A Review of Agricultural and Non-agricultural Real Income for Investigating Food and Nutrition Security Policy in Bangladesh

The study conducted by:

Centre on Integrated Rural Development for Asia and the Pacific

(CIRDAP)

Principal Investigator: **Dr. Mohammed Helal Uddin**

Director Research, CIRDAP &
Professor, Economics, University of Dhaka

Co-Investigators:

Abu Torab Rahim, PhD, Professor Institute of Nutrition and Food Science, DU
Jafar Imran, Assistant Professor, Economics DU & PhD Student, University of Florida
Deen Islam, Assistant Professor, Economics DU & PhD Candidate, Boston University
S. Badruddoza, PhD, Assistant Professor, Agricultural Economics, Texas Tech University, USA

Meeting the Undernutrition Challenge (MUCH) project

Content

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX TABLES

1. Introduction

The Government of Bangladesh has set the National Food and Nutrition Security Policy (NFNSP) 2020 to guide investment programs and policy reforms needed to meet its food and nutrition security (FNS) targets set in line with the Sustainable Development Goals (SDGs) of the United Nations. As mentioned in the preamble of **NFNSP 2020**, Bangladesh has made a remarkable progress in improving food security and nutritional status of its population over the past three decades. A substantial progress has also been made in improving the nutritional outcome in the country. Still Bangladesh faces daunting challenges for ensuring food and nutrition security of its people. One of the important areas identified to be addressed to overcome the NFS challenges in future is agricultural diversification to increase rural household income, maintain agricultural growth, improve food security and dietary diversity, etc. However, recent studies have shown a limited progress in overall crop diversity (**Kazal et al**., 2013). Therefore, we need to assess if diversifying is too emphasized as a policy strategy for improving food security in Bangladesh. To get a sense of the reality of agricultural diversification and its link with nutrition outcomes we need to explore some of the stylized facts of the economy.

1.1 Trend in Crop Diversification

Crop diversification is very low in Bangladesh and it is mostly dominated by rice cultivation alone (**Tisdell et al**., 2019). It has been shown that about 73% of the total cropped area is allocated for rice alone leaving the rest for diversification of other products including wheat, potato, vegetables, pulse, maize, etc (Table 1). The Land-use Diversity Index also reveals the lack of diversification within crop agriculture in Bangladesh. It is a widely used economics index based on the different types of crops grown in an area.

Table 1. Area allocated in Bangladesh to major crops (yearly average in the triennium ending June 2018).

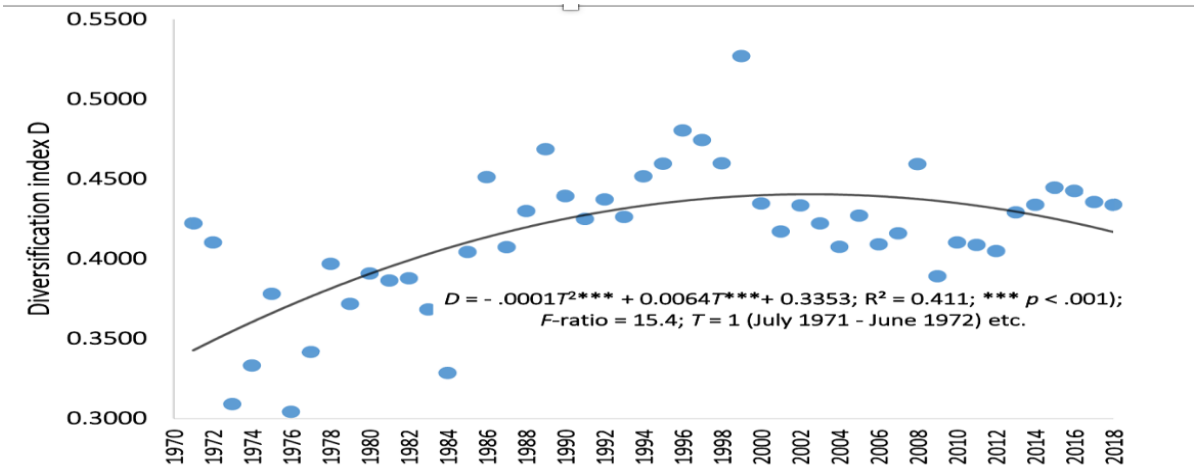
Type of Crops	Area (m ha)	Proportion of Gross Cropped Area Allocated to Crops
Rice	11.33	0.7378
Jute	0.725	0.0472
Potato	0.483	0.0315
Wheat	0.403	0.0262
Oilseeds (9 crops)	0.464	0.0302
Vegetables (40 crops)	0.410	0.0267
Spices (6 crops)	0.404	0.0263
Maize	0.375	0.0244
Fruits (28 crops)	0.302	0.0197
Pulses (10 crops)	0.368	0.0240
Sugarcane	0.093	0.0061
Total cropped area	15.357	1.000

Source: Based on data from BBS ([25], pp. 39–42). Diversification index, $D = 0.4479$.

Figure 1, which obtained from a secondary source, displays the 4-crop diversification index, which is calculated for each year based on land use by 4 crops (rice, jute, potato and wheat). It is obvious

that the trends in diversification was increasing up to 2000 before reverting to a decreasing trend. Thus, a very slow trend toward diversification appears to be evident in Bangladesh.

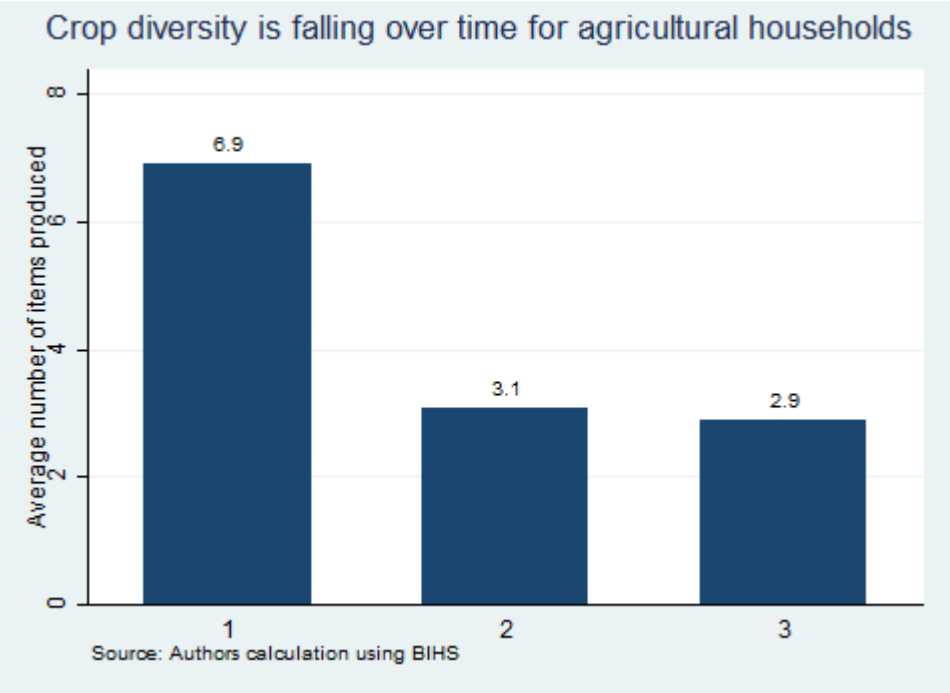
Figure 1: Trends in four-crop D (diversification) index of land used for cropping since 1971-72 to 2017-18 (based on BBS 2019)



Source: Tisdell et al., (2019)

The diversity trend described and displayed above is at aggregate level, that is, agricultural diversity at the macro level which may have link with household level crop diversity and/or diversity at the level of regions/ agroecological zones. From the 3 rounds of Bangladesh Integrated Household Survey (BIHS) data, we find that crop variety at household level is decreasing over the rounds spanning from 2010-16 (Figure 2). Crop diversity score was 6.9 during the 1st round of the survey in 2011-12 which went down to 3.1 during the 2nd round in 2015 and 2.9 during the 3rd round in 2018. This implies that there is a lack of incentive/motivation from the part of the farmers to diversify their agricultural production. But still adequate diversification at the level of agroecological zones can bring a substantial improvement in this drive which is still not strongly evident.

Figure 2: Crop diversity at the household level over 3 rounds of BIHS



1.2 Profitability of Alternative Crops

Several studies calculated financial profitability of crops for different years. They calculated Benefit Cost Ratio (BCR) based on yield (ton/ha), sale price, total cost, gross return and net return of those crops. BCR of some crops for two different years are collected from those studies and presented in Table 2 to show their potential for profitability in case they are cultivated instead of rice. It is evident that for most of the crops presented in this table, diversification away from rice is more profitable. For instance, the BCR of Boro is 1.26 in 2004 which went down to 1.06 in 2010. To the contrary, the BCR of wheat are 1.82 and 1.48 for the corresponding years, respectively. The BCR of maize are 2.15 and 1.89 for the corresponding years, respectively. With respect to BCR, rice is dominated by almost all the crops presented in the table.

Table 2: Profitability of different crops collected from secondary sources

Commodity	Year	Yield (ton/ha)	Sale Price (Tk/ton)	Total Cost	Gross Return	Net Return	BCR
Aus	2004	3.535	8050	22271	30596	8325	1.77
	2010	4.064	18750	64808	79342	14534	1.22
Aman	2004	4.31	7600	21609	38308	16699	1.77
	2010	4.064	18750	64808	79342	14534	1.22
Boro	2004	4.962	7490	28249	35719	7470	1.26
	2010	5.415	17500	95081	100379	5298	1.06
Wheat	2004	2.237	11500	15258	27936	12678	1.83
	2009	2.65	15560	29468	43636	14168	1.48

Maize	2006	7.47	78900	60545	28209	31336	2.15
	2010	7.75	7600	60412	31956	28456	1.89
Jute	2008	1523(fiber kg/ha)	22.77 (Tk/kg)	68712	39227	29485	1.75
Lentil	2000	659 (grain kg/ha)	18 (Tk/kg)	12271	5559	6712	2.21
	2012	1733 (grain kg/ha)	45.63 (Tk/kg)	80572	52734	27838	1.53
Mugbean	2005	1018 (grain kg/ha)	23.00 (Tk/kg)	23983	17264	6719	1.39
Blackgram	2005	1004 (grain kg/ha)	17.66 (Tk/kg)	18866	10421	8445	1.81
Chickpeas	2000	788 (grain kg/ha)	18.35 (Tk/kg)	14460	5153	9307	2.81
	2008	488 (grain kg/ha)	24.91 (Tk/kg)	12154	7754	4396	1.57
Onion	1997	5910 (yield kg/ha)	6.00(Tk/kg)	35476	26963	8512	1.32
	2011	11579 (yield kg/ha)	25.00(Tk/kg)	293566	198306	95260	1.48
Garlic	2006	5385 (yield kg/ha)	27.39(Tk/kg)	147495	72043	75452	2.05
	2011	4392 (yield kg/ha)	105.00(Tk/kg)	461152	218150	243002	2.11
Chili(dry)	2011	1800(yield kg/ha)	180.00(Tk/kg)	3244869	155009	169860	2.09
Potato	2008	24900(yield kg/ha)	12.00(Tk/kg)	298800	124481	174319	2.4
	2010	14200(yield kg/ha)	15.00(Tk/kg)	213000	129855	83145	1.64
Dairy Cow rearing	2002	12.62(cow /farm)	20.81(Tk/litre)	725479	529608	195871	1.37
	2009	4.84(cow/farm)	35.33(Tk/litre)	98000	70972	27028	1.38
Chicken(broiler)	2002	100 (bird/ farm)	111.73(Tk/bird)	11268	8541	2727	1.32
	2009	500 (bird/ farm)	140.30(Tk/bird)	70150	63367	6783	1.12
Chicken(layer)	1995	209 (bird/ farm)		14072	10733	3339	1.31
	2009	1000 (bird/ farm)		1439816	1263032	176784	1.14
Fish (pond)	2009	4505.16 (kg /ha)	70.00 (Tk/kg)	315361	212683	102678	1.48
Shrimp	2009	433.84 (kg /ha)	364.00 (Tk/kg)	190815	106791	86441	1.79

(Source: Miah et al. (2013); Islam et al. (2006); Karim et al. (2010); BJRI (2008); Islam et al. (2000); Rahman et al. (2010); Miah et al. (2005); Islam et al. (2000); Islam (2008); EPC (1997); Islam and Rahman (2011); Baree et al. (2006); Hossain et al. (2008); Parvin (2010); Miah (2002); Rahman (2009); Sultana (2009); Alam et al. (1995); Nahar et al. (2009); Akhter, 2009; Feroz, 2009.)

From the BCR figures in table 2, diversification away from rice seems beneficial for many crops. However, the BCR is declining over the time for rice (ex. Aus, Aman, Boro etc.) and other commodities as well except for onion and garlic. The exception might be due to some sort of seasonality or yearly fluctuation inherent there. This, in general, speaks for declining profitability of farming in general. Now the question is why are the farmers not diversifying to higher BCR crops?

In Bangladesh, 59% of all farm households cultivate land below 0.4 ha among which 25% have a farm size in the range of 0.4–1.0 ha. Calculating the average income of a typical farmer holding less than 0.4 ha of land might be useful in this regard. To calculate average income of a typical farming household, we also need to calculate costs includes the cost of one's own labor, rental of one's own land, etc. But the information on the cost of family labor is inadequate and thus it makes the calculation of such an average income difficult. The guestimate is that the average income of many such farming households will not be large enough to support them with an income level above the poverty line. This is also reflected in the results obtained from the study by **Helal and Islam 2015**, based on BBS HIES data.

1.3 Real Income Trend from Secondary Studies

From the table 3, it is obvious that per capita real income of rural households increased by 31 percent over 1991-2010 which is much less than the overall per capita income growth in Bangladesh for that period. The picture is gloomy if we look into the trend for the rural households at lower income quintiles. The per capita real income of the bottom 20 percent of the rural households went down from Tk. 2820 in 1991 to Tk. 2473, a decrease of 12 percent over that period. There is a 2 percent drop in the per capita real income of the rural households at the next quintile. Even the 6 percent increase in the 3rd quintile is not impressive at all. Per capita real income has grown up 69 percent at the top quintile.

