will further hinder Bangladesh's food security.¹⁵ Thus this decline in rice production poses serious threat to the livelihoods of the rural farmers. As half the population is involved in rice production, through the disruption of the production of rice they lose their principle food source (supply) as well as income source¹⁶.

Climate change and Food Access

Amartya Sen directed the food security from focusing on only available food supplies towards a focus on the household's access to food resources. This will be described using the entitlement approach of Amartya Sen's "Entitlements" are described as the adequate resources need to have the "access" to foods required for a nutritious diet.¹⁷ This dimension connects to climate change through indirect pathways. The access to food of a household is largely dependent on individual level of income and on capabilities and rights. Thus the criteria to ensure food access are affordability, how well markets function (allocation) and whether the preferences are met. The income generating capacity, the amount of compensation an individual receives in exchange of products and goods sold or labor and services provided, and the ratio of cost of a minimum daily food basket to the average daily income determine how food secure an individual is.¹⁸ Agricultural production is the main source of income for many of the livelihoods in the food insecure regions. In these regions many consumers both produce

¹⁵ Sarker, Abdur Rashid. "Impacts of Climate Change on Rice Production and Farmers' Adaptation in Bangladesh." *University of Southern Queensland*. N.p., Sept. 2012. Web. 6 Apr. 2014.

¹⁶ Sarker, Abdur Rashid. "Impacts of Climate Change on Rice Production and Farmers' Adaptation in Bangladesh." *University of Southern Queensland*. N.p., Sept. 2012. Web. 6 Apr. 2014.

¹⁷ Schmidhuber, Josef. "Global Food Security under Climate Change." *Proceedings of the National Academy of Sciences of the United States of America* 104.50 (2007): n. pag. *JSTOR*. Web. 05 Apr. 2014. >.

¹⁸ Dogondaji, Mansur Bello. "Towards Mitigating the Impacts of Climate Change on Food Security: A Global Perspective." *Academic Journal of Interdisciplinary Studies*(2013): n. pag. *Academic Journal of Interdisciplinary Studies*. Web. 6 Apr. 2014

and sell their products. This makes the farmers vulnerable to climatic variations.¹⁹ Agriculture faces constraints where there is continuing increase in population growth however climate change causes a restraint on food production and production volatility.²⁰ Bangladesh's low lying geography, high population density, sea level rise and poverty causes climate change, which lead to severe impacts such as frequent flooding further imposing devastating effects on livelihoods.²¹ The majority of the landmass in Bangladesh consists of floodplains and 30% of the country experiences annual flooding during monsoon while extreme flooding spreads over 60% of the lands of Bangladesh²². Many assessments of flood and cyclone situations show that the effects of climatic calamities such as floods and cyclones come in the form of price hikes during and immediately after such crisis.²³ Table 6 shows the price fluctuations during a climatic shock (flood) during the Northern Bangladesh floods on the rural Kurigram, Jamalpur and Gaibandha districts in 2012. As prices of these daily commodities increase, it poses a great threat to the food accessibility of people. People who have a higher income is still able to afford/buy this commodity while people from the lower range of income face a greater issue in fulfilling their food demands as their real income decreases. ²⁴ For example when the price of rice (staple food) increase, rice consumption remains steady or even increase while non rice consumption declines. This is because when households are already spending the majority of their income on food (often half of their money income is allocated on the staple rice alone – thus this does not provide any safeguard

¹⁹ Brown, M. E., and C. C. Funk. "CLIMATE: Food Security Under Climate Change." *Science* 319.5863 (2008): 580-81. *ScienceMag*. 2 Aug. 2013. Web. 5 Apr. 2014

²⁰ *The State of Food Insecurity in the World: How Does International Price Volatility Affect Domestic Economies and Food Security?* Rome: Food and Agriculture Organization of the United Nations, 2011. Print.

²² "Bangladesh." *UNICEF UK*. N.p., n.d. Web. 08 Apr. 2014.

