

## Climate Change, Agricultural Transformation and Food Security in Northern Bangladesh

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**Abstract:** *Bangladesh is an agro-based country. Agriculture plays an important role to the economic growth and economic development in Bangladesh. Climate is a major factor that influence agriculture sector performance. This paper examines the impact of climatic factor in agricultural transformation and food security in Northern Bangladesh. To serve this purpose, primary and secondary data have been collected from two upazila of Rajsahahi district. These two upazilas are Godagari and Puthia. Initial survey was made to select the study areas. Based on the initial survey finding. These two upazilas have been selected based on the degree of transformation. Climate is defined by rainfall and temperature and agricultural transformation is measured by the share of guava and mango in total cultivable land in the study area. Food security is defined by food availability or production of food. It is seen that rice cultivation land is transformed into guava and mango orchard. As a result, rice cultivation is reduced that will reduce food production. In addition to this, guava and mango will satisfy the nutritional demand of the population. It is observed that rate of transformation of guava is higher in Godagari than Puthia and rate of transformation of mango is higher in Puthia than in Godagari. The preliminary findings suggest that transformation is going to affect the food security situations both positively and negatively.*

**Key Words:** *Climate Change, Agricultural Transformation, Food Security.*

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### **1. Introduction and background information**

Bangladesh economy has been growing over the last three decades. Among the three subsectors of economy, agriculture play an important role to generate employment for its population by increasing productivity and growth. The agricultural sector contributes a lot to the countries GDP, Provide employment for nearly half of the labour force and supplies raw materials.

Bangladesh is a country with a population of almost 160 million (BER, 2016) increasing at a rate of 1.3 percent adding about 2 million labour force every year. Agriculture alone provide 45 percent of total national employment. If we only consider the rural economy, agriculture alone provides employment for more than 70 percent of the rural labour force. Rice is the main crop as well as the staple food of the country and the demand for rice is rising in Bangladesh to its population. The cultivable land is shrinking.

Furthermore, Climate is an important determinant of agriculture. Climate change can influence over the crop, livestock and poultry, fisheries and forestry. Crop is directly affected by the climatic factors such as temperature and rainfall and the frequency of other events such as flood, cyclones and drought. Climate change refers to any changes in major climatic variables over a long time. This change may occur because of natural variability and human activities. Climate variability refers to temporal variation about the mean.

Climate change may also change the types, frequency and intensities of various crops and availability of irrigation water supply. An agricultural system is dynamic because producer and consumers are responding to crop yields, food prices, input prices, resource availability, and technological change. Although this is difficult to estimate these, it is necessary to measure accurate climate change impacts. Failure to estimate this may overestimate the damage of climate change and may underestimate the benefits of climate change.

Moreover, transformation of paddy land to mango and guava orchard is the most important factor that influence over food production. Recently, Northern part of the country is witnessing a rapid transformation within agricultural sector that is transformation of paddy field into guava and mango orchard. This region is historically food surplus area and one of the biggest contributors to national food supply. This transformation of agricultural land to others uses will have a negative impact on total rice production.

During the last decades, scientists studied that greenhouse gas and carbon dioxide (CO<sub>2</sub>) would produce global warming and other significant climate change.

Global warming has been increasing since the 1980s. Earth average surface temperature has increased by about 1.2 to 1.4 degree F in the last 100 years.

Food security is a situation where people have no fear of starvation. One of the major concerns of successive government of Bangladesh is the production, distribution and availability of essential food. The food inflation is about 13% (Bangladesh Economic Review, 2011) in Bangladesh. It is also define a situation in which all people at all time will have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for active and healthy life (World Food Summit, 1996). Food security consists of three important components which are food availability, food accessibility and utilization

## **2. Review of Previous Studies**

Hartarska et al shows that annual temperature significantly decreases agricultural production while more rainfall increases production using the simulation model. If climate change negatively affects an agricultural production a crop yield will decline. Consequently price of agricultural product will increase and it may cause malnutrition for poor.

Noman and Ali (2014) shows that agricultural transformation causes due to economic and environmental factors. Environmental factors such as fall in rainfall, rise in temperature, and fall in ground water level are the major reasons for agricultural transformation. This transformation shifting crop land to mango orchard which reduces the cultivable land and reduce food production. This will worsen the national vulnerable food security. If this process of transformation is continued North-Western region will be shifted from food surplus to food deficit region. so, government comprehensive policy is required to address the issue.