	Per capita real income of rural households		**Growth in quintiles over the periods**
Quintile	**1991**	**2010**	**1991-2010**
Q1	2820	2473	**-0.12**

Q2	4373	4298	**-0.02**
Q3	5766	6124	0.06
Q4	7601	9040	0.19
Q5	13203	22274	0.69
Overall	6753	8841	0.31

Source: Helal and Islam, 2015

Table 3: Growth of per capita real income/rural households

Decomposition of per capita real income into different sub-sectors reveals that income of the agriculture sector has experienced a 14 percent fall while non-agriculture gained by 25 percent over 1991-2010 (Table 4).

Table 4: Decomposition of per capita real income growth of rural households into sectors

Income from	1991-95	1995-2000	2000-05	2005-10	1991-2000	2000-2010	1991-2010
1. Agriculture	-0.12	-0.15	0.07	0.04	-0.26	0.11	-0.14
1a. Farming	-0.11	-0.11	0.04	0.04	-0.21	0.08	-0.12
1b. Wages & Salary	-0.01	-0.05	0.03	0.00	-0.05	0.03	-0.02
2. Non agriculture	0.08	0.28	-0.09	0.02	0.33	-0.07	0.25

Source: Helal and Islam, 2015

Another interesting feature is that there is a decline in the proportion rural households whose main occupation is agriculture. As presented in Table 5, the proportion of households whose main occupation is agriculture went down from 58 percent in 1991 to 38 percent while that of non agriculture went up from 25 percent in 1991 to 41 percent in 2010. It seems convincing that the per capita real income of households from agriculture is not increasing much but that of non-agriculture is increasing relatively more. In fact, the per capita real income of agricultural households decreased for the bottom 2 quintiles. Therefore, there is a trend among agricultural households to switch out it rather than staying there and operating with higher level of crop diversification. **Dawe, 2015** identified price volatility, production risk, lack of substantial investments as the major impediments to diversification away from rice in some of the Asian countries including Bangladesh. Definitely, these factors are making agriculture less profitable and thus less attractive which has been reflected in the figures described above as stylized facts.

The poverty rate remains almost the same for agricultural households whereas it went down for other sectors including non-agriculture. Which means the non-agriculture sector is playing a stronger role for rural households in terms of income generation and poverty alleviation compared with the agriculture-sector.

Table 5: Proportions of households and Poverty Rates in different income groups over 1991-2010

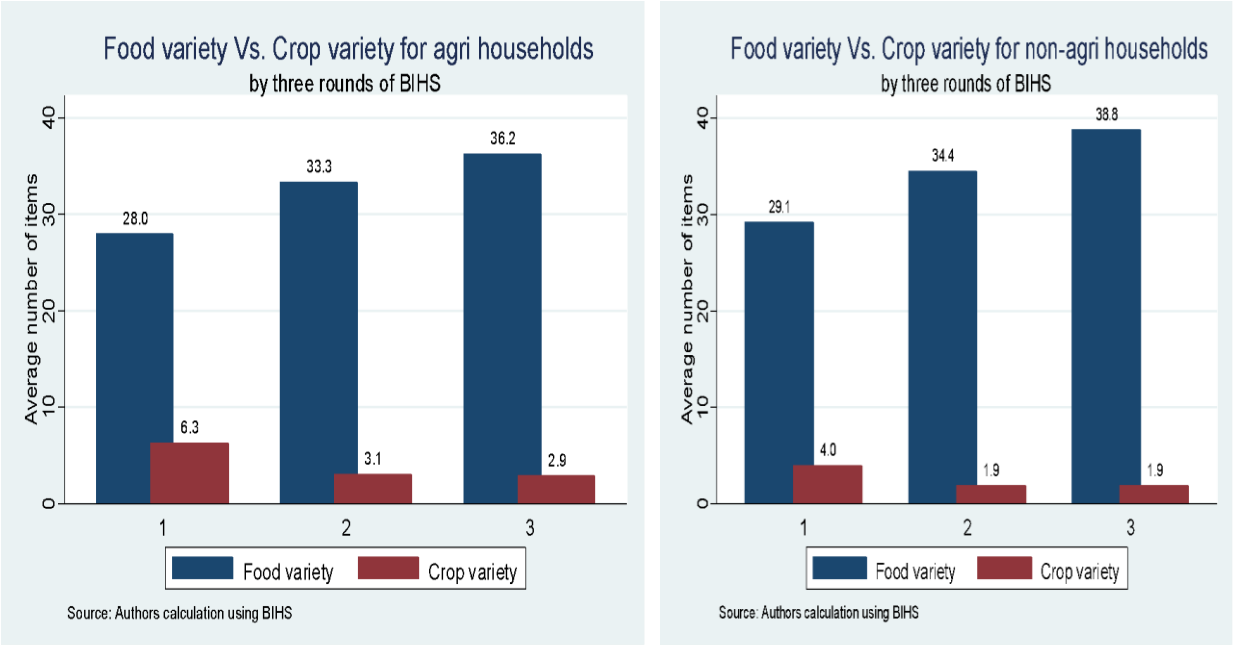
Year	1991		2010	
Occupation/Income Group	**Prop.**	**Poverty Rate**	**Prop.**	**Poverty Rate**
1. Agriculture: farming and wages & salary	0.58	54	0.38	56
2. Non agriculture	0.25	53	0.41	46

Source: Helal and Islam, 2015

1.4 Link of Crop Diversity with Nutrition Outcomes

For healthier and more balanced diets, diversification in food consumption is considered as the most effective way (FAO 2013). A common index of dietary diversity (DD) at individual and household levels is to score the food items consumed from various food groups identified by 24-h food consumption frequency recall. Therefore, dietary diversity score (DDS) is frequently calculated from various dietary consumption surveys to measure nutrition outcomes. Different variants of DDS are Household Dietary Diversity Score (HDDS), Women Dietary Diversity Score (WDDS) and Children (CDDS), Household Food group Variety Score (HFVS) and so on.

Figure 3: Inverse relation between crop diversity and dietary diversity



It is clear from Figure 3 that there is an inverse relationship between crop diversity and dietary diversity for both agriculture and non-agricultural households over 3 rounds of BIHS data. To understand this relationship at a greater detail we present HDDS, HFVS, WDDS, CDDS, MDDS, crop VS, monthly income and household size for agricultural and non-agricultural households over 3 rounds of BIHS. Table 6 presents them for round 1 of the survey conducted during 2011-12. The number of non-agricultural households and mean outcome are represented by obs1 and Mean1 while obs2 and Mean2 represents the corresponding figures for agricultural households.

Table 6: Differences between Agri and Non-agri households over different dietary scores, crop variety and monthly income for round 1 of BIHS

	obs1	obs2	Mean1	Mean2	diff	p value
HDDS	3403	3100	7.79	7.67	.124	.001
HFVS	3403	3100	29.13	27.99	1.145	0
WDDS	3401	3099	10.22	10.21	.013	.853
CDDS	1575	1355	7.69	7.99	-.295	.011
MDDS	3064	2918	10.25	10.39	-.136	.07
Crop VS	2682	2819	5.06	6.90	-1.842	0
Monthly income	3403	3100	6324	5291	1033.39	0
Household Size	3403	3100	4.2	4.2	-.002	.962

Table 6 shows that the mean HDDS is 7.67 for agriculture households which is slightly higher than that of non-agricultural households and the difference is statistically significant. Similar pattern is evident for HFVS even though insignificant differences are evident for CDDS and MDDS. Crop diversity is significant higher for agricultural households which is expected. But the average monthly income of agricultural households is significantly lower than that of non-agricultural households. This signals a strong relationship between DDS and income though. Similar pattern is observed for round 2 and 3 survey data (see Appendix A1 and A2 for round 2 and 3 figures, respectively).

1.5 Objective of the Study

Now the question is: what is wrong with non-agriculture playing a strong role in terms of income generation, poverty alleviation or better nutrition outcomes as we have observed above?

- First, it is too early to conclude such a role of non-agriculture, especially for nutrition outcomes. Because we need to net out of the effects of confounding factors through econometric analysis to reach to a final conclusion which is one of our focus points for this study.

- Second, switching out of agriculture may not be harmful as long as there is surplus labour in rural households. As long as there are adequate number of households in agricultural production there should not be problem with such a switching out of agriculture. But there is a debate on whether there is still enough surplus labor in rural Bangladesh.
- Third, switching a huge number of households out of agriculture is a threat for our future food security. The global price hike episode of 2007-08 shows that there is no global market for staple food like rice during crisis. For instance, India, Thailand and other rice exporting countries refused to export rice during 2007-08. Therefore, we need to produce them on our own. This asks for steps toward agriculture to make them attractive to the farmers. Some may argue mechanization as the solution to such a problem but it is still a long way to reach such solution.
- It is often argued that the Government is providing subsidies to agriculture and so they are profitable which is often not true from the perspective of impact/profitability. It has not been reflected in the stylized facts of per capita real income decomposition in the past.

Therefore, the general objectives of the study are to:

a) Better understand the relative weights of agriculture and non-agriculture sector of the rural economy in designing food security and nutrition policy for the rural population.

b) Understand nutrition outcomes of households belonging to agriculture and non-agriculture and generate policy suggestions to improve on the plan of action in this regard.

c) Understand why farmers are switching out of agriculture and suggest policies to slow them down.

And the specific objectives are to:

i) Explore inter-temporal changes in the per capita real income of households across occupations in agriculture and non-agriculture.

ii) Examine the income dynamics at different income quantiles of households to see the diversification/specialization pattern of different sizes of farming households.

iii) Explain the dynamics of per capita real income of agricultural and non-agricultural households over 1990-2016 along with their implications for nutrition outcomes.

iv) Explore the link between per capita real income of rural households and nutrition outcomes across agriculture and non-agriculture.

v) Compare estimated dietary diversity of rural households of different occupations in agriculture and non-agriculture

vi) Figure out whether the role of agriculture in achieving nutrition outcomes is overstated and that of non-agriculture is understated in case of designing food and nutrition policy

vii) Investigate the real income dynamics of agriculture and non- agriculture to explain why farmers are increasingly switching out of agriculture.

viii) Assess the potential role of price level, price volatility and production risks in pushing farmers out of agriculture.

ix) Explain if the terms of trade are going against agriculture pushing farmers out of agriculture and so on.

The organisation of the study report is as follows. Section 2 estimates the per capita real income of rural households and then decomposes them into subsectors of the rural economy. Section 3 estimates and explains the relationship among nutrition outcomes, real income and crop diversity.

Section 4 explains the factors behind farmers' switching out of agriculture and section 5 explains the gaps in food and nutrition policy of Bangladesh while section 6 concludes the study.

2. Real Income Dynamics of Rural Households

Per capita real income of rural households has been estimated with the purpose of exploring the changes occurred in the rural economy of Bangladesh with respect to livelihood activities and their related dynamics. The estimation of real income and their decomposition are divided into two categories. The first category is to explore its dynamics across sectors of the rural economy. For example, the overall per capita income of rural households has been derived dividing the total income of rural households by the number of rural household times household size. For per capita real income from agriculture has been derived by dividing total income from agriculture divided by the number of rural household times household size. Per capita real income from non-agriculture or off-farm activities, remittance and other group of activities has been derived in a similar fashion. This type of decomposition helps to trace the sectoral dynamics of economic activities.

To the contrary, the second category of estimation and decomposition goes in line with occupational groups and it traces the changes across the groups. For example, a household with its largest share of income from agricultural activities is categorized as agricultural household.

Similarly, a household with its largest share of income from non-agriculture is categorized as non-agricultural household. The overall per capita income of rural households is the weighted average of the averages of all groups. This estimation and decomposition help us to explore the changes across occupational groups which may strikingly differ from sectoral dynamics.

2.1 Methodology and Data

Estimation of per capita rural income from 5 set of Household Income Expenditure Survey (HIES) data (HIES 1995-96, 2000, 2005, 2010 and 2016) is challenging. One reason for so is differences in income modules across surveys. Another reason is missing data problems and handling of them in a similar fashion across surveys in a statistical package. To make the estimates consistent with other studies especially with BBS calculation we have made a couple of corrections for missing values and outliers. For crops, we replace the outlier and missing prices by the average prices. This reduces the effects of outliers from the revenue side. To reduce the outlier effect from the expenditure side, we have calculated net income and treated the lowest 1% percent observation as missing, which helps us find the mean value of net crop income more accurately. We have done a similar adjustment for business income, where we removed the lowest 1% and the highest 1% values of net business income to reduce the problem of outliers from both the revenue and expenditure sides.

For wages and salary, we replace the missing values by the respective profession's average value. Also, the overall mean income will not be the same, but close to the household's number-weighted mean total income. The reason is that the overall income is calculated using population weights, which will be missing if we calculate weighted average of quintile level mean total income. The population weights vary at different quintiles.

To categorize rural households into different income sectors, we have used income criterion in the spirit of **Helal and Islam**, 2015. Here a household is classified as agricultural household if the major share of its income comes from agriculture. Thus, based on the major share of income, we first categorized households into one of the four major sectors of income: Agriculture, Non-agriculture, Remittance, Property income. Households in each of these categories are further divided into a more specific income sector. Agricultural households are initially divided between farming and wage earners, and then farming households are further classified into one of the following categories: cropping, livestock, poultry, fishery, and forestry.

Similarly, non-agricultural households were subdivided into one of three categories: wage earners, salaried income, and business enterprises. Households with the majority of income coming from remittances are again grouped into either foreign remittance or domestic remittances and transfers. Finally, households for which property income is the main source of income are classified into three categories: Income from rent, Income from assets, and other income. We then find the overall average per capita income and average per capita income from the major source for each of these types of households.

Table 7: Comparison of Rural Per Capita Nominal Annual Income Estimates with BBS estimates

Year	BBS estimates of rural PCI	Our estimates
1995-96	8364	6752

2000	11136	9323
2005	14952	14052
2010	25560	23617
2016	39132	39947

Source: BBS HIES final reports 2010 (page 28) and 2016 (page 30).

Table 7 shows that estimated per capita rural income reported in BBS' final report of HIES 2010 and 2016, and our estimates. BSS reports per member monthly income with rural-urban breakdown. We multiplied the rural per member income by 12 to get the annual per capita income in rural areas, which are reported in column 2, Column 3 reports our estimates of annual per capita income in rural areas using different HIES. Our calculation of annual per capita income is slightly underestimated compared to BBS estimates only except for the survey year 2016, where our calculation is slightly larger than that of reported in HIES 2016 final report. In our calculation of annual per capita income, we included income from agriculture (agricultural enterprises and wages), non-agricultural incomes (non-agri wages, salary, business enterprises), remittances (both domestic and foreign), transfers (social safety nets), and property income (income from rent, assets, and other incomes, which includes interest income, pension, gratuity, etc.)