²³ Mazumdar, Shuman. *The Economics of Early Response and Resilience: Bangladesh Country Study*. N.p.: GOV.UK, May 2013. PDF.

²⁴ Amir, Khaled, and Tanvir Ahmed. "Climate Change and Its Impact on Food Security in Bangladesh: A Case Study on Kalapara, Patuakhali, Bangladesh." *Earth Science & Climatic Change* (n.d.): n. pag. Web.

when prices increase.²⁵ This leaves families to maintain their consumption of rice to the expense of more nutritious food which is required for a healthy lifestyle such as vegetables, fruits, fish and dairy²⁶. Thus the concept of Giffen goods could be used to show to illustrate the dependency of rural households on rice, as the staple food rice is believed to have an upward sloping demand curve²⁷, however this shows that the rural households lack the intake of nutritional consumption thus making them food insecure. The dependency of a given household on agriculture for income, and the nature of a household's exposure to food price are important factors to address while tackling the issue of the effects of climate change on food access²⁸. According to Sen's approach, even though there is food available, however the rural population is hindered from the "access" to it because of their income and price hike. As the data obtained is from a small farming area it shows that the household will be spending the majority of its' income on food and thus climate change affects its structure disproportionately.

Climate change and food utilization

"Food utilization" refers to how a person uses food and nutrients and also on the quality of nutrients. Climate change affects the ability of individuals to use food completely due to the alterations of the conditions for food safety and changing the disease pressure from vector, water and food borne diseases. Climatic variations can cause a vicious cycle where infectious diseases cause hunger and this in turn makes the population more

²⁵ Ericksen, N. J., Q. K. Ahmed, and A. R. Chowdhury. "Socio-Economic Implications of Climate Change for Bangladesh." *Forum for Physical Development for Bangladesh*. Bangladesh Unnayan Parishad (BUP), n.d. Web. 6 Apr. 2014.

²⁶ Torlesse, H. et al. "Association of Household Rice Expenditure with Child Nutritional Status Indicates a Role for Macroeconomic Food Policy in Combating Malnutrition." *The American Society for Nutritional Sciences*, (n.d.): n. pag. 2003. Web. 6 Apr. 2014.

²⁷ Lekhe, Fatima, and Lamiya Islam. "Giffen Behavior for Rice Consumption in Rural Bangladesh." *International Journal of Applied Economics* (2011): 48-59. Web. 6 Apr. 2014.

²⁸ Lobell, David, and Marshall Burke. "2." *Climate Change and Food Security: Adapting Agriculture to a Warmer World*. Dordrecht: Springer, 2010. 21-25. Print.

susceptible to being affected by these diseases.²⁹ Thus some scientists argue that climate change is the biggest threat to global health in the 21st century, thus leading to widespread diseases and premature death.³⁰ A few examples of food security and nutrition related diseases are Diarrhea, acute respiratory infections, measles and meningitis. These causes the nutritional needs of those victims affected by it to increase, while simultaneously reducing the rate of absorption of nutrients and their utilization the body. Lower labor productivity and a higher dependency ratio are all consequences of increasingly poor health in a community³¹. ICDDR,B forecasted that the Bangladesh population would be extremely vulnerable to the increasing prevalence of diseases such as cholera, dengue, cardiovascular and respiratory diseases due to climate change and malnutrition due to food scarcity and a reduction in food production.³² Cyclone Sidr in 2007 on the coasts killed 3500 people, destroying 500,000 homes and affecting 845,000 households. Outbreaks of diseases such as diarrhea, pneumonia, typhoid, hepatitis and skin disease were noticed. Postdisaster epidemiological study showed that there were 1076 cases of cholera reported, identifying polluted water being the probable source of this outbreak. A survey found that the nutritional status of flood exposed to malnutrition were 90% and 53% respectively. This shows the effect of climate change on food security in terms of marginalization of women and children due to increased climatic vulnerability. In Bangladesh, salinity is a huge climatic calamity. Sea level rise and fluctuations due to climate change causes higher contamination of ground water and surface water supplies with salinity. Currently 20 million people living along the coast are affected due to salinity. A case study done on the coastal area of Satkhira shows that 61% of the rural households were drinking contaminated saline pond water and 81% use it for household purposes. *Vibrio Cholerae* the bacterium for cholera can

