Bangladesh Journal of Political Economy

Vol. 29, No. 1, June 2013, pp. 139-150
Bangladesh Economic Association
(ISSN 2227-3182)

Climatic Variability, Agricultural Transformation and Food Security in the North-Western Bangladesh

A.N.K.Noman*
Kazi Julfikar Ali**

Abstract *The Process of transformation of agriculture in the Northern Bangladesh has been going on for more than a decade. The nature of transformation could be characterized as the transformation of rice fields into mango orchards. This is changing the very basic characteristics of the socio-economic activities as well as the life style of the people in this area. There are several reasons which are guiding the transformation process from behind. Among different reasons, economic factor was found to be the principal reason. The environmental factors like fall in rainfall, change in the pattern of rainfall, fall in ground water level, rise in temperature, increase in pest attack etc. have significant indirect influence on transformation. These climatic factors are actually influencing transformation by influencing cost-benefit scenario of mango and rice cultivation. In that regard, a survey was conducted in Nawabgonj sadar Upazilla under Nawabgonj district in March 2014 and data were analyzed. In this study climatic variability is defined in terms of variability in rainfall, transformation is defined in terms of the ratio of mango orchard to total cultivable area, and food security is defined in terms of food production or availability. To establish functional relationship among the variables a regression was estimated and results presented. The results support the hypothesis that transformation is influenced by climatic variability and return from cultivation. This transformation is permanently shifting crop land to orchards causing a sharp reduction of cultivable land which in turn is reducing food production. It is important to note that this region is one of the major contributors to national food supply and this tendency of*

* Professor, Department of Economics, University of Rajshahi.
** Assistant Professor, Department of Economics, University of Rajshahi.

transformation may increase the vulnerability of the already weak national food security situation. This needs urgent policy attention and intervention by the government.

Key words: *Climatic variability, Agricultural transformation, Food Security, Northern Bangladesh.*

1. Introduction and background information

Bangladesh economy has been growing consistently over the last three decades and the growth has accelerated during the last decade. One of the major contributors behind the growth is the consistent performance of the agriculture sector. Again the performance of agriculture sector is dominated by the performance of the crop sector.

Bangladesh is a country with a population of almost 160 million, increasing at a rate of 1.3 percent, adding about 2 million labour to the existing 72 million every year. Agriculture is still the principal economic activity and the single largest contributor to GDP. It provides 45 percent of total national employment. If we only consider the rural economy, then agriculture alone provides employment for more than 70 percent of the rural labor force. Among the various agricultural products, rice is the main crop as well as the staple food of the country and the demand for rice is constantly rising in Bangladesh with nearly 2.3 million people being added each year to its population. Bangladesh is still dependent on food import and the pressure on import is on a rise in recent years. To feed the growing number of population is one of the big challenges this country is facing now. The cultivable land is shrinking alarmingly in the country. Urbanization, building of settlement and river erosion are the main factors responsible for loss of productive agricultural land. Bangladesh also faces production constraints due to a number of unexpected calamities such as flood, drought, erratic rainfall, lack of irrigation facilities, river erosion and salinity of soils etc.

Moreover, one of the most grievous challenges that Bangladesh agriculture will have to face is the adverse impact of climate change (CC). It is projected that the production of rice will be reduced by more than eight percent by 2050 because of the change in temperature. Predicted sea level rise is likely to inundate a huge land of the coastal belt. Flood, drought and cyclone are expected to be more frequent and severe that may toll a serious damage in the agriculture sector. So, shrinking of agricultural land as well as production, adverse impact of CC compounded with a large population will put the country's food and income security at a great risk.