2.2 Decomposition of Per Capita Income of Rural Households

2.2.1 Per Capita Rural Income and its breakdown into Sectors and Sub-sectors

The bottom row of Table 8 presents the per capita annual income of rural households at current prices. The income went up from Tk. 6752 in 1995-96 to Tk 39947 in 2016, an increase by 492% over the 20 years period. The income from agriculture went up by 236% whereas that of non-agriculture went up by 540% over that period. The striking difference over agricultural and non-agricultural income growth is worth noting. Even though the growth of income from remittances and transfers is close to the growth of overall per capita income of rural households. The growth of other income was unusually high because of its very small value in 1995-96.

Table 8: Breakdown of Per Capita Nominal Income of Rural Household into Sectors/Annual

	1995-96		2000		2005		2010		2016		PCI growth over 1996-2016
Income from	PCI	As %	PCI	As %	PCI	As %	PCI	As %	PCI	As %	
1. Agriculture: farming and agricultural Wages & Salary	2927	43	3393	36	3198	23	9843	37	9836	25	236%
2. Nonagricultural income	2699	40	3293	35	6223	44	8830	33	17280	43	540%
3. Remittances and Transfers	879	13	1150	12	1875	13	2240	8	5069	13	476%
4. Other Income	247	4	1487	16	2756	20	2703	10	7762	19	3045%

Total (1+2+3+4)	6752	100	9323	100	14052	100	23617	88	39947	100	492%

If we look into the share of income from agriculture as percent of total per capita income then we observe an interesting picture. The share of agriculture went down from 43% in 1995-96 to 25% in 2016 whereas the share of non-agriculture went up 40% in 1995-96 to 43% in 2016. It reflects the fact that rural agriculture is shrinking whereas non-agriculture expanding along with expansion for other income category. So far, the story of agriculture looks not that bad. But if we convert these nominal figures into real income which is purchasing power of individuals with an adjustment for inflation then the reality becomes evident.

Table 9 presents the per capita real income of rural households along with contribution from different sectors. Per capita real income of rural households increased by 69% only over the referenced 20 years period. The real income from agriculture decreased by 4% against the 83% increase for income from non-agriculture. This is a real concern for agricultural sector when agriculture is highly focused for reaching National Food Policy objectives. From now we will focus on real per capita income instead of nominal one to get true picture of consumption and welfare.

Figure 4: Per Capita Real Income of Rural Households with Agricultural and Non-agricultural Breakdown

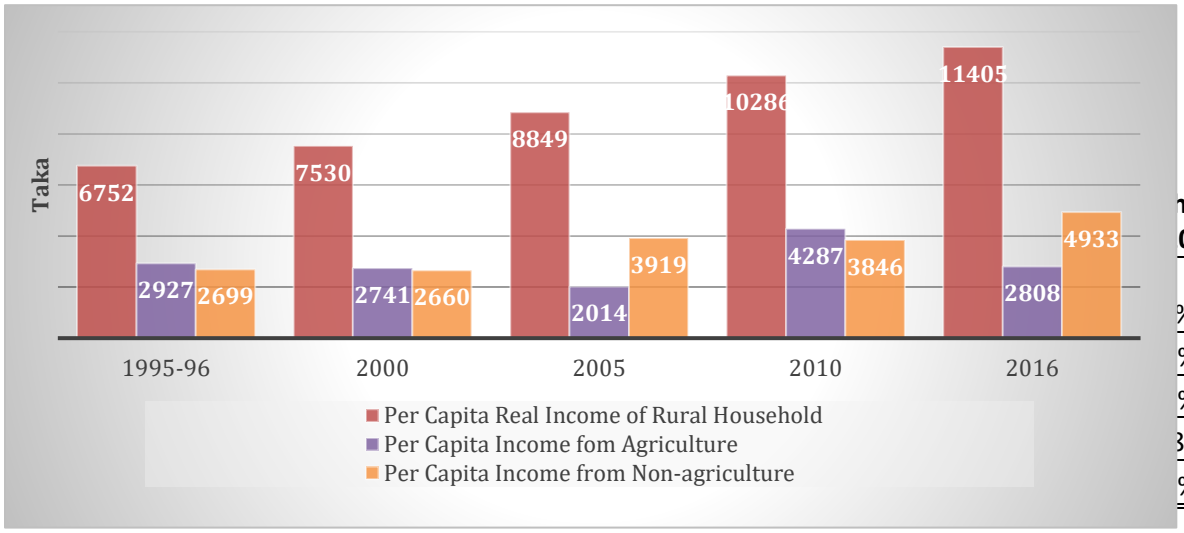


Figure 4 shows the bar chart representing overall per capita real income of rural households along with that of agriculture and non-agriculture. We can see the dynamics of real income changes for every 5 years from this figure. The average per capita real income of rural households went up from Tk. 6752 in 1995 to Tk. 11405 in 2016 and the increase was steady. The increase of non-agricultural real income was steady too. To the contrary, the corresponding figure for agriculture went down from Tk. 2927 in 1995 to Tk. 2808 even though it was significantly large in 2010. Here

the income from remittances and transfer and other incomes are not reported, but we need to add them to reach the per capita total income.

Figure 5 shows the breakdown of agricultural income into farming and wages and salary categories. It is obvious that income from farming went up from Tk 2027 in 1995-96 to Tk. 2409 in 2000. It was depressed to Tk. 1105 in 2005. It went up to Tk 3310 in 2010, but the inexplicable down to Tk. 1400 in 2016. However, the per capita real income from wages and salary went up to Tk. 1408 in 2016 from Tk. 900 in 1995-96, an increase of 56 percent over the 20 years period. It was depressed down to Tk.332 in 2000, but thereafter a steady increase was observed for rest of the survey periods.

Figure 5: Trend of Per Capita Real income from farming and Wages & Salary

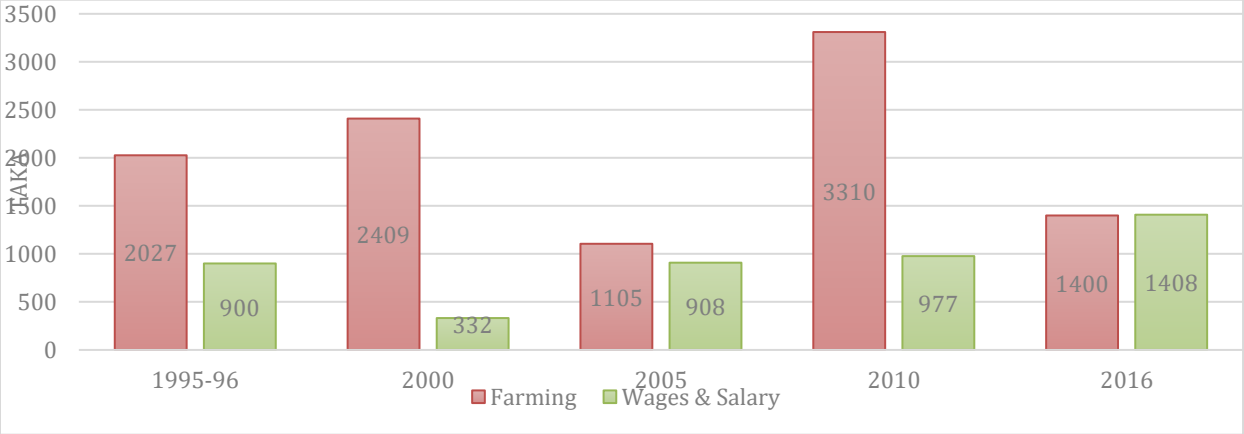


Figure 6 shows the trend of crop production over the 20 years period. It is clear that there was down trend for real income from crop product till 2005 and then it shot up to the highest in 2010 and the falling it drastically in 2016. If we consider the share of crop production in the total per capita real income then the scenario goes in line its revealed trend. The share of it went down from 27 percent in 1995-96 to 8 percent in 2016 while it reached the highest 32 percent in both year 2000 and 2010.

Figure 6: Trend of Income from Crop Production over 1995-96-2016

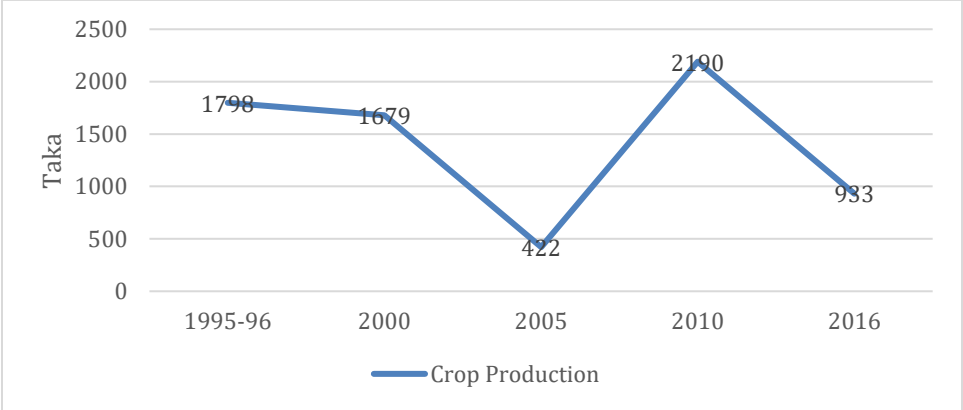
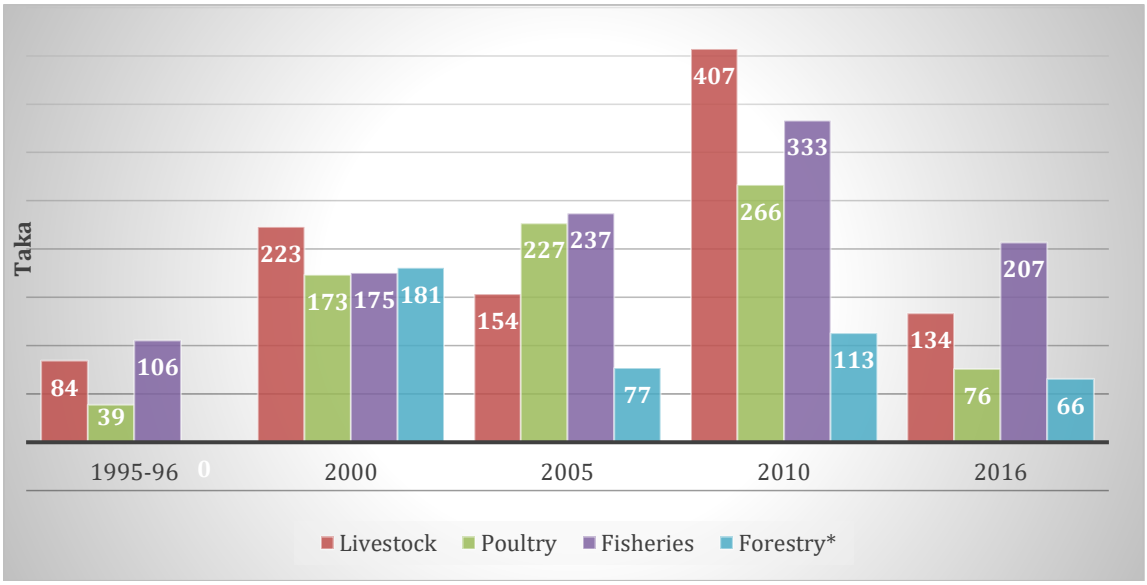


Figure 7 shows the trend of per capita real income from livestock, poultry, fisheries and forestry. There was a upward trend for all of them till 2010 and then all of them depressed during the following five years and that was captured in 2016. However, the upward trend was well pronounced for livestock, poultry and fisheries till 2010, forestry was not consistent here though.

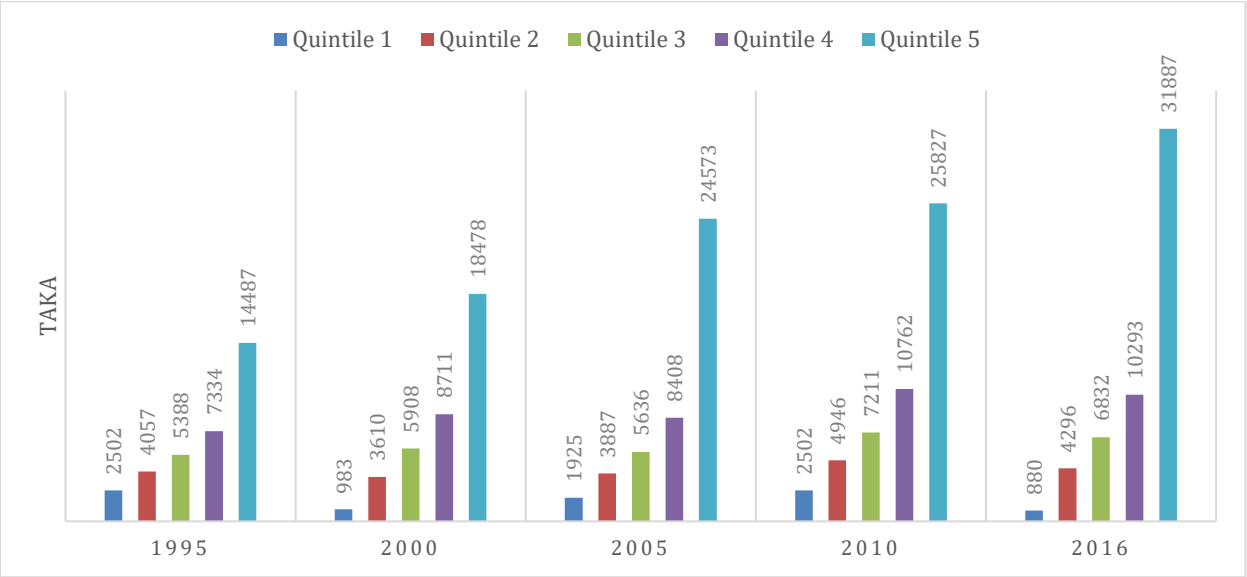
Figure 7: Trend of Income from Livestock, Poultry, Fisheries and Forestry over1995-96-2016



2.2.2 Decomposition Per Capita Real Income across Income Quintiles

So far, we look into the per capita real income dynamics over all rural households. Therefore, the differential trend of it on the different income category of households was not considered there. There exists a striking difference across income quintiles over the total and different components of real income contribution. It shows that the decline in real income from agriculture is well pronounced for bottom 2 quintiles and that of upper quintiles looks steady. Figure 8 shows that the annual per capita real income of bottom 20 percent of the rural households (i.e., Quintile 1 households) went down from Tk. 2502 in 1995-96 to Tk. 880 in 2016, a 65 percent decrease over the 20 years period. It is noteworthy that it went up to Tk. 2502 in 2010. Quintile 2 households experienced a 6% increase over that period while an increase of 27% for quintile 3 households. Quintile 4 experienced an increase of 40% and the top quintile gained 120% over that period.