A. K. Enam and R, Salim, 2005 shows that Bangladesh become dependent on import of food and increase of international price of food increases the price of food in the domestic market this increases the sufferings of the household of Bangladesh. But there is a lack of modern technique in their paper. Their research paper should use sophisticated econometric technique to make the research up to date.

Rahman and Khan, 2005, show that availability of food is an important element of food security. Food availability is a function of food production, food import and food aid. Domestic production is a major concern of a government. The major problem of increase of production of food is inefficient water supply and

fertilizer decrease of the quality of soil productivity. Investment in agriculture has been reduced from 14% in 1976-81 to 4.5 % in 2000 and 2001. Donor funding has also reduced. Development project related to food security do not implement properly.

J. Shafikuzzaman and A. N. K. Noman (2011) shows that the transformation of paddy field to mango orchard is witnessed in the Northern Bangladesh. The Northern Bangladesh is the major contributor to the National food supply. The transformation of agricultural land to other play negative role to the National food supply. Since half of the population are involved with the agriculture. The reduction of food production will reduce the income of the agricultural labourer. This transformation of agriculture will deteriorate the poverty situation in Bangladesh.

Noman and Julfikar (2014) shows that climatic factors are responsible for agricultural transformation. They conducted this study in Nawabgong sadar upazila. They used some variables such as variability of rainfall, transformation is defined as ratio of mango orchard to total cultivable area and food security. One of the important drawbacks is that this study is conducted based on only one upazila.

### **3. Objectives of the Study**

- ii) Investigate the nature, causes, and types of transformation of agriculture
- ii) To estimate the consequences of transformation on food security

### **Methodology and data**

To achieve the above mention objectives a field survey was conducted during January-February 2017. To find out personal opinions on different issues related to the objectives of the study, farmers were interviewed. A total number of 70 such individual interviews were conducted. The collected data were tabulated and analyzed with the help of simple statistical techniques. A cost-benefit analysis was also done to identify the true causes and nature of transformation.

In this study, the relevant micro level data are collected from Upazilla Agricultural Office and also directly from the farmers to identify the nature, causes and impact of transformation. The data are related both with climatic variable as well as economic variable.

The net return from guava and mango orchard is very high in comparison to that of crop production. Crop production depends on environment. The risk factor for

crop production is also higher. So, the land owners and 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. Food security is defined in terms of food production and food availability.

Among the 16 Upazila of Rajshahi, Puthia and Godagari where intensity of transformation is higher are taken under investigation. In this study, important variables are revenue, crop compositions, production structure, productivity, temperature and rainfall. As part of the study some of the findings are presented in this article. Time series analysis will be conducted using net revenue of Aus, Aman and Boro, average rainfall, maximum temperature and minimum temperature

### **Basic Facts of Study Area**

#### **Climate**

The study area bears a moderate and pleasant climate. The temperature, humidity and coldness of the study area are not high. The summer season commences from April and continues up to the end of June. The rainy season comes at the end of June and stays up to September. The winter season starts from the middle of November and lasts up to the end of February. The minimum and maximum mean temperature, vary from 25.5<sup>0</sup>c to 38.7<sup>0</sup> c. The rainfall is heavy during July to September. The annual rainfall of the district recorded in 2011 was 1862 millimeters. The level of humidity was about 77 % in April and about 88 % in July.

#### **Area**

Godagari is the largest with an area of 472.13 sq km (182.24 sq mile) which is 19.61% of total area of the zila. Puthia is 192.64 km which is 8 percent of zila.

#### **Population**

According to population Census 2011, total number of household was 72186 and population was 3, 30,924 in Godagari. and the household and population are 52922 and 2,07,490 respectively in Puthia.