In addition to that, transformation of paddy land to other uses is another most important factor that is undermining the cereal production. Recently, the north-western (NW) part of the country is witnessing a rapid transformation within agricultural sector, that is transformation of paddy field into mango orchard. This region is historically a surplus food producing area and one of the biggest contributors to national food supply. Since Bangladesh is experiencing a continued annual shortage of grain, transformation of agricultural land to other uses will definitely have a negative impact on total cereal production as well as on the economy. It is going to put Bangladesh to a great challenge to maintain its food-population balance. The only way out for Bangladesh is to import more and more cereals from the international market. But, the international food supply is also under constant threat at the changing climatic condition and growing number of population worldwide.

Moreover, the concern is not all about the production of cereals but also the livelihood system and food security of the majority of the population. Since half of the total labor force depends solely on agriculture, any change in agricultural sector has substantial impact on their income and employment situation. This agricultural labor force is also the poorest and most vulnerable section of the country. There are a lot of inherent factors associated with their poverty and livelihood vulnerability. Such vulnerability arises mainly from the unemployment, income deficit, and instability of agricultural production. These people have less ability to recover from any disaster. No doubt, transformation of agriculture compounded with the above stated factors will worsen the poverty situation in the country. Hence, a core concern for Bangladesh is to sustain her rice productivity while protecting food security and employment for the majority of the population.

So the principal focus of the study is to identify the nature and causes of agricultural transformation and to assess the impact of transformation on food production and accessibility i.e. the major components of food security.

There are very few studies available on this issue. The previous studies on this issue were conducted by the first author himself where the methodological approach was different. In this study more disaggregated data are used to pinpoint the relationship among the variables encouraging the process of transformation. This relationship is estimated with the help of regression function estimation. This adds more insight to the studies on the process of transformation. In this study the variability of rainfall is considered for the months of June to August, the sowing season for the principal crop, transplanted Aman. Usually the other studies consider variability of rainfall or average rainfall for the year. This does not reflect the true scenario on this issue.

2. Objectives of the study

The principal purpose of the study is to highlight the various perspectives of causes and possible impact of transformation of paddy field to mango farming. Therefore, the study focuses on the following key issues:

i) Investigate the nature, type and causes of transformation of agriculture; and

ii) Assess the impact of agricultural transformation, especially the mango farming on production of food grain.

3. Conceptual framework of the study

Agriculture depends on nature, and the production decisions are basically guided by profitability. The farmers behave rationally and take decisions accordingly. The change in climatic factors influences the production activities by pushing the cost of production up and net revenue down. The tenants are less willing to share the produce according to traditional practice. So it is no longer profitable for the owners to rent their land to the tenants. Again the net return from mango orchard is very high in comparison to that of crop production. The risk factor for crop production is also higher. So the land owners and the farmers are rapidly transforming their land from cereal production to mango orchard. As a consequence, cultivable land is shrinking fast and posing a threat to food security.

4. Methodology

4.1 The data

For purpose of the study, the relevant micro-level data were collected from Upazilla agricultural offices and also directly from the farmers and other stakeholders to identify the nature, causes and impact of transformation. The data related to both climatic variables as well as economic variables were collected to establish the relationship between agricultural transformation and climatic variability and net revenue.

Among the 16 northwestern districts, five districts namely, Rajshahi, Natore, Naogaon, Nawabgonj, and Dinajpur, where the intensity of transformation is higher, were taken under investigation. Two Upazillas from each district were selected for the study purpose. So the total number of Upazillas under investigation were 10. As part of the ongoing study some of the findings from Chapai Nawabgonj district are presented in this article.

4.2 The model

The collected data were analyzed using basic statistical techniques. In addition, a regression function is estimated showing the relationship between agricultural transformation and variability of rainfall and average net revenue of the cereals. The functional expression is as follows:

Where,

Q = agricultural transformation to mango orchard per hector
X_1 = variability of rainfall per year
X_2 = average net revenue of cereal crops per hector
= error term

A priori expectation about the sign of the coefficient is . The error term is assumed to be random and serially independent having zero mean with finite variance. The empirical model is estimated by OLS method. Diagnostic tests for autocorrelation and multicollinearity were carried out to improve the quality of estimation.