Figure 8: Per Capita Real Income of Rural Households at Different Quintiles



Therefore, the per capita real income trend of bottom 2 quintile households deserve attention. When the Government wants to bring upliftment in nutrition outcomes the prime focus should be these households. We need to look into the differential trend for further breakdown of their per capita real income.

Figure 9: Per Capita Real Income from Agriculture at Different Quintiles

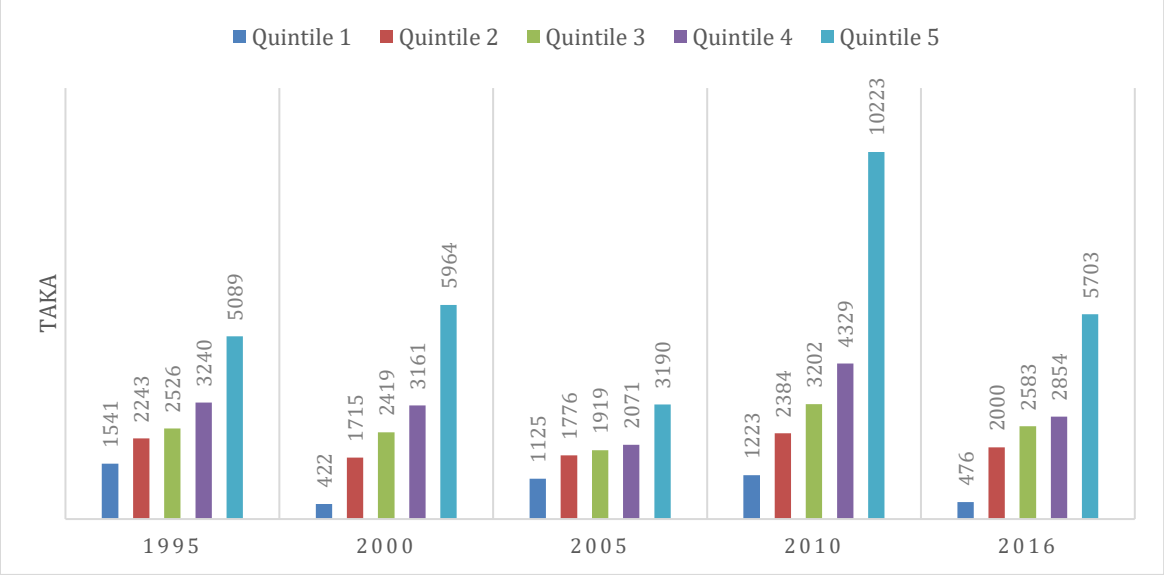
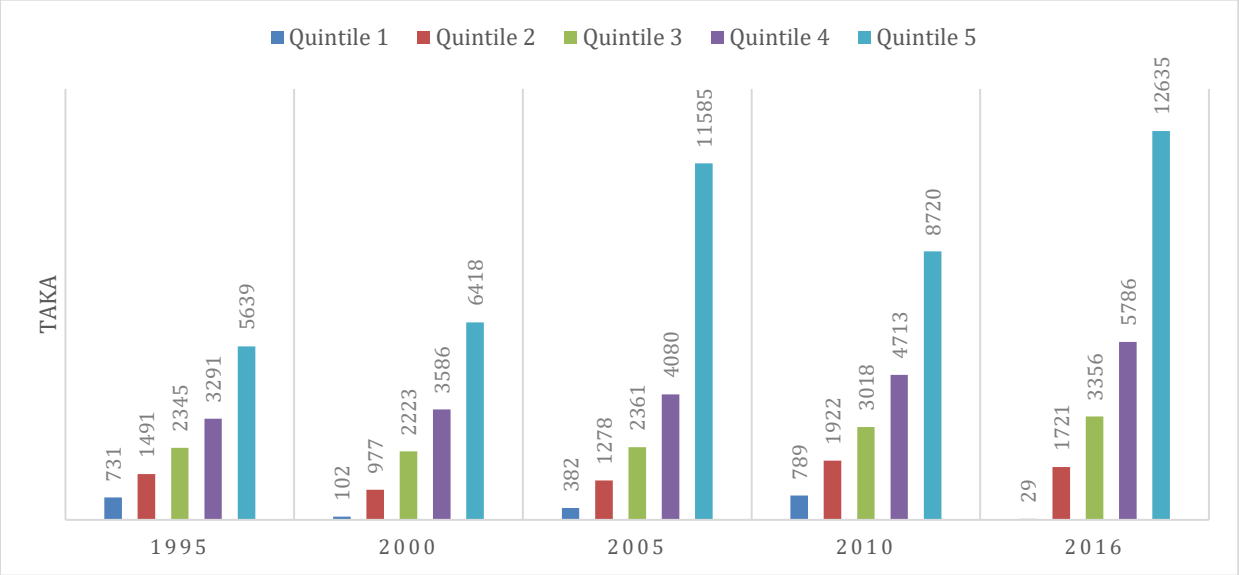


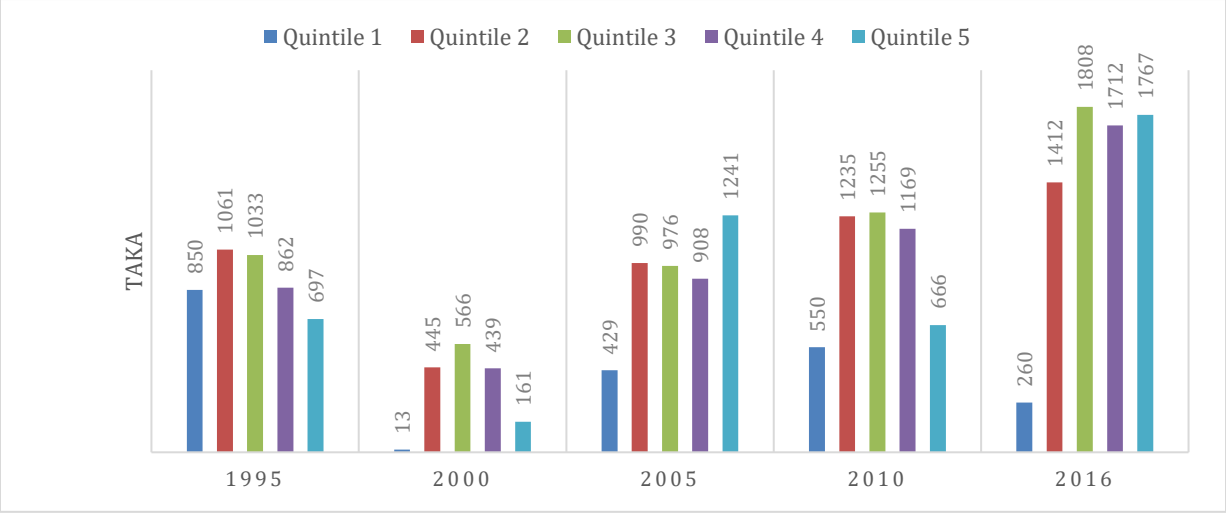
Figure 9 shows that even in case of depressed agricultural income in year 2016, the top quintile households gained 12% over income from agriculture. Rural households of all other quintiles experienced fall in their per capita income from agriculture with bottom quintile households losing by 69% over that period. Figure 10 shows per capita real income gain from non-agriculture for different quintiles. All the households except the bottom quintile gained over that period. The gains are 15%, 43%, 76% and 124% for quintile 2, 3, 4 and 5 households along with fall of 96% for the bottom quintile. Therefore, the non-agriculture is providing a steady growth of per capita real income over that period for most of the households.

Figure 10: Per Capita Real Income from Non-agriculture at Different Quintiles



If we look into trend of per capita real income from farming then we get a similar picture as depicted for income from agriculture (Appendix A3). However, the trend of per capita real income from wages & salary is interesting. As Figure 11 shows, this component of per capita real income experienced a substantial increase for all quintiles except the bottom quintile. We need to further breakdown it to see the role of wages and salary separately.

Figure 11: Per Capita Real Income from Wages & Salary at Different Quintiles



2.3 Decomposition of Rural Income into Occupations

The difference between the estimation in section 2.2 and 2.3 is that in the former case income estimation was calculated over all household members in rural areas except for the estimates derived for quintile level disaggregation. In that section, all income from a sector was summed up

and then the total was divided by the total number of people in rural areas to obtain the per capita income. For example, for income from agriculture we obtain the total income from agriculture then divide it by the total number of people in rural areas. Obviously, a significant number of rural people are not be engaged in agricultural activities. But in this section, we have identified agricultural households based on if the lion's share of the income of a household is from agriculture. Similarly, we have identified the non-agricultural households based on if the lion's share of a household's income comes from non-agriculture or off-farm activities and so on. This focuses on the condition of those who are engaged in a particular sector or sub-sector of the rural economy

2.3.1 Decomposition of Per Capita Rural Income into Occupational Groups

The real income from agriculture decreased by 4% against the 83% increase for income from non-agriculture as described in section 2.2. But the scenario is different when we consider the per capita real income from agriculture by agricultural households. As presented in last column of row 3 in Table 10, the per capita real income rise for agricultural households is 54%. For non-agricultural households, income from non-agriculture grew by 76%. The increase is 52% for farming households, 67% for crop producing households, 32% for livestock producing households, 1131% per poultry growing households, 25% for fishery farmers, 6054% for forestry. Per capita income from agricultural wage earners increased by 88% whereas the income from non-agriculture increased by 76%.

Table 10: Per capita Annual Real Income of Rural Households

Income Group	1995	2000	2005	2010	2016	% Growth (1996-2016)
a. Agriculture (Farming and agricultural labor)	4893	5271	4115	8346	7531	54
a1. Farming (Crop, livestock, poultry, fishery, and forestry)	5328	5343	3193	9578	8103	52
Crop Production	4994	4535	1935	7510	8349	67
Livestock	3385	1119	1971	12501	4478	32
Poultry	261	2778	2136	10142	3210	1131
Fisheries	6527	4036	3909	11090	8133	25
Forestry*	75	2058	2516	3733	4615	6054
a2. Agricultural Wage	3428	3662	4159	4793	6450	88
b. Income from non-agriculture	5802	6626	8403	8213	10216	76

Now the picture is different even though the dominance of non-agriculture is still well pronounced and the increase in non-agricultural income is more consistent than that of agriculture. Is it still commensurate with the overall per capita real income change for the entire Bangladesh economy? As shown in Table 9, the overall per capita real income of rural households increased by 69% over the 20 years period whereas the increase in overall per capita real income at the national level almost double of that for the referenced period.

Table 11: Change in Overall Per Capita Real Income for Bangladesh over 1995-2016

1995	2000	2005	2010	2016	2016-1995

GDP PC (Constant 1995 US$)	329	376	443	560	761	131%
GDP PC (Constant 1995 taka)	13243	15125	17793	22507	30601	131%

Data source: WDI

Table 11 shows that the national per capita real income of Bangladesh increased by 131% over 1995-96 to 2016. Therefore, the rural households with almost half of the national average income are expected to look for better opportunities outside of rural areas.

Table 12: % of Rural Households in different sectors/sub-sectors of Rural Economy		
Income Group	**1995**	**2016**
a. Agriculture (Farming and agricultural labor)	**50**	**37**
a1. Farming (Crop, livestock, poultry, fishery, and forestry)	**27**	**16**
Crop Production	**26**	**11**
Livestock	0	1
Poultry	0	1
Fisheries	1	2
Forestry*	0	1
a2. Agricultural Wage	**23**	**22**
b. non-agriculture	**41**	**44**
Non-agricultural wage	20	19
Non-agricultural Salary	0	13
Non-farm Enterprise	21	11
c. Remittances and Transfers	**8**	**9**
Foreign remittances	7	6
Domestic remittances and transfers	1	3
d. Property Income (Rent and other income)	**1**	**8**
Rent from Land	0	3
Asset income	0	1
Other income	1	4

Table 12 presents the percent of rural households in different subsectors of rural economy as their major income activities. It shows that 50% of the rural households used to agricultural households in 1995 and that decreased to 37% in 2016. As shown in Helal and Islam 2015, the percent of households in agriculture used to 58% in 1991-92. The percent of people in farming used to 27% in 1995 which went down to 16% in 2016. The percent of people engaged in agricultural labor remained almost the same. There is a slight increase in the percent of rural households in non-agriculture, which went up from 41% in 1995 to 44% in 2016.

3. How agricultural diversity and household income affect dietary diversity: Evidence from Bangladesh

3.1 Introduction

Recent policies in Bangladesh have been focusing on crop diversification, aiming at promoting rural economic resilience and improving food and nutritional security (e.g., Islam and Hossein, 2015; Islam et al., 2018; De Pinto et al. 2020). A number of studies and policies support crop diversification as a potential instrument for greater dietary diversity (Keleman et al. 2013; Fraval et al. 2019; Islam et al., 2018). The underlying link here is that dietary diversity measures a household's access and consumption of different food groups and is a useful indicator of nutritional status (Keding et al., 2012; Ruel, 2003). Dietary diversity is commonly fathomed with dietary diversity score (DDS)—the number of food groups consumed—and the food variety score (FVS)—or the number of food items consumed (Kennedy, 2013).

Where the association between a variety of food choices and nutrition is understandable (e.g., Armar-Klemesu, 2000; Carletto et al.; 2015), the role of crop diversification in encouraging dietary diversity must be evaluated carefully in the context in which it takes place. Efficient production and sale of staple or cash crops may improve a household's choices and income, but inefficient diversification can lead to foregone income and losses in dietary diversity (Sibhatu et al., 2015; Passarelli et al., 2018). The scenario is particularly relevant for the agricultural sector in Bangladesh as the crop diversity has been very low and dominated by the cultivation of rice (Tisdell et al., 2019). Bangladesh Bureau of Statistics reports the proportion of gross cropped area allocated to rice is over 73% (11.33 million ha). Since its independence, Bangladesh has been lacking diversification in agriculture (diversification index is less than 0.4 with 100 being the maximum), and the overall trend toward diversification is very slow (less than 0.0064 per year).