#### **The economic situation**

The economy of the study area is predominantly agricultural. Out of total holdings of the district, almost 56% holdings are farms that produce varieties of crops,

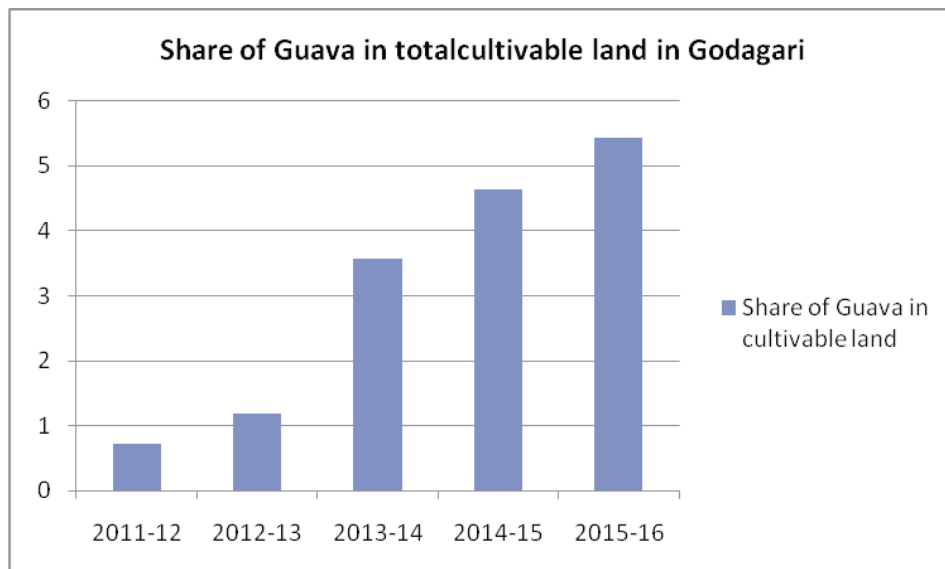
namely local and HYV paddy, wheat, potato, pulses and other minor cereals. Various fruits like mango, guava, banana, coconut etc are grown in the districts.

### Basic Facts of Godagari Upazila

#### Guava farming in Godagari Upazila

The godagari upazila is witnessing a rapid transformation in the agricultural sector. In 11-12, about 0.71 % of total cultivable land was under guava farming. In 2015-16, about 5.42 of cultivable land has been under mango farming. The guava farming is five times higher than initial situation. The present status of the guava farming is shown in the diagram given below.

Figure 1: Share of Guava in total cultivable land in Godagari



#### Mango farming in Godagari Upazila

In 11-12, about 0.82 % of total cultivable land was under mango farming. In 2015-16, about 1.53 of cultivable land has been under mango farming. The rate of transformation of mango farming is lower than the guava farming in Godagari upazila. The present status of the mango farming is shown in the diagram given below. The mango farming is double than the initial farming

Figure 3 shows that the share of boro in total cultivable land is about 50 percent in 2009-10. This is reduced to 40 % in 2012-13. This is stable up to 2015-16.