²⁹ Schmidhuber, Josef. "Global Food Security under Climate Change." *Proceedings of the National Academy of Sciences of the United States of America* 104.50 (2007): n. pag. JSTOR. Web. 05 Apr. 2014.

³⁰ Costello, Anthony, Mustafa Abbas, "Managing the Health Effects of Climate Change." *The Lancet* 373.9676 (2009): 1693-733. Print.

³¹ Mao, R. "Climate Change Is Deadly: The Health Impacts of Climate Change." *The Health Practitioner's Guide to Climate Change: Diagnosis and Cure* (n.d.): n. pag. Earthscan. Web. 6 Apr. 2014.

³² *Our Strategy- Annual Report*. Bangladesh: ICDDR,B, Apr. 2011. PDF.

survive longer in saline water, which makes these contaminated areas perfect for breeding of Cholera.³³ Along with cholera, diarrhea, along with a wide variety of other diseases such as hypertension were rampant along the coast.³⁴ This poses further threat to the Malnutrition (food security variable) and disease (variable induced by climate change) interact in a vicious cycle, inadequate food consumption increases the vulnerability to diseases while infections such as malaria, measles, diarrhea and pneumonia hinders the absorption process of the human body of adequate nutrients.³⁵ Lost human productivity, poor school performance (which lowers labor productivity even further in the future), are all threats that malnutrition poses.³⁶

Climate change, population increase and food security:

There are important implications of poverty and population increase on climate change and food security. Thus it is important to discuss these variables in the context of the impact of climate change on food security in Bangladesh. Bangladesh is the third most populous country in South Asia with a population of 16 crore and 964 people living in every square kilometer.³⁷ Population growth poses high stress on limited land resources when human population increases. Food production depends on croplands and water supply, climate change poses severe threats to both of these resources by

³³ Borroto, R. J. "Global Warming, Rising Sea Level, and Growing Risk of Cholera Incidence: A Review of the Literature and Evidence,"." *Geo Journal* (1998): 111-20. Web. 6 Apr. 2014.

³⁴ Khan, Aneire E., Wei W. Xun, Habibul Ahsan, and Paolo Vineis. "Climate Change, Sea-Level Rise, & Health Impacts in Bangladesh." *Environment: Science and Policy for Sustainable Development* 53.5 (2011): 18-33. Print.

³⁵ *World Food Insecurity and Malnutrition: Scope, Trends, Causes and Consequences*. N.p.: FAO, n.d. PDF.

³⁶ Kjellstrom, Tord, R. Sari Kovats, Simon J. Lloyd, Tom Holt, and Richard S. J. Tol. "The Direct Impact of Climate Change on Regional Labor Productivity." *Archives of Environmental & Occupational Health* 64.4 (2009): 217-27. Web. 6 Apr. 2014

³⁷ Population 14.23cr." *Population 14.23cr*. N.p., n.d. Web. 08 Apr. 2014

reducing crop yields, water salination etc. Thus both of these effects together diminishes food security.³⁸