It is quite possible that the low crop diversification is an outcome, rather than a constraint, for Bangladeshi farmers given their options. Helal and Islam (2015) find that per capita real income in the agriculture sector has been falling in the last decades, but growing for all other sectors. Moreover, the benefit-cost ratio for most alternative crops can hardly compete with the leading crops. Not surprisingly, non-agricultural households have been enjoying more food items than agricultural households. Hence, policymakers and stakeholders need to understand the relevance of crop diversification in dietary diversity before promoting crop diversity for a better nutritional outcome.

The objective of this section is to estimate the effects of agricultural diversity and income on the dietary diversity of a household and its members. We use multiple measures of crop diversity and dietary diversity obtained from a country-wide household-level panel to find that crop diversity does not necessarily improve the number of food items consumed, but it increases the consumption in the nutrition group. However, the relationship between crop diversity and dietary diversity is endogenous and influenced by households' productivity. Most importantly, we find that household income consistently supports dietary diversity, regardless of crop diversification and household characteristics.

3.2 Literature Review

Why do we need diversification in food and agriculture? A number of studies find evidence that the diversification of agriculture is closely connected with nutrition and food security. For example, crop diversification increased food security through employment, income generation, and nutritional access in the temperate region of Jammu and Kashmir (Wani, 2012). Households with high crop diversity had about 34% of their income from agriculture (crops, horticulture, and livestock) compared to 25% among households with low crop diversity. This is because the diversification of crops may create more employment opportunities for small and marginal farm households, and increase the intensity of nutrient production, which reduces the pressure on limited arable land (Wani, 2012). Household micronutrient access is also significantly and positively associated with crop diversification. In Malawi's household farms, all four indicators of household micronutrient access (Iron, vit-A, Zinc, Folate) were found to increase significantly with the adaption of crop diversification (Mazunda et al., 2015). A similar result was found in Tamil Nadu between the consumption of nutrients and crop diversification (Chinnadurai et al., 2016). However, even though the impact of crop diversification on agricultural income and nutrition is positive, the marginal effects of an additional crop on the dietary diversity of the household can be quite small. Therefore, the magnitude of the diversification effect should also be considered in assessing the effect of food security and household nutrition (Nielsen et al., 2013, Sibhatu et al., 2015).

However, the empirical evidence on the relationship between agricultural diversification and consumption diversification is mixed. Agricultural diversity contributes to more diverse households—as well as individual-level diets—by increasing more income-generating pathways, and is also associated with positive increments in young child linear stature of the low and middle-income countries (Kending et al., 2012; Jones, 2017). On the contrary, diversification of crop could not be found to have a positive effect on food security and nutrition, especially for poorer households in some of the empirical and case studies on crop diversification in the rural part of some developing countries (Fleuret & Fleuret, 1980; Lunven, 1982; Rajendran, 2017).

Lunven (1982) evaluated six case studies of agricultural and rural development projects in Africa and Asia to find that improved nutrition is not intrinsically a benefit of agricultural development projects such as crop diversification among rural farmers. The impact of crop diversification on the dietary diversity of households can be heterogeneous depending on household income level, socio-economic endowment, and behavioral characteristics. Households having an average crop income benefit from crop diversification increase dietary diversity at a decreasing rate. On the other hand, households with a below-average crop income can increase their dietary diversity score from their existing score at an increasing rate. Although marginal and poor farm households can increase their dietary diversity through crop diversification resulted from increasing crop income, the change in dietary diversity score may not be substantial if we ignore socioeconomic endowment and behavioral characteristics of the household (Rajendran, 2017).

Income is a critical component to consider while analyzing agricultural diversity and dietary diversity. A comprehensive review of researches on low and middle-income countries reveals that agricultural biodiversity and diet-diversity have a small but positive association depending on the

extent of the diversification (Jones, 2014; Kumar et al., 2019). In Guatemala, a study among small farm households revealed that food security and nutrition outcomes were more likely to be negatively affected in households that diversified from potato production. Though for wheat and vegetable growers, or even large potato farms, no negative association was found between nutrition outcomes and crop diversification. While compared to the traditional farmers, the potato farmers with small farms suffered from adverse income and nutritional status deteriorated when diversified. As the farm size increased, the household income and nutritional status increased with crop diversification.

However, this increased food security could not be proved as a result of income increase alone, rather a complementary health and education program to improve nutrition outcomes among farmers was recommended (Immink & Alarcon, 1991). In that line, small farming households in central Malawi who have adopted crop-diversification enjoyed a significant increase in their dietary diversity and food security; primarily because cattle ownership, access to credit, and education attainment complemented crop diversification to improve households' food consumption scores (Mango, 2018). In particular, training and availability of information on nutrition and food consumption have a positive and significant association with dietary diversity. Engaging in off-farm income activity also shows a positive effect on diet in one of the district's food diversity and consumption (Mazunda et al., 2015; Murendo et al., 2019).

Apart from income and education, livestock diversification is also found to be positively associated with household dietary diversity. In the Guruve and Mt Darwin districts of Zimbabwe, crop and livestock diversification increased dietary diversity among pulse-producing farmers. Increase in investments of diversified production (e.g. pulse, cereals, roots, and tubers) coupled with investment in cattle and small livestock (e.g. poultry, goats, etc.) increased nutrition and variety of food consumption among smallholder farmers (Bhagowalia et al., 2012; Fanzo et al., 2013; Sukla, 2019; Murendo et al., 2019). Murendo et al. (2018) find that livestock diversification and vegetable production increased household and women's dietary diversity in rural Zimbabwe.

Rural infrastructure dictating physical access to the market plays an important role in crop diversification and food security. Evidence shows that infrastructural constraints and cost of transportation limited the choice of food in rural villages of Benin, and households had to depend on production in general. This is intuitive because households located far away from the market may not have alternative access to produce, hence may lack access to many food items. An increase in the distance to the market reduced dietary diversity by 0.2% and 0.1% in Guruve and Mt Darwin respectively (Mazunda et al., 2015; Murendo et al., 2019). Ethiopian research suggested that the effect of crop diversification on aggregate household diets and child health was positive and varied by market access (Tesfaye, 2020). In Zimbabwe, market access, cultivation of fruits and legumes increased the dietary diversity, especially for women and children (Murendo et al., 2018). Access to extension services and storage facilities are some of the other factors affecting the diversity of food consumption (Adjimoti & Kwadzo, 2018).

The study that closely matches our one is Islam et al. (2018). Using an initial survey of the data set we use, Islam et al. (2018) find a small positive association between farm diversification and

dietary diversity under a Poisson fixed-effects regression. The study has several shortcomings. First, it does not consider the income effect of crop production on dietary diversity. Authors use off-farm income as a predictor that shows a positive effect on dietary diversity. However, crop income may also encourage farmers to sell more and consume less. Second, the authors use a Poisson regression that assumes no overdispersion of outcome variables—which makes the estimates inconsistent. Third, while authors admit that crop diversity is endogenous to dietary diversity, they address it with fixed effects which is unlikely to capture the time-variant unobserved skills of the household—such as productivity.

The current study contributes to the literature in ways. First, it uses a three years' panel of household surveys for additional insight. Second, the study utilizes a combination of OLS, Poisson, and Negative Binomial robust fixed-effects models to address functional form misspecification. Third, we apply a control function approach to control for the endogenous association, and found evidence that not controlling for endogeneity produces misleading results. Finally, we check the effect of food crop as well as a total crop on the intra-household composition of dietary diversity, and find heterogeneous effects of crop diversity on men, women, and children.

3.3 Methodology

We estimate the effect of agricultural diversity on dietary diversity, given the household characteristics. The analysis is conducted at the household level first, and then separately done on three subsamples consisting of men, women, and children of the household. The goal is to understand the prevalence of dietary diversity and its predictors for vulnerable members of households especially for children, elderly members, and women using the same data set.

$$y_{it} = f(ad_{it}, inc_{it}, X_{it}, \eta_i) \quad (1)$$

where, y_{it} is the outcome variable for household i in year t, and f represents a function. We consider two specifications of dietary diversity: (1) the number of food items consumed in the last seven days (an item-based measure of dietary diversity or FVS), and (2) the number of items in 12 nutrition group consumed in the last seven days (a group-based measure of dietary diversity or DDS). The nutrition groups are (1) cereals, (2) roots and tubers, (3) pulses and legumes, (4) eggs, (6) meat, (7) fish and seafood, (8) oils and fats, (9) sugar and honey, (10) fruits, (11) vegetables, and (12) spices. Both outcomes are measured at the (1) household level, and also for the (2) male, (2) female, and (3) children subsample.

Our key variables of interest are agricultural diversity (ad_{it}) and household income (inc_{it})[1]. We use two definitions of agricultural diversity: (1) the number of food crops produced by the household, and (2) the number of total crops produced by the household. The vector X_{it} consists of time-variant household and community characteristics, and η_i represents the time-invariant (fixed) effects.

There are several challenges in the estimation of equation (1) above. First, we cannot observe household and community-specific time-invariant factors. We use panel fixed-effects regression

[1] Unlike a few previous studies (e.g., Islam et al., 2018), we did not use off-farm income separately because money is fungible, and using agricultural income alone can be highly collinear with other agricultural controls.

to resolve the issue. Second, the outcome variables are count variables, which might make the OLS estimates inconsistent and inefficient. A Poisson regression approach is appropriate for count variables. However, the variance of count variables is generally larger than the mean in practice, which would make Poisson estimates inconsistent. Therefore, we choose to use the Negative Binomial (NB) model for our analysis. We present results from all three models for comparison, OLS for the baseline estimates, Poisson if the overdispersion test is rejected, and NB when the variance of the outcome variable is larger than its mean. Third, dietary diversity and crop diversity can be endogenous. Since both variables are choices made by households, there might be many unobserved confounders that simultaneously affect both, e.g., a more productive or industrious household can have both dietary diversity and crop diversity. Omitting any of such confounders will cause endogeneity.

To address the endogeneity issue, we use the control function approach (Wooldridge 2015). The approach involves estimating the model of endogenous regressors as a function of instruments—analogous to the first stage of two-stage least-squares (2SLS)—and then use the estimated errors as an additional regressor in the main model. Choosing a control function is more suitable than 2SLS for nonlinear models like Negative Binomial (Wooldridge 2015). We use two variables that represent households' level of productivity: household ownership of a tractor and a pump act as instruments. We indicate these variables with vector Z and use them as instruments. Ownership of these machines—with income and education being controlled under household characteristics (X_{it}) in the main regression—indicates households' level of productivity, but is not necessarily related to households' food choices. Many households may diversify their food consumption regardless of pump or tractor ownership.

For the control function approach, we predict the agricultural diversity using the instruments and the vector of controls:

$$ad_{it} = \beta_0 + \theta Z_{it} + \gamma X_{it} + e_{it} \quad (2)$$

where, β_0 stands for the intercept, θ is the parameter with instrumental variables, γ is the parameter with other variables X_{it}, and e_{it} is the error term.

Finally, the errors are most likely to be heteroskedastic because greater values of crop diversity may result in more variation in dietary diversity, depending on household choices. We calculate robust standard errors to address heteroskedasticity in all models.

3.4 Overview of the data

We use the three rounds of Bangladesh Integrated Household Survey (BIHS) data available from the International Food Policy Research Institute (IFPRI 2020). The data contain household surveys conducted in 2011-12, 2015, and 2018. Table 13 shows the summary statistics of the variables. As discussed above, there are eight dependent variables and two major independent variables, each combination was analyzed separately in the three models discussed above. The average number of items consumed by the household is 33, whereas the average number of items consumed that fall one of the twelve nutrition groups is about eight. Not surprisingly, children consume fewer food items but more nutritious items compared to men and women in the household.

The two measures of agricultural diversity—total crop count and food crop count produced by the household—have averages around 4 and 3. Household monthly income is around eight thousand dollars in the sample. Following the literature, other household characteristics include age and education of household head and its female members, household size, cultivable land available to the household. Agricultural households are defined by the household's receipt of over 50% of its income from agriculture. Other predictors are the presence of a market in the village and survey round. The two Instrumental variables suggest that about one out of three households in the sample has a tractor or pump.

Figure 12 simply compares the number of crops produced and the number of items consumed by survey rounds. The dietary diversity has grown from about 30 to 40 items between 2011 and 2019 in the sampled households. On the contrary, crop diversity has been declining from five to around two. This supports our previous observation that crop diversity has been declining in Bangladesh, which may not affect dietary diversity. However, to understand the partial effect of crop diversity on dietary diversity holding other variables constant, we conduct an econometric analysis in the following section.

Table 13. Summary statistics

Variable	Mean	Std. Dev.	Min	Max
Dependent variables (dietary diversity)				
Number of items consumed in the HH in last 30 days	34.558	10.023	1	89
Items consumed by children	8.931	3.873	1	34
Items consumed by women	11.076	3.873	1	37
Items consumed by men	11.146	3.878	1	35
Number of items in food groups consumed in the HH	8.419	1.356	1	11
Groups consumed by children	4.078	1.449	1	12
Groups consumed by women	3.098	1.503	1	12
Groups consumed by men	3.162	1.478	1	12
Key independent variables (crop diversity)				
• Agricultural diversity: total crop	4.87	3.641	0	49
• Agricultural diversity: food crop	3.76	3.005	0	43
Other independent variables				
HH monthly income in thousand dollars	9.18	9.729	.008	225.883
Agricultural HH=1, else 0	.58	.494	0	1
HH has any female earner=1, else 0	.743	.437	0	1
Age of HH head in years	43.729	18.613	0	108
HH head is male=1, else 0	.101	.301	0	1
Classes passed by HH head in years	3.257	4.011	0	16
Avg. class passed by women in the HH in years	1.855	1.504	0	14
Avg. age of HH women in years	15.359	8.216	0	84
HH size (number of HH members)	5.157	2.114	1	23
Farm size (total cultivable land in decimal of an acre)	107.219	138.546	0	2589.5
Village has market=1, else 0	.418	.493	0	1
BIHS survey round	2.027	.799	1	3
Instruments				
HH has irrigation pump=1, else 0	.379	.485	0	1
HH has tractor=1, else 0	.326	.469	0	1
Number of HHs		5,564		
Observations		11,785		

Source: Authors' calculation using BIHS data. *Note:* HH stands for household throughout the paper.