Figure 2: Share of Mango in total cultivable land in Godagari

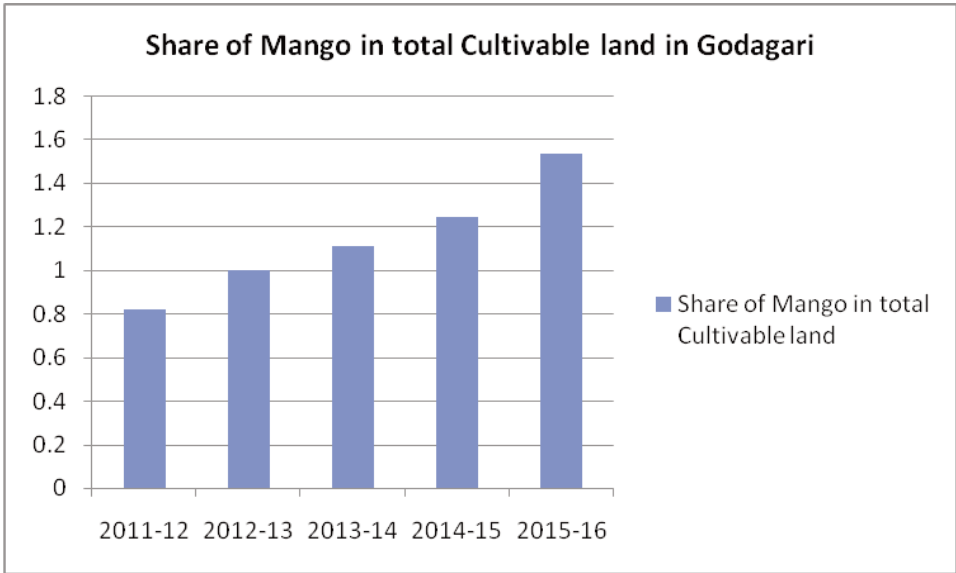
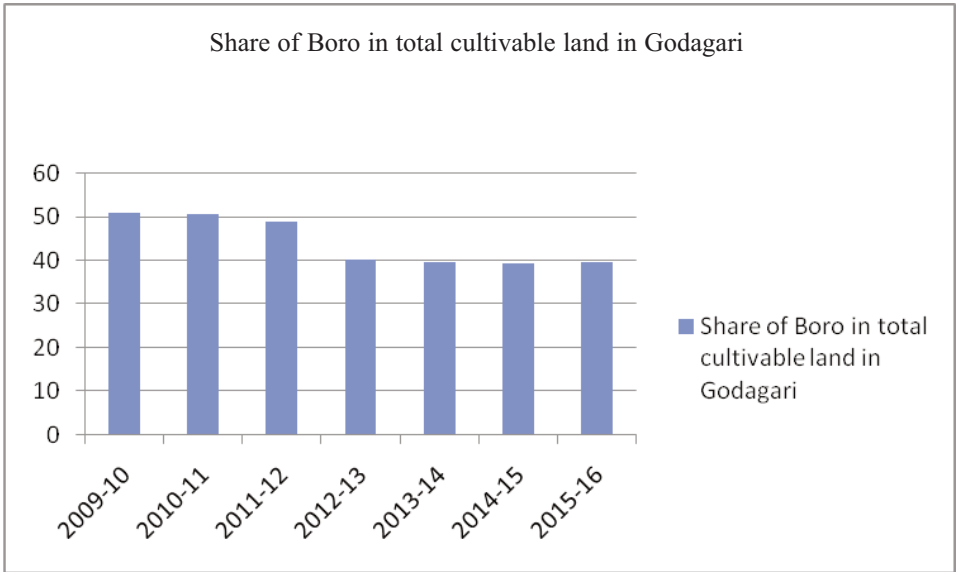


Figure 3: Share of Boro in total cultivable land in Godagari



So, it is clear from the figures that the share of orchard in total cultivable land increases and cultivable land of rice reduces. This will reduce production of paddy that is a threat to food security.

*Table 1 : Total area and production of different rice crop from 2009-10- 2015-16 in Godagari*

Year	Aus		Aman		Boro	
	Area (Hectare)	Production ( MT)	Area ( Hectare)	Production ( MT)	Area (Hectare)	Production ( MT)
2009-10	11725	30485	29000	76555	19200	65803
2010-11	11850	30731	28750	76634	19055	72440
2011-12	12658	27278	28735	75093	18365	71497
2012-13	10630	27866	24411	77626	15150	54175
2013-14	11443	12225	23700	21095	14950	52312
2014-15	12225	31785	26650	84120	14750	56050
2015-16	12370	32327	26630	84417	14950	61295

Table-2 shows that cultivable area of Guava was 270 hectare in 2011-12. This increased to 2050 hectare in 2015-16. It is also seen that share of Guava in total cultivable land was 0.71 percent in 2011-12. This increased to 5.12 percent. This indicates that production of Guava increased. The cultivable land of Mango was 310 hectare in 2011-12 . This increased to 580 hectare in 2015-16. This indicates that share of mango in total cultivable land is increasing over the years.

*Table 4 : Total Cultivable land in Godagari*

Types of Crop Land	Area ( hacter )	%
Single Crop	5100	12.90
Double Crop	20742	52.49
Tripple Crop	13683	34.63
Total	39510	100

Source: Upazila Agricultural Office, Godagari

### **Fall in Production in rice in Godagari**

Table 4 shows that the cropping intensity in Godagari shows that about 13 percent of total arable land is single cropped, about 53 percent is doubled cropped and the

*Table 5 :Production and Demand of food in Godagari*

Description of Item	Total (MT)
Demand for food	62780
Production of food	214114
Surplus of food grain	151334

Source : Upazila Agricultural Office, (UAO ), Godagari ( 2016-17)



rest is triple cropped. Under the present circumstance, Godagari is surplus of food. Under the present rate of transformation of rice field to guava and mango orchard, within 10 years about 20 percent of total arable land will be transformed to guava and mango orchard. As a consequences, there will be a fall in rice production.