Climate Change, Poverty and Food Security

Studies have shown that increase in crop reductions causes linear increase in poverty in the rural areas. 60% of the crops damaged by cyclones in Bangladesh could increase the poverty level by the same percentage due to vulnerability of the rural households in terms of their resources. This is shown in table 7 ³⁹. The data presented on the table was formulated by a consultation group of key experts on climate change. The human vulnerability is dependent on both the exposure to stresses as well as the capacity to cope with stresses (climatic variations). Vulnerability and poverty are interconnected, because the likelihood to exposure to a livelihood change (climatic shock) is greater among those who are impoverished. This is due to the fact that they spent a large proportion of their resources either purchasing/producing food thus this decreases the resources they could use to cope with climatic shocks. This shows the interrelatedness of poverty and climate change.⁴⁰ Thus a livelihood approach helps expand on this topic. For example if the livelihoods associated with the study who result is shown in figure, the rural households associated the “assets” (social, natural, capital) are deployed in a series of livelihood activities (farming) through which household income is generated to meet the basic needs to the household. Reliable and secure “access” to these “assets” is essential for the livelihoods of the poor. Climate change impacts this system by creating a shock (drought, floods, climatic variable change) which decreases resource flow which is required for these households. Thus posing threats to income, food production, leading to food insecurity which furthermore leads to poverty. ⁴¹

³⁸ *Why Population Matters to Food Security*. Washington: Population Action International, n.d. PDF.

³⁹ *Policy Study on the Probable Impacts of Climate Change on Poverty and Economic Growth and the Options of Coping with Adverse Effect of Climate Change in Bangladesh*. Bangladesh: UNDP Bangladesh, May 2009. PDF

⁴⁰ Hulme, David, and Andrew Shepherd. *Chronic Poverty: Meanings and Analytical Frameworks*. Manchester: International Development Department, Nov. 2001. PDF.

⁴¹ *Livelihoods and Climate Change: Combining Disaster Risk Reduction, Natural Resource Management and Climate Change Adaption in a New Approach to the Reduction of Vulnerability and Poverty*. Winnipeg: International Institute for Sustainable Development, 2003. 1-16. Print.

Conclusion

This essay aimed to analyze the impacts of climate change on food security by describing the impact of climate change on the various dimensions of food security (food availability, food access and food utilization) and by analyzing the relationship between these two variables through the variables in the context of the growing population issue and poverty issue. As shown in this essay, the impact of climate change on food production varies, because various climatic variables impact the yield of rice crops differently. However, future impacts of climate change on rice as shown by Yu, are dramatic due to the reduction of crop yields as a result of climate change. Climate change affects food access through increases in food prices and reduction in real incomes of the farmers that could be used to improvise their food security. Food utilization is affected by climate change through the spread of different diseases which hinders human productivity. In the context of Bangladesh, population growth and poverty are important to determine the relationship between climate change and food security. While population growth and climate change together pose threat the land resources for the production of food. The effect of poverty on climate change and food security can be shown through a livelihood framework as explained previously.

This essay only considers the impacts of the climate change on the food security of rural livelihoods of Bangladesh. However the pressure of climate change on land resources increases the urbanization in Bangladesh increases due to increasing migration of the rural population as climate change acts as a stress on their livelihoods. In Dhaka, 15 million people are urban poor, and they are constantly battling issues of food security, poor access to health care and sanitation and wide variety of diseases. This shows that the impact of climate change on food security is not only limited to the rural areas, even urban areas are affected, thus this can be seen as a widespread issue which is present all over Bangladesh. ⁴²

⁴² "Climate Change and Urbanization: Perspective Bangladesh." / *Habitants De L'Asie / Nouvelles / Home*. N.p., n.d. Web. 07 Apr. 2014.