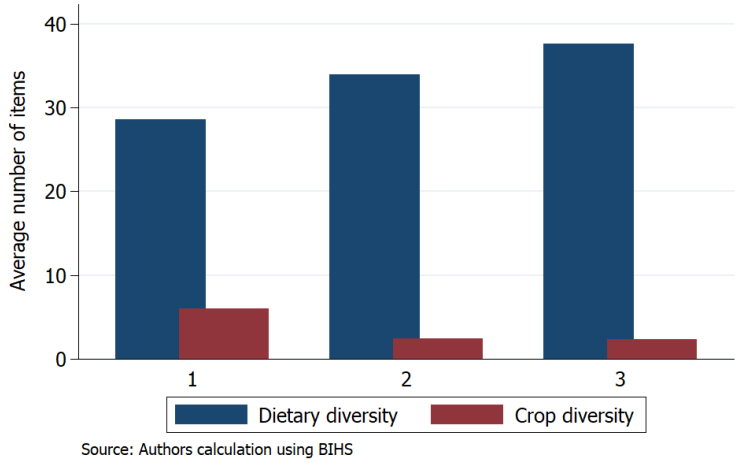


Fig 12. Items consumed and produced by households by three rounds of BIHS.

3.5 Analysis and Findings

We test if, and to what extent, diversity in food production affects dietary diversity, and whether controlling for covariates, especially income, sustains the results. We evaluate the hypothesis under both linear and non-linear settings, and control for endogeneity. The process leads to 96 regressions in total: 48 for running regressions of dietary diversity on agricultural diversity in food crops, and 48 for running regressions of dietary diversity on agricultural diversity in any crop. We begin the discussion with the first set. To save space, we put the coefficient estimates of regressions at the household level in Tables 1 and 2. Results from regressions using men, women, and children subsamples are placed in the Appendix. We also created three figures with only two coefficients of interest—agricultural diversity and household income. We find that the results are mostly consistent across models and measures of dietary diversity.

Tables 14 shows the effects of diverse crop production on the number of food items consumed by households. A simple OLS fixed effects model indicates that diversity in food production does not necessarily affect household diversity in food consumption when household income and other variables are controlled for. However, the coefficient becomes statistically significant at the 10% level in nonlinear models like Poisson fixed-effects (0.00184) and at the 1% level in Negative Binomial fixed effects (0.0044). This implies about a 0.004 items increase in the number of food items consumed by households due to an additional food crop produced by the household. The effect of monthly income is about 0.00296 for Negative Binomial; suggesting that a thousand dollar increase in monthly household income leads to a consumption of nearly three food items more by households.

Other coefficients are similar for Poisson and Negative Binomial models. The mean education of female members and the presence of a female earning member grow dietary diversity by 0.0295 and 0.0244 items, respectively. However, the mean age of female members has a negative significant association (-0.00264) representing the situation that elderly women have less access to diverse food options. Bigger households enjoy more food items (0.0214), so do households with farms (0.000127). The presence of a village market does not necessarily increase the dietary

diversity (-0.0138) in the household. It is possible that a village market enables households to sell theirs produces instead of consuming them. The positive coefficient with the survey round variable (0.108) implies growth in dietary diversity in Bangladesh over time. Households with elder and educated household heads have greater dietary diversity. The coefficient with the gender of the household head appears to be statistically insignificant.

Table 14 also shows results from the same three models after controlling for endogeneity. Interestingly, the effect of crop diversity becomes negative significant in all three models: OLS (-0.523), Poisson (-0.0178), and Negative Binomial (-0.0118) after controlling for endogeneity. This suggests that greater production of food crops may not increase dietary diversity, rather households may decrease their consumption by 0.0118 items. The significant coefficient with control function residuals also indicates that the crop diversity variable is endogenous to dietary diversity. The positive effects of agricultural diversity in food crops on the food diversity of households must have originated from the simultaneity or omitted Variables discussed above. The apparent positive association becomes negative once we control for the household's level of productivity with control function. Intuitively, greater crop production may encourage dietary diversity for households that are more productive in agriculture, but not for a typical household. Further explanation can be obtained from the income variable. A thousand BDT rise in monthly income results in a consumption of 0.003 food items in the household. The estimates with monthly income are positive, and consistently increase for each model as we control for endogeneity. Estimates with other variables remain similar, but the negative sign with the male household head variable is noticeable.

Nevertheless, dietary diversity based on item count does not guarantee a balanced, nutritious diet. The marginal population may consume several types of carbohydrates and vegetables without having access to any protein items. In order to avoid the shortcoming of the item-based measure, we categorize the items into twelve nutrition groups: (1) cereals, (2) roots and tubers, (3) pulses and legumes, (4) eggs, (6) meat, (7) fish and seafood, (8) oils and fats, (9) sugar and honey, (10) fruits, (11) vegetables, and (12) spices. The results for household-level regressions are presented in Table 15.

Similar to the item-based measure, we get a positive association between group-based dietary diversity and agricultural diversity in food crops, but negative when we control for the endogeneity. Control function residuals indicate the presence of endogeneity as well. The village market dummy becomes insignificant in the endogeneity-controlled NB model. The presence of a village market may facilitate selling food items instead of consuming them, but not necessarily items from the nutrition groups. Other predictors are also robust regardless of endogeneity controls. For instance, the presence of at least one female earning member, average education of female members, household size, and farm size have positive significant effects on dietary diversity, whereas agricultural household dummy and mean female age have negative ones. Dietary diversity in terms of food groups is also increasing over time in Bangladesh—shown by the coefficient with the survey round variable.

We repeat the analysis above by three subsamples within the household: men, women, and children. Tables B1-B6 in the appendix show the results. The overall negative effect of agricultural diversity on item-based dietary diversity holds across all three groups—with and without controlling for endogeneity. However, significant positive associations emerge across groups for group-based dietary diversity. For example, the endogeneity-controlled NB model has an estimate of -0.0504 for women's food item consumption (Table B1), but that of 0.0408 for women's food group consumption (Table B2). Figure 13 plots the estimates by groups for a more straightforward comparison. The horizontal axis shows the coefficient estimates with our variable of interest—agricultural diversity in food crops, and the vertical axis indicates the sample used for running the regressions. The shape of the dots implies models whereas the size of the dots stands for the level of statistical significance. Larger dots mean more significant results. The top panel plots estimates from the group-wise measure of dietary diversity, and the bottom panel from item-wise dietary diversity. The results are further divided into two columns—results from endogenous regression are placed on the left and endogeneity-controlled estimates are placed on the right column. Finally, the dashed vertical line represents a coefficient estimate of zero.

Figure 2 suggests that the level of statistical significance increases as we control for endogeneity. Estimates move further away from zero under endogeneity-controlled regression. Poisson and NB model have similar results, but OLS tends to overestimate or underestimate the effects. The estimates are positive significant for children, men, and women under a dietary diversity measure based on nutrition group (top-right of Figure 13), but negative significant for all samples under a measure based on item count (bottom-right of Figure 13). In words, an increase in agricultural diversity in food crops increases dietary diversity within the nutrition group, especially for men and women, and decreases consumption of the overall number of food items. Women seem to be the biggest beneficiary of agricultural diversity as their consumption of nutritious food groups increases the most (top-right of Figure 13). An increase in crop diversity increases women's food group count by 0.0408 (Table B2), which is respectively 0.0349 for men (Table B4) and 0.0221 for children (Table B6).

So far we have measured the effect of agricultural diversity in food crops on dietary diversity. For robustness, we check the effect of any crop (food plus non-food) on dietary diversity. Figure 14 shows the coefficient estimates for agricultural diversity in any crop. The results for this set of regressions show exactly the same pattern, with a slightly smaller magnitude. This is intuitive because the impact of growing any crop will not be as much as the impact of growing a food crop on dietary diversity.

Figure 12 plots the coefficient estimates with household monthly income for all samples and models. An increase in income increases the consumption of nutritious food groups in the 14 household regardless of the endogeneity (top panel of Figure 14), especially for children. A similar increase in income may increase consumption of food items across all samples (bottom-right panel). That is, greater income raises an overall number of food items consumed for all groups, but children get to consume more nutritious items.

Table 14. Impact of agricultural diversity in food crop on household food consumption

Dependent variable: Number of food items consumed by the household

	Endogenous			Endogeneity-controlled		
Variables	OLS	Poisson	NB	OLS	Poisson	NB
Agricultural diversity (food crop)	0.0460	0.00184*	0.00440***	-0.523***	-0.0178***	-0.0118***
	(0.0337)	(0.000961)	(0.000804)	(0.0776)	(0.00222)	(0.00196)
HH income in thousand BDT	0.0650***	0.00142***	0.00296***	0.0777***	0.00188***	0.00328***
	(0.0138)	(0.000362)	(0.000263)	(0.0140)	(0.000368)	(0.000266)
Agri. HH dummy	-0.467**	-0.0143**	-0.0369***	0.0900	0.00510	-0.0241***
	(0.220)	(0.00645)	(0.00478)	(0.228)	(0.00667)	(0.00497)
HH has any female earner	0.973***	0.0267***	0.0244***	1.318***	0.0387***	0.0322***
	(0.208)	(0.00609)	(0.00495)	(0.212)	(0.00618)	(0.00500)
Age of HH head	0.0460***	0.00126***	0.000630***	0.0510***	0.00144***	0.000751***
	(0.00975)	(0.000300)	(0.000133)	(0.00968)	(0.000298)	(0.000134)
HH head is male	-1.193	-0.0423	-0.00659	-1.866	-0.0682	-0.0170*
	(1.547)	(0.0496)	(0.00886)	(1.587)	(0.0501)	(0.00894)
Classes passed by HH head	0.0175	0.000947	0.00850***	0.0439	0.00182	0.00949***
	(0.0790)	(0.00232)	(0.000698)	(0.0786)	(0.00231)	(0.000706)
Avg. class passed by HH women	0.691***	0.0197***	0.0295***	0.696***	0.0201***	0.0303***
	(0.105)	(0.00305)	(0.00178)	(0.105)	(0.00305)	(0.00178)
Avg. age of HH women	-0.0652***	-0.00212***	-0.00264***	-0.0633***	-0.00208***	-0.00258***
	(0.0182)	(0.000566)	(0.000309)	(0.0183)	(0.000568)	(0.000308)
HH size	1.257***	0.0295***	0.0214***	1.252***	0.0295***	0.0218***
	(0.123)	(0.00338)	(0.00129)	(0.123)	(0.00340)	(0.00129)
Farm land owned by HH	0.00386***	0.000114***	0.000127***	0.00428***	0.000129***	0.000161***
	(0.00121)	(3.33e-05)	(1.95e-05)	(0.00120)	(3.35e-05)	(1.97e-05)
Village has market	-0.831***	-0.0238***	-0.0138***	-0.892***	-0.0257***	-0.0165***
	(0.224)	(0.00659)	(0.00468)	(0.223)	(0.00654)	(0.00467)
BIHS survey round	3.336***	0.102***	0.108***	2.321***	0.0679***	0.0795***
	(0.137)	(0.00399)	(0.00302)	(0.187)	(0.00532)	(0.00437)
Control function residual				1.634***	0.0570***	0.0434***
				(0.200)	(0.00585)	(0.00482)
Constant	17.72***		3.081***	21.11***		3.172***
	(0.852)		(0.0131)	(0.948)		(0.0163)
Observations	13,084	11,767	13,084	13,084	11,767	13,084
R-squared	0.265			0.271		
Number of HH	5,814	4,497	5,814	5,814	4,497	5,814

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 15. Impact of agricultural diversity in food crop on household food category consumption//Dependent variable: Number of food groups consumed by the household

	Endogenous			Endogeneity-controlled		
Variables	OLS	Poisson	NB	OLS	Poisson	NB
Agricultural diversity (food crop)	0.00421	0.000614	0.00196***	-0.0781***	-0.00962***	-0.00677***
	(0.00498)	(0.000592)	(0.000495)	(0.0116)	(0.00138)	(0.00119)
HH income in thousand BDT	0.00743***	0.000796***	0.00136***	0.00928***	0.00103***	0.00153***
	(0.00175)	(0.000204)	(0.000136)	(0.00178)	(0.000208)	(0.000138)
Agri. HH dummy	-0.0567*	-0.00700*	-0.0122***	0.0238	0.00301	-0.00546*
	(0.0344)	(0.00413)	(0.00290)	(0.0358)	(0.00430)	(0.00303)
HH has any female earner	0.0791**	0.00917**	0.0112***	0.129***	0.0154***	0.0153***
	(0.0325)	(0.00390)	(0.00305)	(0.0331)	(0.00397)	(0.00309)
Age of HH head	0.00150	0.000157	3.28e-05	0.00223	0.000249	9.68e-05
	(0.00165)	(0.000203)	(8.08e-05)	(0.00163)	(0.000201)	(8.09e-05)
HH head is male	-0.0925	-0.0142	0.00972*	-0.190	-0.0270	0.00411
	(0.332)	(0.0413)	(0.00538)	(0.339)	(0.0421)	(0.00542)
Classes passed by HH head	0.0147	0.00194	0.00466***	0.0186	0.00241*	0.00519***
	(0.0121)	(0.00145)	(0.000397)	(0.0121)	(0.00145)	(0.000402)
Avg. class passed by HH women	0.0744***	0.00880***	0.0174***	0.0751***	0.00895***	0.0179***
	(0.0168)	(0.00199)	(0.00106)	(0.0168)	(0.00199)	(0.00106)
Avg. age of HH women	-0.00774**	-0.000946**	-0.00117***	-0.00748**	-0.000916**	-0.00113***
	(0.00327)	(0.000403)	(0.000214)	(0.00325)	(0.000402)	(0.000214)
HH size	0.0677***	0.00717***	0.00524***	0.0669***	0.00714***	0.00545***
	(0.0184)	(0.00218)	(0.000740)	(0.0184)	(0.00218)	(0.000743)
Farm land owned by HH	0.000622***	7.47e-05***	6.50e-05***	0.000682***	8.24e-05***	8.41e-05***
	(0.000163)	(1.95e-05)	(1.05e-05)	(0.000165)	(1.99e-05)	(1.06e-05)
Village has market	-0.0654*	-0.00761*	-0.000560	-0.0742**	-0.00867**	-0.00206
	(0.0354)	(0.00425)	(0.00284)	(0.0353)	(0.00423)	(0.00285)
BIHS survey round	0.343***	0.0415***	0.0416***	0.196***	0.0235***	0.0264***
	(0.0218)	(0.00262)	(0.00193)	(0.0287)	(0.00339)	(0.00267)
Control function residual				0.236***	0.0295***	0.0231***
				(0.0304)	(0.00364)	(0.00290)
Constant	7.095***		1.955***	7.586***		2.005***
	(0.139)		(0.00802)	(0.152)		(0.00997)
Observations	13,084	11,767	13,084	13,084	11,767	13,084
R-squared	0.115			0.122		
Number of HH	5,814	4,497	5,814	5,814	4,497	5,814

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

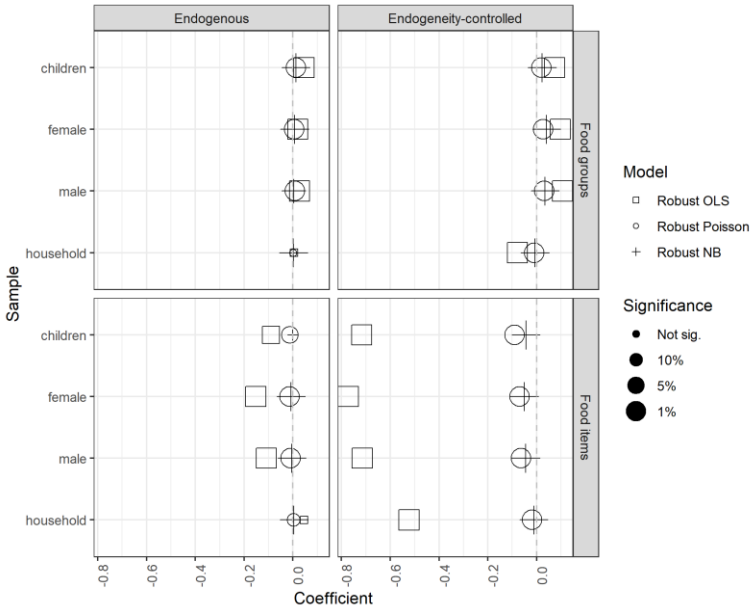


Fig 13. Impact of agricultural diversity in food crop on dietary diversity. The shape of the dots implies models whereas the size of the dots stands for the level of statistical significance. Larger dots mean more significant results.