Table 8 : Revenue from Guava, Mango and Aus, Aman and Boro

Age of Guava orchard	Production Mound	Revenue (Per hacter)	Cost ( Per hacter)	Return ( Per hacter)
2-3 years	561.75	831390	501830	329560
Field Survey, 2017				
Age of Mango Orchard	Production (Mound)	Revenue ( Per hacter)	Cost (Per hacter)	Return (Per hacter)
10-15 years	262.15	324878	69746	254188
Field Survey,2017				
Kinds of Paddy	Production (Mound) Per hacter	Revenue (Per hacter)	Cost (Per hacter)	Return (Per hacter)
Aman	118.5	78645	63665	11235
Boro	142.31	98545	63342	38625
Field Survey,2017				

The finding from the field survey shows that economic factor is the most important factor which influencing over the rapid transformation of the rice area into mango and guava orchard. Calculations of the return of the above table show that mango and guava orchard more profitable than rice cultivation.

Table 9: Monthly Rainfall in Puthia Upazila from 2012 – 2016 (Millimeter)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2012	-	-	6	90	26	103	131	76	135	96	66	-	729
2013	5	17	12	25	110	204	132	206	226	197	-	-	1134
2014	00	35	09	55	166	292	256	324	321	17	00	00	1475
2015	05	18	25	146	175	395	348	274	187	39	11	03	1626
2016	36	00	17	20	195	25	411	11.3					293

Source: Upazila Agricultural Office, UAO

Basic Facts of Puthia Upazila

Monthly rainfall, total rainfall are presented in the above table. The findings shows that the highest rainfall is during the time between May and September. The rainfall is low between the month November and February. It is observed that the highest amount of rainfall was in 2015.

Table-10: Total area and production of different rice crop from 2009-10 to 2015-16 in Puthia

Year	Aus		Aman		Boro	
	Area (hectare)	Production ( MT)	Area ( hectare)	Production ( MT)	Area (hectare)	Prouduction ( MT)
2009-10	100	225	4890	16953	4630	32837
2010-11	90	219	4500	21600	3550	12365
2011-12	90	286	4600	22080	3100	11160
2012-13	110	286	4600	22080	3535	17115
2013-14	150	383	3100	10198	2650	12112
2014-15	141	338	3350	10699	2730	11820
2015-16	90	216	4100	13104	2735	18300

Source: Upazila Agricultural Office (UAO), Puthia

Table-6: This table shows that cultivable land of boro reduced significantly. This also shows that share of boro in total cultivable land reduced from 30 percent to 19 percent in Puthia. It is also seen that the share of guava in total cultivable land increased. In addition to this share of mango in total cultivable land increases. This indicates that there is a transition of paddy to guava and mango .It is seen that share of boro in total cultivable land reduced but share of mango and guava in total cultivable land increased significantly. So, there is a clear transition of agricultural crop from boro to mango and guava in Puthia