4.3 The basic features of the study area

This study area is the part of High Ganges River Floodplain. The area is predominantly highland and medium highland. There is an overall pattern of olive-brown silt loams and silty clay loams on the upper parts of floodplain ridges and dark grey, mottled brown, mainly clay soils on ridge sites and in basins. Most ridge soils are calcareous throughout. General soil types predominantly include Calcareous Dark Grey Floodplain soils and Calcareous Brown Floodplain soils. Organic matter content in brown ridge soils is low and higher in dark grey soils. Soils are slightly alkaline in reaction. General fertility level is low.

5. Climatic factors

5.1 Sowing and harvesting periods

Table 1 shows the sowing and harvesting time for major rice crop in Bangladesh. Aman is cultivated in about 50 percent of the total cultivable land whereas Boro covers more than 40 percent of the total cultivable area (GOB, 2011). The sowing period for HYV transplant Aman is late June to mid August. During this period water requirement is the highest but the rainfall pattern shows that the variability of rainfall is also very high during this period (Table 3). During boro cultivation period the rainfall is seldom seen in the area. So it is totally dependent on underground irrigation water. The irrigation statistics shows that the area under irrigation was not expanding anymore during the last decade, rather the command area under the DTWs and STWs are shrinking gradually.

Table 1 : Sowing and Harvesting Period of Major Rice Crops

Principal Crop	Time of Sowing/Transplanting	Time of Harvesting
1	2	3
Aman HYV Transplant	Late June to Mid August	December to early January
Boro HYV and Hybrid	December to Mid February	Mid April to June

Source: *BBS, 2011*

Table 2 shows that the number of DTWs installed in the area increased from 192 in 2005 to 219 in 2013, while the area irrigated under these DTWs fell from 4640 hectares to 3495 hectares in 2013. So not only the command area is shrinking but the total area under DTW irrigation has registered a decline. As a consequence, the area under Aman and Boro cultivation as well as the production has marked a

Table 2 : Number of machines and irrigated areas under different irrigation methods 2005 - 2013

	DTW		STW		LLP		Total
Year	number	area	number	area	number	area	area
2005	192	4640	2956	14867	294	3230	22737
2006	197	3834	3233	13281	294	4795	21910
2007	197	4370	3443	13493	422	4763	22626
2008	208	5226	3424	9551	315	3963	18740
2009	219	2960	3554	11560	311	4413	18933
2010	220	4790	3528	10665	256	4565	20020
2011	225	4870	3528	11731	256	3820	20421
2012	219	4875	3420	11550	250	3800	20225
2013	219	3495	3205	11150	237	3415	18060

Source: *DAE, Chapainawabgonj sadar Upazilla, 2014*

sharp decline (Table 2). The lands where these crops are cultivated are also suitable for mango cultivation. So shrinkage of these areas is witnessing the process of transformation from rice cultivation to mango orchards.

Usual practice for Aman cultivation is that it is basically a rain fed crop. So the cost of irrigation for Aman is always low. But because of the increase in the variability of rainfall during the sowing season and afterward, the cost of irrigation for Aman is how registering an upward trend and has already pushed the cost of production up. As a consequence, the net revenue is showing a falling trend for this crop. This is also true for Boro. Because of less availability of underground water the cost of irrigation is also increasing and as a consequence net revenue is showing a decline. This fall in revenue is prompting the process of transformation.