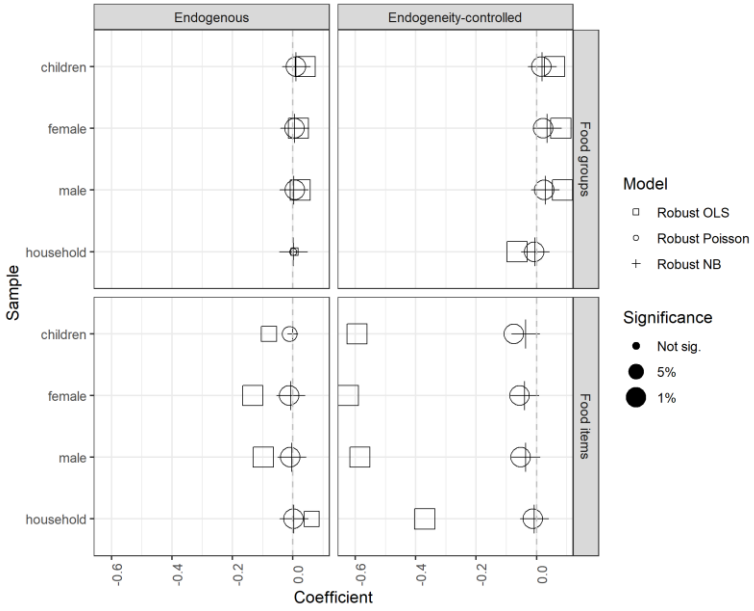


Fig 14. Impact of agricultural diversity of any crop on dietary diversity. The shape of the dots implies models whereas the size of the dots stands for the level of statistical significance. Larger dots mean more significant results.

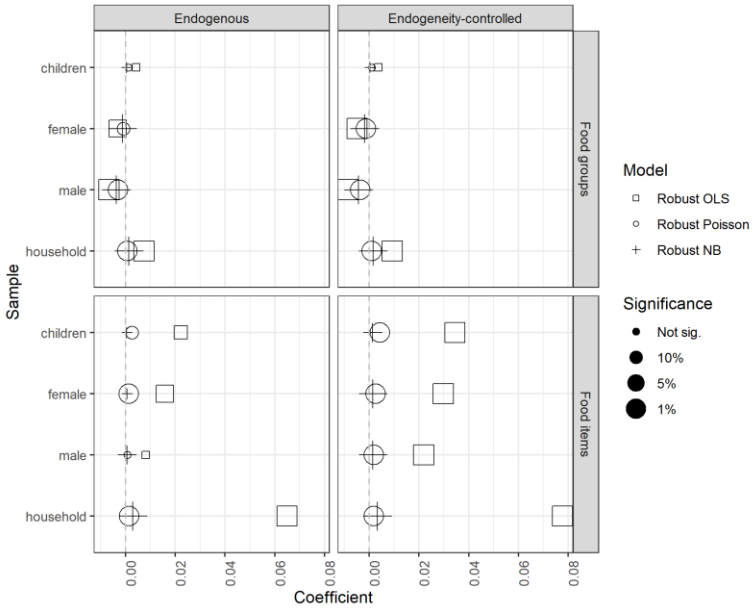


Fig 15. Impact of household income on dietary diversity. The shape of the dots implies models whereas the size of the dots stands for the level of statistical significance. Larger dots mean more significant results.

3.6 New Insights, Policy Implication, and Limitation

Our study points to three important features of studying dietary diversity. First, the relationship between dietary diversity and crop diversity is endogenous, and ignoring the feature can be misleading. As Rajendran (2017) points out, the effect of crop diversification may not be substantial if we ignore household behavioral characteristics. Almost all regressions show a significant coefficient with control function residuals. Controlling for endogeneity results in a negative sign of the coefficients for households in item-based regressions. This finding contradicts Islam et al. (2018) but supports Sibhatu et al. (2015) that diversification may lead to inefficiencies and losses in dietary diversity.

Second, we find evidence of dietary diversity increasing in the household for nutritional group-based measures but not for item-based measures. That is, households with greater crop diversity may not have access to more food items but have a more balanced food consumption basket. Women in the household are the biggest beneficiaries of this increase whereas children are the smallest. This evidence suggests that crop diversity can be promoted for a more balanced diet in the household, especially for women.

Third, the negative coefficient in item-based regressions may point to the income effect on diet choices. It is possible that a negative effect can be observed due to adverse income effects (e.g., Immink and Alarcon, 1991). One cannot however guarantee that an increase in crop diversity decreases dietary diversity, rather households that spend less effort in farming has a greater chance of spending the time in non-farm activities that offer higher wages (Helal and Islam, 2015). This facilitates greater consumption of food items, and hence generates a negative association.

Fourth, Income has positive effects on item-based dietary diversity for each subgroup. Thus, the growth in dietary diversity can be consistently attributed to household income across groups, rather than crop diversity. We found the effect of food crop and total crop almost similar on dietary diversity—which is counter-intuitive because only food crop can directly contribute to diet. The underlying factor here is income. That means, as long as the crops have market value, households can achieve equivalent dietary diversity producing any crop. The presence of income effect makes food crop and total crop equally contributing to dietary diversity.

Fifth, female education, and earning female members are the two other noticeable predictors of dietary diversity. Our results are consistent with Islam et al. (2018) from a women empowerment perspective; that educated and earning women may help households attain a greater diversity in food consumption.

Finally, many studies in the literature found a very small effect of crop diversification on dietary diversity (De Pinto et al. 2020). We find that, while income is potent enough to encourage dietary diversity, crop diversification is required for a more balanced diet. Moreover, the effect will be heterogeneous due to the heterogeneity of productivity across households. Perhaps a method-mix would fit the purpose better. For instance, Fraval et al. (2019) recommended interventions through income generation that may contribute to crop and livestock production and diversity.

A limitation of our study is the lack of in-depth nutritional information. While the food groups indicate essential components of a diet, further insights can be drawn from a granular decomposition of nutrition among men, women, and children of the household.

3.7 Conclusion

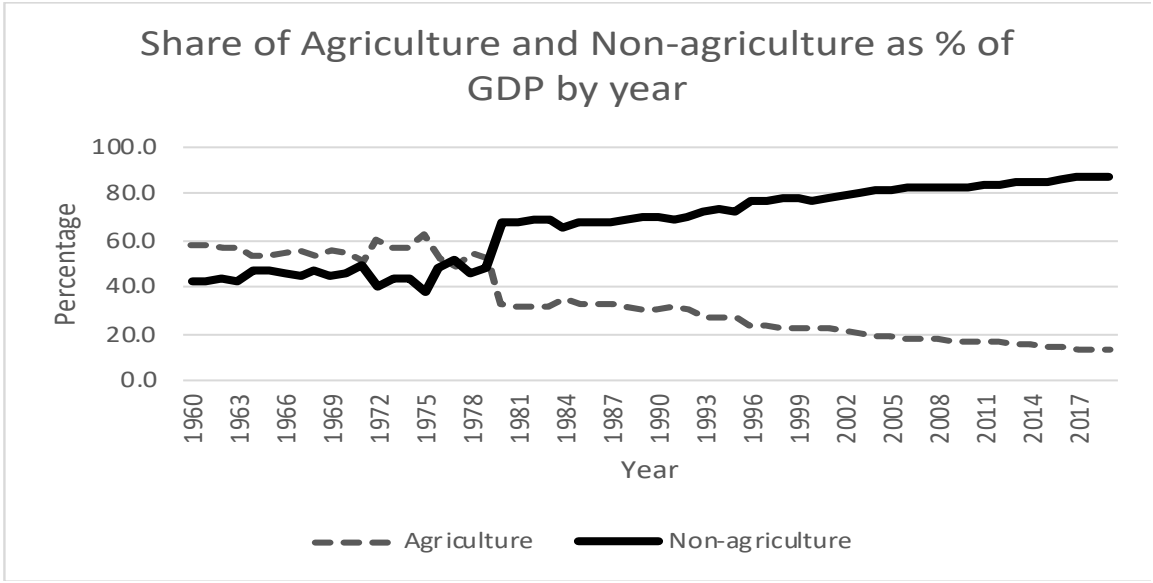
Our study offers some new insights regarding crop diversity and its possible impact on dietary diversity. While some households may benefit from crop diversity, given their level of productivity, many others will suffer from low income, inefficient production, and lack of dietary diversity resulted from an equilibrium displacement. Policymakers and stakeholders need to consider the heterogeneity among households and evaluate the context before taking a “one size fits all” approach.

4. Explaining Switching out of Agriculture

4.1 Introduction

As described above, the Government of Bangladesh has set the goal of the Bangladesh Second Country Investment Plan 2016-2020 (CIP2) to achieve an improved food security and nutrition for all the people of the country by making food systems nutrition-sensitive and sustainable. "Diversified and sustainable agriculture, fisheries and livestock for healthy diets" is one of the five investment pillars of CIP2 to reach the National Food Policy (NFP) objective. But the growth of agriculture is not in line with the overall growth of the country. Currently, Bangladesh economy is dominated by non-agricultural sector in terms of size and proportion of GDP. Over the last two decades, the share of agriculture in GDP declined while that of non-agriculture has grown continuously. While the share of agriculture in GDP was 59.6% in 1972 its share has become only 12.7% of GDP in 2019. On the other hand, non-agriculture supersede agriculture as share of GDP in 1980 and continued to dominate until now (Figure 16).

Figure 16: Share of Agriculture and Non-agriculture as percentage of GDP by year



Source: WDI

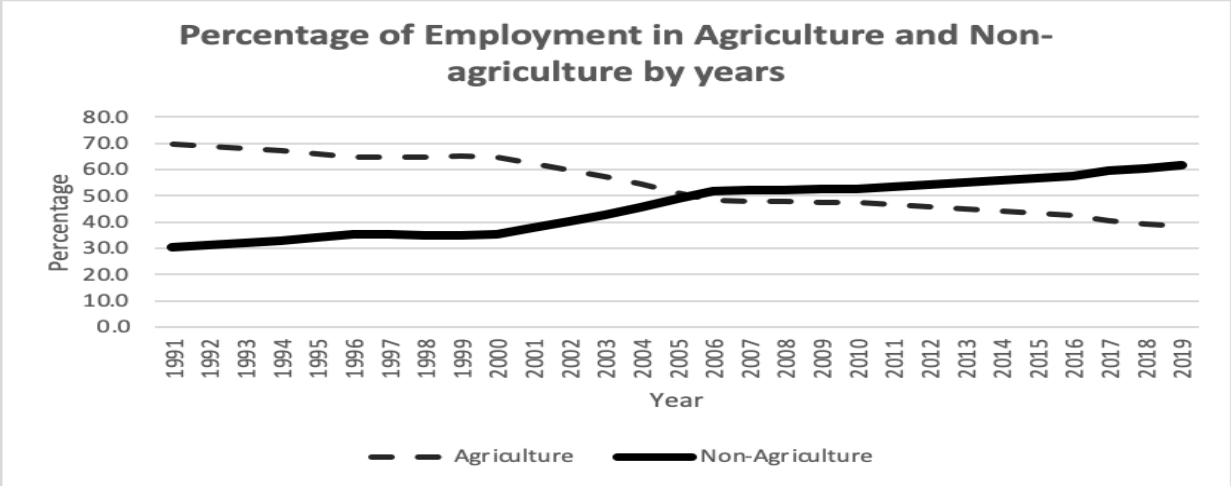
The share of non-agriculture as percentage of GDP has grown tremendously after independence and at present the contribution of non-agriculture (consist of industry and service together) in GDP is 8 times higher than agriculture as shown in this graph. Agriculture as traditional sector has been dominant sector of Bangladesh economy since independence. However, it had lost it dominance to other sectors like manufacturing and service sector combinedly in 80s. Since then, agriculture as a sector in Bangladesh continue to fall as percentage of GDP due to lack of productivity, urbanization, increased volatility in prices and revenues. As a result, the recent growth episode of Bangladesh is mainly driven by the momentum of non-agricultural sector.

To assess the relative strength of a sector we need to assess the scope of employment along with its share of the GDP even though the relative strength of a sector in generating employment

changes overtime. It happens due to the decision of individuals to engage in a sector based on resource endowment, relative profitability/ gain/remuneration of the sector compared with other competing sectors. Traditionally, agriculture was the dominant sector in Bangladesh where most of the people were employed. This dominance of agriculture reversed in early 2000 as service and industry emerged as better remunerative sectors compared with agriculture. Agriculture started slowing down in early 1990s and this trend has continued until now. In 1991, 69.51% of the employed people were engaged in agriculture while its employment share declined to 38.30 in 2019 (Figure 17).