Figure 5: Share of Guava in total cultivable land in Puthia

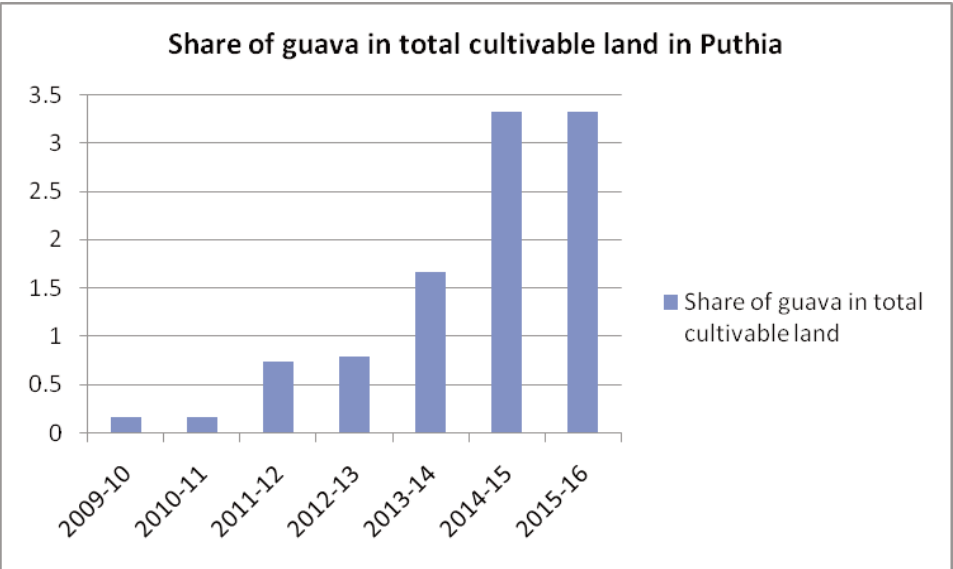
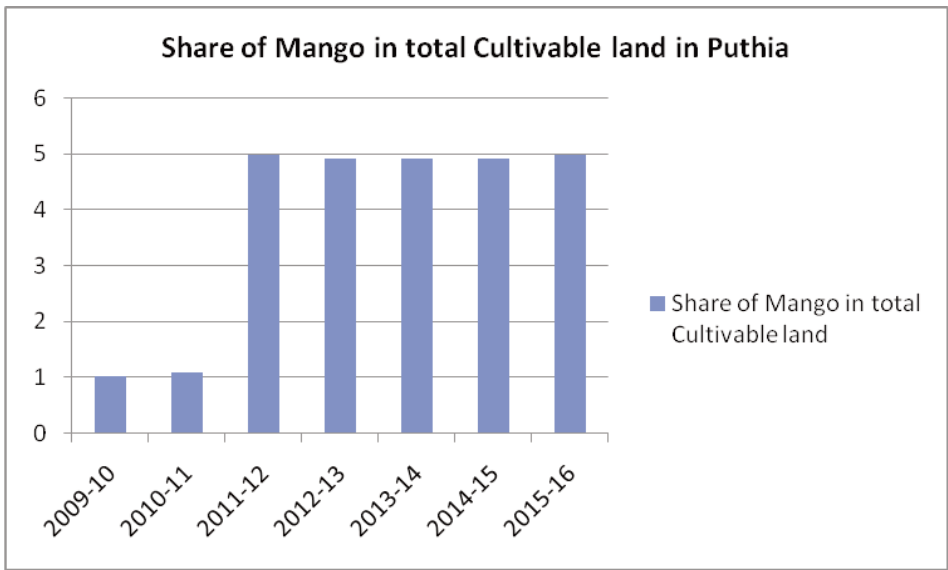


Table-7 shows that share of guava in total cultivable land increased from 0.15 to 3.32 %. This indicates that guava production increased in more than two times. It is also indicated that share of mango in total cultivable land in Puthia increased significantly.

Figure 6 : Share of Mango in total cultivable land in Puthia



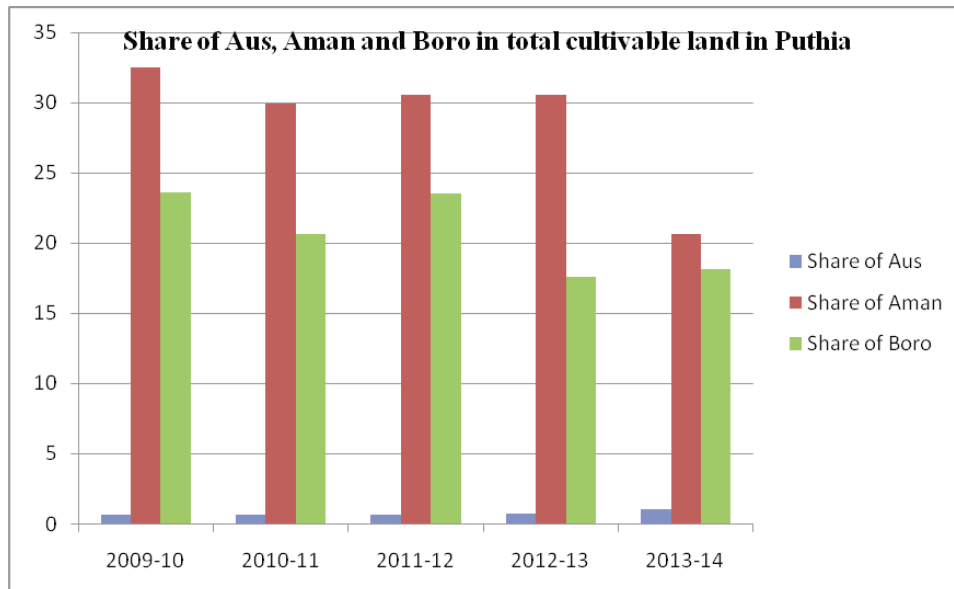
**Guava Farming in Puthia Upazila:** In 2009-10 about 0.15 % of total cultivable land was under guava farming. In 2015-16, about 3.32 percent of cultivable land has been under guava farming. The guava farming is four times higher than 2009-10.