Monthly rainfall, average yearly rainfall and the log variability of three months and twelve months are presented in Table 3. The findings show that the monthly variability for the peak three months namely in June, July and August are much higher than the yearly variability. The water requirement during the sowing

Table 3 : Monthly rainfall in Nawabgonj district from 1999 to 2013 (millimeters)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	V_In_3	V_In_12
1999	0	0	0	9	144	478	364	425	388	60	53	0	8.09	10.53
2000	3	48	16	56	304	264	200	103	826	14	0	0	8.79	10.94
2001	0	0	0	3	235	144	186	124	203	228	0	0	6.91	9.25
2002	0	0	0	116	90	96	205	195	233	59	9	0	8.20	8.95
2003	0	42	53	5	25	303	247	69	118	177	0	0	9.61	9.28
2004	26	0	0	65	117	290	278	66	199	387	0	0	9.67	9.83
2005	18	0	100	21	83	46	409	397	56	217	0	0	10.66	10.01
2006	0	0	19	38	353	246	191	203	165	33	19	0	6.73	9.58
2007	0	41	5	5	112	282	827	258	240	0	0	0	11.55	10.97
2008	2.5	9	0	44	115	379	285	152	154	47	0	11	9.47	9.64
2009	0	11	14	18	201	208	210	216	248	47	5	0	2.85	9.32
2010	0	0	9	70	101	214	275	97	222	67	0	9	9.01	9.17
2011	0	0	62	82	149	771	180	347	209	32	0	0	11.44	10.81
2012	10	0	2	62	25	98	208	154	228	20	0	0	8.01	8.88
2013	0	11	0	59	116	109	180							

Source: *DAE, Chapainawabgonj sadar upazilla, 2014*

season is high and any variability during this period hampers the production activities badly. It may also significantly push the cost of production up.

6. Economic factors

Transformation of rice fields into mango orchards are presented in Table 4. An increase of 750 percent during last eight years is seen in column 4 and 5. In 2005

Table 4 : Change in mango and rice area in Nawabgonj sadar upazilla 2014

Year	Total Cultivable Area (hectare	Orchards (hectare	Crop land under plantation (hectare)	% increase	Total Orchard (hectare	% increase	Orchards as % of total Cultivable Area
1	2	3	4	5	6	7	8
2005	34100	2188	200		2388		7%
2013	31500	2600	1700	750	4300	80	14%

Source: *UAO Chapainawabgonj, 2014*

total mango orchards was only seven percent of total cultivable land which increased to 14 percent in 2013.

Table 5 shows net revenue from mango orchard per hectare. A mango orchard may remain productive for more than a century. So as the trees grow older the production increases with the size of the trees. So the calculations of return are a little bit tricky. The above figures presented in Table 5 are the average minimum during normal years. The variations of production in off season and on seasons are also taken into consideration for the calculation. If we compare the net revenue from mango orchard with the average net revenue from cereal crops then it could be seen that the return from mango orchard is five to ten times higher than that of cereal crops.

Tenancy relationship has also a very important role to play to encourage the process of transformation. More than fifty percent of our land is cultivated under

Table 5 : Revenue from a mango orchard per hectare (1 hectare = 7.49 bigha)

Age of Orchard	Average number of Trees per hectare	Average production per tree (kg)	Production per hectare (kg)	Average wholesale price per kg	revenue per hectare	Cost per hectare	re he
1	2	3	4	5	6	7	
5-10 years	75	30	2250	35	78750	7500	7
10+ Years	75	135	10000	35	350000	25000	32

Source: *UAO Chapainawabgonj, 2014*

sharecropping. With the increase in the cost of production the owners are getting less share of output from the tenants. So they are more willing to transform their land to orchards.

The change in the pattern of rainfall has increased the vulnerability of production. Irrigation cost has increased significantly. The average rainfall does not show much variability but it is not following any clear pattern, farmers are now becoming more dependent on irrigation water. The increase in the price of input as well as wage of the agricultural labours has pushed the cost of production up.