The adaptation strategies which need to be used to combat the effects of climate change on food security in rural livelihoods, should focus on the allocation of the 4 livelihood assets of the rural households : physical resources (building shelters), human resources (strategies to prevent the spread of malnutrition and other infectious diseases through the promotion on sanitation , medicines), social resources (community based approaches which would focus on community based development), financial resources (provision of financial resources such as microcredits etc which would increase their livelihood options. Furthermore the adaptive strategies must also include the allocation of information, skills, technology and opportunities which would raise income. Reducing vulnerability to climate change through protection of existing assets (the ecosystems which the community depends, improving risk management are all important strategies that could be implemented to alleviate poverty, and reduce the effects of climate change on food security of the poor rural households of Bangladesh.⁴³ Action Aid suggest a sustainable agricultural approach which requires the input of affordable and appropriate technology to increase farmer's resilience to climate change, integrated cropping, strengthening of farmers' traditional and scientific knowledge and innovation through the use of community development programs, and increase women's access to and control over resources for production, processing and distribution are among the few methods suggested. ⁴⁴

The climate change effects on food security are diverse. The adaptive strategies suggested above could help prevent the devastating effect of climate change on a rural household. It should also be emphasized that decreasing the rate of population increase and poverty alleviation are the two important barriers the government has to overcome reduce the effects of climate change on food security.

⁴³*Promoting Adaptation to Climate Change in Bangladesh.* Bangladesh: PRACTICAL ACTION BANGLADESH, n.d. PDF

⁴⁴*Lessons from Farmers Adapting to Climate Change.* N.p.: Action Aid, n.d. PDF.

Appendix

Table 1 ⁴⁵

	Yield (kg per acre)			Maximum temperature (°C)			Minimum temperature (°C)			Rainfall (mm)		
	Aus	Am	Bor	Aus	Am	Bo	Aus	Am	Bo	Aus	Ama	Bor
	s	an	o		an	ro		an	ro		n	o
Mean	470	616	1058	32.1	30.3	29.6	24.9	22.3	15.7	54726	45587	14659
Std. dev.	105	126	220	0.43	0.35	0.49	0.31	0.30	0.37	8511	8528	4493
Maximum	720	855	1560	33.1	31.0	30.8	25.6	23.1	16.4	66908	60465	24261
Minimum	310	396	728	31.2	29.5	28.6	24.4	21.8	14.7	32864	24783	6369
Skewness	0.86	0.28	0.57	-0.14	-0.17	0.20	-0.02	0.34	0.13	-0.58	-0.00	0.30
Kurtosis	2.78	1.97	2.52	2.58	2.62	3.03	2.06	3.03	2.24	2.61	2.52	2.36

Regression Results

Table 2

Aus Model

The results for the Aus model.

⁴⁵ Sarker, Abdur Rashid. "Impacts of Climate Change on Rice Production and Farmers' Adaptation in Bangladesh." *University of Southern Queensland*. N.p., Sept. 2012. Web. 6 Apr. 2014. <<http://eprints.usq.edu.au/23523/>>.

Independent variables	Coefficient	<i>t</i> -Value	<i>p</i> -Value
<i>max t</i>	12.39***	3.40	0.001
<i>min t</i>	-2.03	-0.50	0.617
<i>train</i>	0.90***	4.53	0.000
Model Pseudo $R^2 = 0.37$			
Adjusted $R^2 = 0.32$			
Sparsity = 0.452			
Quasi-LR statistic = 16.81			
Prob (Quasi-LR stat) = 0.000			

Represents the 1% level of significance.

Table 3⁴⁶

The results for the Aman model.

Independent variables	Coefficient	<i>t</i> -Value	<i>p</i> -Value
<i>max t</i>	5.59*	1.93	0.061
<i>min t</i>	-6.97**	-2.09	0.044
<i>train</i>	0.83***	4.15	0.000
Model Pseudo $R^2 = 0.29$			
Adjusted $R^2 = 0.25$			
Sparsity = 0.327			
Quasi-LR statistic = 43.08			
Prob (Quasi-LR stat) = 0.000			

Represents the 1% level of significance.

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Represents the 5% level of significance.

⁴⁶ Sarker, Md. Abdur Rashid, Khorshed Alam, and Jeff Gow. "Exploring the Relationship between Climate Change and Rice Yield in Bangladesh: An Analysis of Time Series Data." *Agricultural Systems* 112 (2012): 11-16. Print

*

Represents the 10% level of significance.