**Mango farming in Puthia Upazila:** In 2009-10, about 1.01 percent of total cultivable land was under mango farming. In 2015-16 about 4.98 percent of cultivable land has been under mango farming. The mango farming is five times higher than 2009-10.

**Fall in Production in Rice**

The above table shows that the cropping intensity in Puthia shows that about 7 percent of total arable land is single cropped, about 82 percent is doubled cropped and the rest is triple cropped. Under the present circumstance, Puthia is surplus of food. Under the present rate of transformation of rice field to guava and mango orchard. About 20 percent of total arable land will be transformed to guava and

Figure 7: Share of Aus, Aman and Boro in total cultivable land in Puthia



mango orchard. As a consequence, there will be fall of rice production. This is a threat to food security in Bangladesh.

Table 13: Total Cultivable land in Puthia

Types of Crop Land	Area ( hacter )	%
Single Crop	854	7.22
Double Crop	9708	82
Tripple Crop	1263	10.68
Total	11825	100

Upazila Agricultural Office, Puthia

The finding from the field survey shows that economic factor is the most important factor which influencing the rapid transformation of the rice area into mango and guava orchard, calculations of the return of the above table shows that mango and guava orchard more profitable than rice cultivation.

In this diagram it is seen that, share of guava in total cultivable land in godagari is higher than the share of guava in total cultivable land in puthia . That is the land quality is favourable for guava in godagari than puthia.

In this diagram, it is seen that share of mango in total cultivable land is higher in Puthia than share of mango in total cultivable land in Godagari. It is observe that

Table 14: Production and Demand of food in Puthia

Description of Item	Total ( MT)
Demand for Food	119326
Production of Food	150010
Surplus of Food Grain	30684

Source: Upazila Agricultural Office, Puthia ( 2015-16)

Table 8 : Revenue from Guava, Mango and Aus, Aman and Boro in Puthia

Age of Guava orchard	Production Mound	Revenue (Per hacter)	Cost ( Per hacter)	Return ( Per hacter)
2-3 years	1258	1887480	1123500	763980
Field Survey, 2017				
Age of Mango Orchard	Production (Mound)	Revenue ( Per hacter)	Cost (Per hacter)	Return (Per hacter)
10-15 years	269.64	539280	1675776	372702
Field Survey,2017				
Kinds of Paddy	Production (Mound) Per hacter	Revenue (Per hacter)	Cost (Per hacter)	Return (Per hacter)
Aman	119.84	95872	66600	29181
Boro	191.74	122236	87558	38423
Aus	87.88	66810	60189	6621
Field Survey,2017				

land of Barendra region of Godagari is not favourable for mango cultivation. It is observed that after 6-7 years of mango cultivation many farmers cut mango orchard due to lack of growth of mango tree. In addition to this taste of mango of Barendra region in Godagari is not good. But the land quality of Puthia is favourable for mango cultivation. The growth of mango tree is high and the taste of mango is good. So the transformation rate of mango orchard is higher in Puthia than Godagari.