Table 6 : Total area and production of different rice crops from 2005-2013

	Aus		Aman		Boro	
Year	Area (hectare)	Production (MT)	Area (hectare)	Production (MT)	Area (hectare)	Production (MT)
2005	16655	25983	10450	28034	13730	50937
2006	16070	27300	10650	32758	12520	40690
2007	16170	30062	10450	29083	11560	41233
2008	17315	31540	10700	33017	11690	49299
2009	18195	31538	10750	28907	11620	46573
2010	17140	27365	10850	27007	11050	40756
2011	18250	39618	10910	32685	12565	50763
2012	18160	23666	10250	28060	12220	50703
2013	16050	31520	7500	21450	11250	46835

Source: *UAO Chapainawabgonj, 2014*

7. Empirical results

Table 7 shows the casual relation among the agricultural transformation, rainfall variability and net revenue of rice, wheat and maize production of Nawabgonj district. The coefficient of variability of rainfall is 0.003 and it is significant at 10 percent level. The results show that as variability of rainfall increases by 1 percent agricultural transformation from rice cultivation to mango orchards increases by 0.003 percent. The coefficient of net revenue is -0.079 and it is statistically significant at 1 percent level. The sign of the coefficient is also consistent with the theoretical relationship presented in the empirical model. The results show that as net revenue increases by 1 percent agricultural transformation decreases by 0.079

Table 7 : Causal relation among the agricultural transformation, climatic variable and net revenue of cereal crops

Variable	Coefficient	Standard error	T statistic	*P* value	Tolerance	VIF
Constant	0.689	0.098	7.054	0.00		
Variability of Rainfall	0.003	0.012	1.758	0.10	0.981	1.020
Net Revenue	-0.079	0.001	-6.413	0.00	0.981	1.020
R square	0.898					
Durbin – Watson test	1.057					

Source: *Own estimated result, 2014*

percent. Multicollinearity is tested by Variance inflation factor (VIF). The threshold value of VIF for testing the severity of multicollinearity is 5. The value of VIF in the table is less than 5, which means there is no multicollinearity problem in this model.

8. Conclusion

The data analysis results and the empirical estimations show that the process of transformation of rice field is influenced by both the climatic and economic factors. The data also indicates that a significant amount of cultivable land has already been transformed permanently into mango orchard. The consequence of transformation has already been felt in terms of rice production. Similar findings were obtained from a pilot study in Porsha Upazilla under Nawgoan district (Noman, 2011). The degree of transformation was found much higher in Porsha than that in Nawabgonj. Both of these areas are surplus crop producing areas and significant contributors to national food supply. It is observed that the production of the major crops in both of the areas is registering a decline. If the process of transformation continues in this manner, there is very high possibility that these areas will become net deficit area in crop production within a decade. This will pose a threat to national food security on the face of rising food demand both arising from increasing population and income. So it is high time to address the issue in a comprehensive national food security policy and act accordingly.

The study is only confined to the Nawabgonj district. So, the study did not provide the actual picture of the entire region. The quality of the study could be

improved further by incorporating other areas. The pitfalls of regression like normality need to be addressed for achieving more reliable results. Another shortcoming of this study is that it did not analyze the time series Property like unit root test etc. because of the short span of the data series.

References

1. GOB (2011), Agricultural Statistics, Bangladesh Bureau of Statistics, Ministry of Planning, Government of Bangladesh.
2. Noman, A.N.K. (2004): "Transformation of Agriculture in North-Western Districts of Bangladesh." *Bangladesh Journal of Political Economy*, Volume 18, Number 1, June 2003, Dhaka, Bangladesh.
3. Noman, A.N.K. and Joarder, S. (2010): "Transformation of Agriculture in the North-Western Bangladesh: Exploring the Vulnerabilities of the Poor People's Livelihood and Adaptive Capacity", unpublished research report, Department of Sociology and Department of Economics, University of Rajshahi, Bangladesh.
4. Noman A.N.K. and Joarder S. (2011): "Climate Change, Agricultural Transformation and Issues of Food Security in Bangladesh", *Bangladesh Economic Studies*, Vol. 13, June 2011, Rajshahi University Economic Association, Department of Economics, University of Rajshahi, Bangladesh. ISSN 0526 1662