Table 4⁴⁷

Table 6.

The results for the Boro model.

Independent variables	Coefficient	t-Value	p-Value	VIF
<i>cons</i>	1.71	1.04	0.305	
<i>max t</i>	-1.57**	-2.49	0.018	1.71
<i>min t</i>	1.24***	3.12	0.004	1.71
<i>train</i>	0.02	0.99	0.330	1.42
Model, $R^2 = 0.29$				
Adjusted $R^2 = 23$				
Durbin-Watson = 1.98				
F-statistic = 4.59				
p-Value of F-statistic = 0.008				
Breusch-Pagan chi-square = 1.05				
Prob > chi-square = 0.30				

Represents the 1% level of significance.

**

Represents the 5% level of significance.

Assumptions

The monthly data between the period 1972-2009 period was used and then converted as the average for the 1972-2009 period for the growing seasons of the concerned crops.

The methods, variables and calculations are described in detail in the following document

http://eprints.usq.edu.au/23523/1/Sarker_2012_whole.pdf

⁴⁷ Sarker, Md. Abdur Rashid, Khorshed Alam, and Jeff Gow. "Exploring the Relationship between Climate Change and Rice Yield in Bangladesh: An Analysis of Time Series Data." *Agricultural Systems* 112 (2012): 11-16. Print

Table 5⁴⁸

	<i>Climate change scenarios</i>					
	<i>A2 and B1</i>		<i>A2 only</i>		<i>B1 only</i>	
	<i>2030s</i>	<i>2050s</i>	<i>2030s</i>	<i>2050s</i>	<i>2030s</i>	<i>2050s</i>
Aus	-0.27	-1.52	-1.11	-3.51	-0.14	0.01
Aman	-0.37	-0.62	-0.42	-1.49	-0.37	-0.40
Boro	-3.06	-4.74	-1.68	-5.54	-3.76	-3.54
Wheat	2.05	3.44	2.23	3.74	1.33	3.03

Source: Crop modeling results from Yu et al. (2010, p. 54).

Detailed Information on the computations are available:

http://mcgill.worldcat.org/title/a-stochastic-simulation-approach-to-estimating-the-economic-impacts-of-climate-change-in-bangladesh/oclc/5154837338&referer=brief_results

⁴⁸ Thurlow, James, Paul Dorosh, and Winston Yu. "A Stochastic Simulation Approach to Estimating the Economic Impacts of Climate Change in Bangladesh." *Review of Development Economics* 16.3 (2012): 412-28. Print.

Table 6⁴⁹

	Commodity Prices befor, during and after floods 2011			
Commodity	Befor e	During	current	% increase
Coarse rice	33	37	28	12%
atta (Wheat)	18	25	24	39%
Potato e	N.A.	28	12	-
Lentil	78	96	65	23%
soybean oil	113	124	116	10%
small fish	86	73	69	-15%
		Avg % increase for all commodities		14%

Detailed information available :

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228494/TEERR_Bangladesh_Background_Report.pdf

Table 7⁵⁰

⁴⁹ Mazumdar, Shuman. *The Economics of Early Response and Resilience: Bangladesh Country Study*. N.p.: GOV.UK, May 2013. PDF

Climatic Events	Level of Impacts (%)					
	Identified Impacts		Poverty		Economic growth	
Drought	25	40	8	30	2	5
Cyclone	60	70	60	70	15	17
Coastal inundation	10	15	5	8	1	2
Erratic rainfall	20	30	10	20	2	4
Temperature variation	05	7	2	5	1	2
Heat wave	-	2	-	1	-	1
Fogginess	10	15	2	3	1	1

Source: Consultation workshop with key experts, 2008

Detailed information is available :

<http://fpd-bd.com/wp-content/uploads/2013/04/The-probable-impacts-of-climate-change-on-poverty-and-economic-growth-and-the-options-of-coping-w.pdf>

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