Conclusion

The data shows that a significant amount of cultivation land has been transformed permanently into guava and mango orchard. The consequence of transformation has already been felt in terms of rice production. Similar findings were obtained from sadar Upazila Nawabgong ( Noman and Julfiqar, 2014 ) . The degree of transformation from rice field to guava orchard is higher in Godagari than that of Puthia. The degree of transformation from rice field to mango orchard is higher in

Figure 4 : Comparative analysis of guava farming in Godagari and Puthia Upazila

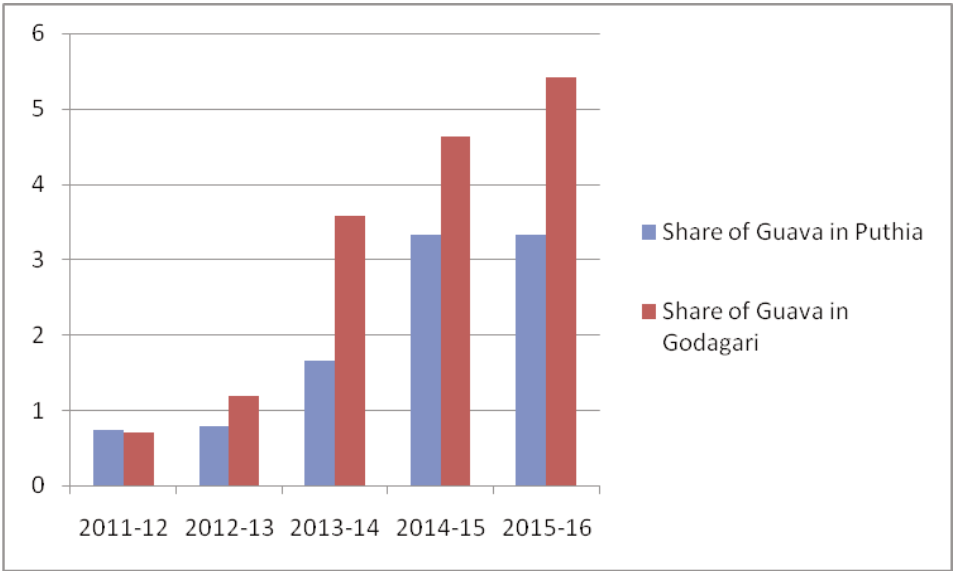
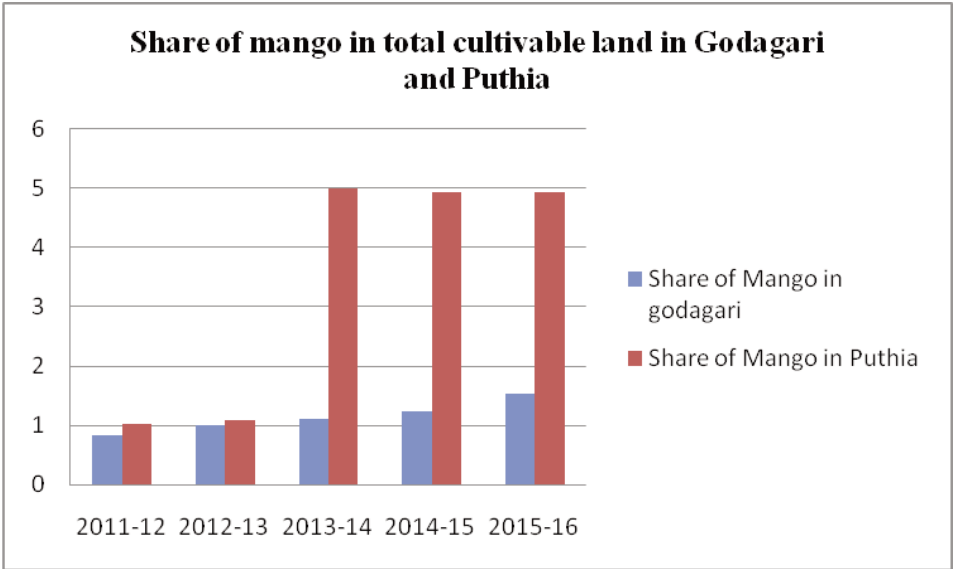


Figure 5 : Comparative analysis of Mango farming in Godagari and Puthia Upazila



Puthia than that of Godagari. Both of these areas are surplus crop producing areas and significant contributors to national food supply. It is seen that the production of the major crops in both of the areas declines. If the process of transformation continues in this manner, there is a very high possibility that these areas will not produce surplus crop. This will pose a threat to national food security.

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