However, people engaged in agriculture has not declined drastically in terms of absolute number. Even though population has grown from 105 million in 1990 to 163 million in 2019 and the relative share of people employed in agriculture declined drastically, the absolute number of people engaged in agriculture decreased only slightly in 30-year span i.e., from 4,24,33,671 people in 1991 to 3,69,18,476 people in 2019. For year-to-year change in the number of people engaged in agriculture is shown in table C1 in appendix.

Figure 17: % of Employment in Agriculture and Non-agriculture in Bangladesh



Source: WDI

Figure 17 shows that non-agriculture surpassed agriculture as a major source of employment since 2005 and it has been maintaining steady growth in terms of employment generation. A significant portion of population has been leaving agriculture due to a diverse better-remunerative employment opportunities outside agriculture. Rural households are no longer just a food-production entity they are also the important sources of labor supply for manufacturing and service sectors of the economy. Even within the rural areas, fewer people are now depending entirely on agriculture. The greatest expansion has been in the services sector and there has been a continuous movement of labor from surplus sector (agriculture) to deficit sector (non-agriculture).

It is evident from GDP share and employment ratio that people are switching from agriculture to non-agriculture. To assess the relative returns across sectors, we need to investigate the productivity differential across sectors. Per capita contribution can be a proxy measure of productivity that is defined as the ratio of share of GDP to share of employment of that sector. The

ratio of GDP to employment in Bangladesh agriculture was 0.46 while that of non-agriculture was 2.24 in 1991. This ratio stands 0.33 for agriculture and 1.42 for non-agriculture in 2019 (Table 16). For year-to-year change of GDP to employment ratio see table C2 in Appendix.

Table 16: Trend in GDP to Employment Ratio in Bangladesh

	Year	1991	1995	2000	2005	2010	2016	2019
Ratio of GDP to Employment	Agriculture	0.46	0.41	0.35	0.36	0.36	0.33	0.33
	Non-Agriculture	2.24	2.14	2.2	1.67	1.57	1.5	1.42

Source: Author's calculation based on WDI data

Ratio of GDP to employment declined for both agricultural and non-agricultural sector. However, the ratio for non-agricultural is still much higher than that of agriculture. This implies a relatively higher productivity in non-agricultural sector compared with agriculture. As a result, returns from non-agricultural sector are likely to be higher in Bangladesh. So far, the trend of agriculture versus non-agriculture has been discussed based on the overall economy of Bangladesh which means non-agriculture represents the rest of the economy. The real income decomposition of rural households conducted in Chapter 2 deals with agriculture, non-agriculture, remittance and other income categories.

Chapter 2 explains that the per capita real income of rural households is not increasing in line with the overall growth of the per capita GDP or income. More importantly, the per capita real income of agricultural households is growing very slowly compared with its non-agricultural counterparts. As a result, the incidence of poverty is lower among non-agricultural households than their agricultural counterparts. The nutrition outcomes are also not better for agricultural households either. The accumulated response is farmers' switching out of agriculture over the studied period of 20 years from 1995-96 to 2016.

As presented in Table 12 in chapter 2, the proportion of households whose main occupation is agriculture went down from 50 percent in 1995-96 to 37 percent in 2016 while that of non agriculture went up from 40 percent in 1995-96 to 43 percent in 2016. It seems convincing that the per capita real income of households from agriculture is not increasing much but that of non-agriculture is increasing relatively more. In fact, the per capita real income of agricultural households decreased most for the bottom 2 quintiles. Therefore, there is a trend among agricultural households to switch out agriculture rather than staying there and operating with a higher level of crop diversification.

Though agriculture is declining in Bangladesh it still has an enormous importance in the context of food supply, food security and eco-system maintenance which is reflected in the NFP objectives. Switching out of agriculture may hurt the food security of Bangladesh because of its increased dependence on external sources of food supply. During the recent onion crisis, we saw how neighboring countries set export ban on onion to pacify the prices in their local markets jeopardizing the food security in Bangladesh. The waning of agricultural sector implies that

Bangladesh has to depend heavily on foreign countries to feed its 163 million people. This overdependence on foreign country may be a dangerous ploy on strategic point of view. Agriculture is traditionally a labor-intensive production process in Bangladesh. Though mechanization in agriculture has started recently but it is still a labor-intensive process. With this background, shifting of overwhelming labor from agriculture and employing capital intensive process may decline the marginal productivity of capital-intensive sector. Concomitantly, weakening of a labor-intensive sector may add pressure on the government to create an enormous employment opportunity in alternative sectors.

Therefore, the objectives of this chapter are to:

i) Investigate the real income dynamics of agriculture and non-agriculture to explain why farmers are increasingly switching out of agriculture.
ii) Assess the potential role of price level, price volatility and production risks in pushing farmers out of agriculture.
iii) Explain if the terms of trade are going against agriculture pushing farmers out of agriculture and so on.

4.2 Analytical Framework and Methodology

Switching out of agriculture reflects the fact that there is a relatively lower incentive in agricultural production compared with its counterparts in rural non-agriculture and/or manufacturing/service sectors in the economy. Relative incentives are reflected by relative profitability or income associated with their relative variability. Measuring the relative profitability, riskiness and change in agriculture against non-agriculture/manufacturing sectors is a difficult task. We can look at the **Prebisch-Singer Hypothesis** to gather ideas about the likely problem associated with a relatively less attractive incentive for agricultural activities.

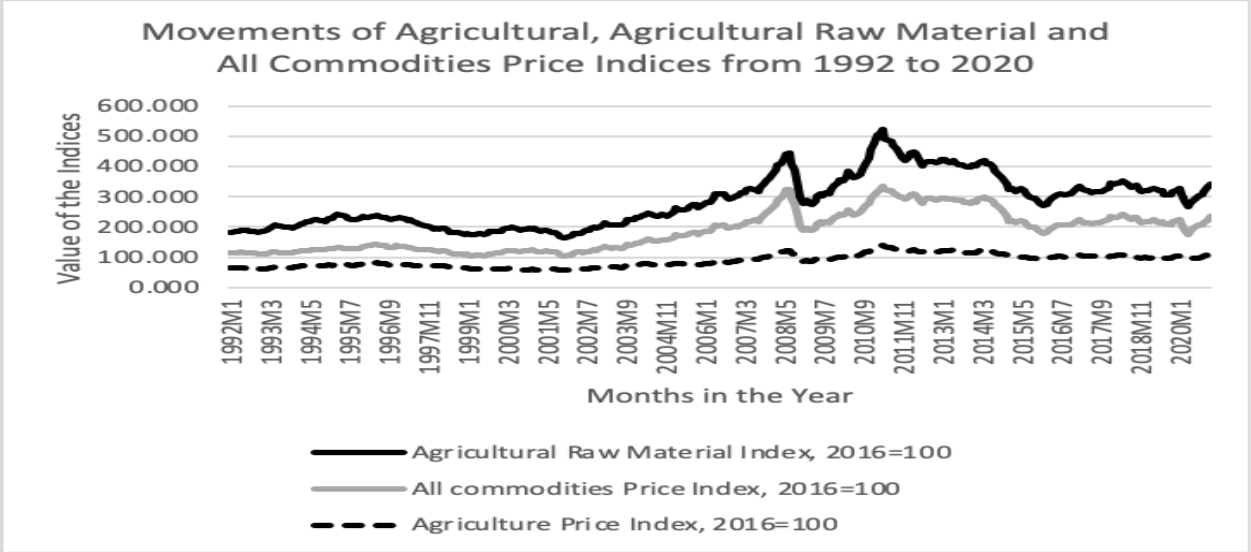
4.2.1 Prebisch-Singer hypothesis (PSH)

According to PSH, there has been a tendency of deteriorating agricultural barter terms of trade worldwide as the rise of price of agricultural commodities is generally lower than the rise of the price of manufacturing commodities (**Prebisch**, 1950; **Singer**, 1950). PSH presents the fact that there is a long-term tendency of barter terms of trade between primary products and manufacturing products to deteriorate for the worldwide. The reason for this deterioration is that wages and prices in primary product are determined competitively while these of manufacturing are determined by mark-up pricing and union-employer bargaining (Bloch & Sapsford, 2000). Price of primary products is also characterized by high degree of volatility due to seasonality, natural shock and production risks (Arezki et al., 2014). Additionally, in the long run income effect is dominant and it transmitted on food price through manufacturing price channel only (Baffes & Etienne, 2016). Monopoly power of manufacturers and technical progress in that sector simultaneously prevent the price fall in manufacturing sector. To the contrary, the relatively low-income elasticity of primary commodities generates lower demands for them counteracts to price rise of agricultural commodities (Singer, 1950).

Figure 18 shows that though worldwide agricultural price index remain stable, agricultural raw material index has increased during 1992 to 2020. As a result, profit margin from agriculture has

declined worldwide. So, this evidence suggests that on an average agriculture has become a nonlucrative venture worldwide. On the other hand, we see a persistent rise in all commodity price index. As long as cost increase for all commodities follows similar trend as price increment, there is high possibility of higher margins exists in other sectors than agriculture worldwide. This provides evidence that Prebisch-Singer Hypothesis hold for the world in general.

Figure 18: Agriculture, its Raw Materials and All Commodities Price Indices // 1992 to 2020



Source: IMF Commodity Price Indices

4.2.2 Relevance of PSH in the context of sector dynamics in Bangladesh

Even though PSH explains the global dynamics relating sectoral bias of price level, it has implications for local dynamics too. One of the problems of agricultural price is that it is usually abated by import policies, government intervention and protection mechanism. For instance, the government of Bangladesh sets a procurement price every year to affect the market prices of different variety of rice and to collect a certain amount of rice for public storage. The procurement prices are set in line with the import parity and export parity prices given the level of cost incurred. It seems convincing that the global price trend which is differential across primary commodities and manufacturing products enters into the price level of Bangladesh. From farmers' switching out of agriculture, the fall of share of agriculture in GDP and employment in Bangladesh one can easily infer that agriculture is becoming relatively less attractive relative to its competing sectors. That means the real income from agriculture either falling or not increasing in commensurate with other sectors. One way to assess this is testing of PSH in the context of Bangladesh economy. That is to look into the dynamics of terms of trade of agriculture against the manufacturing sector, or service sector in line with the Prebisch-Singer Hypothesis. According to the hypothesis, the price of primary commodities declines relative to the price of manufactured goods over the long term, which causes **Terms of Trade (ToT)** of primary-product-based economies to deteriorate.

ToT is a widely accepted tool to measure the relative strength and movements among the sub-sectors of an economy. It is often used to evaluate the extent and intensity of mobilization of resources including workforce within the sectors of an economy (Vittal, 1988). Intersectoral

movements not only unveils the return of that particular sector, but also discloses the relative strength among subsectors of an economy. Besides, ToT has been a powerful apparatus to assess the relative movement of income and wealth among sectors or various economic categories inside an economy.

ToT can be estimated in various ways with each of them having its strength and weakness. The most popular method of ToT is defined as the ratio of the wholesale price index of agricultural commodities to the wholesale price index of manufactures which is usually calculated as follow (Mitra, 1977; Spatafora & Tytell, 2009).

$$\text{Terms of Trade (ToT)} = \frac{\text{Wholesale Price Index of Agricultural Commodities}}{\text{Wholesale Price of Manufacturing Commodities}}$$

An alternative method of price indices is using agricultural GDP deflator and manufacturing/industrial GDP deflators to estimate ToT. Constructing an index based on GDP deflators that is based on implicit price deflators derived from the value added in agriculture and non-agriculture has been used as an alternative to calculate ToT. The third method uses the value of the commodities traded between agricultural and non-agricultural sectors for intermediate and final consumption. Using the values as weight a composite index of export and import has to be constructed between sectors to determine net barter terms of trade. In the process, marketed-surplus of agriculture on the barter terms of trade is used to calculate income terms of trade (Thamarajakshi, 1969). Third method is often criticized for omitting agricultural purchases that is used for capital formation. This method suffers from imperfection due to non-inclusion of several non-food items, data scarcity and weightage problem.

We planned to estimate the ToT of the agriculture against the manufacturing sector based on the recent price data of DAM. But the lack of available data on price index of agricultural commodities and manufacturing commodities for recent years pushed us for alternative measures. As a result, we take resort to the second method which is using the ratio of GDP deflators as a proxy measure of ToT.

4.2.3 Estimation of ToT by alternative proxy variables (i.e., GDP deflators)

Given the data limitation we have improvised our estimation of TOT as the ratio of Agricultural GDP deflator and Manufacturing/Industrial GDP deflator. It is a broad-based method and is not dependent on a particular type of price like wholesale price. However, it is calculated on the basis of aggregate data while other TOT methods are based on disaggregated data. Previously BBS estimated TOT based on agricultural wholesale price index and manufacturing wholesale price index of selected commodities up to 2006. We did not find their methodology and data source to apply that methodology for later years. So, data deficiency and information gap lead to adopt a new methodology to calculate TOT.

However, ToT is not the entire story to explain the episode of farmers' switching out of agriculture. Sometimes, a persistent increase (decrease) in ToT of agriculture may reflect lower (higher) profit margin for producers if there is a relatively higher increase in cost for agricultural commodities. In that case, we would need to supplement this finding with other complementary data in order to

conclude about the relative unattractiveness of agriculture. In the later case, we can supplement our findings on rural real income decomposition to quantitatively reach a conclusion. It is worth noting that beyond price level, price variation, fluctuation of income resulted from those variation and income stability play crucial role for determining which sectors they continue to operate.

4.3 Results of ToT Estimation

Figure 19 shows the trend of GDP deflators for agriculture and manufacturing where GDP deflator for agriculture is seen to sharply increase till 1979 with some fluctuations across years. Then it is seen to fall in the next couple of years. Thereafter it started rising till 1989 and then it fluctuated and dropped to its lowest in 2006. Since then it started rising again till date. Manufacturing GDP deflator was significantly lower till 1979 then it surpassed agricultural GDP deflator and then it remained close to agricultural GDP deflator till 2011. After that agricultural GDP deflator started rising more than manufacturing one. These trends of both the deflators are reflected in the trend of agricultural ToT against manufacturing sector in figure 20.

Figure 19: Trends of GDP Deflators in Agriculture and Manufacturing Sector

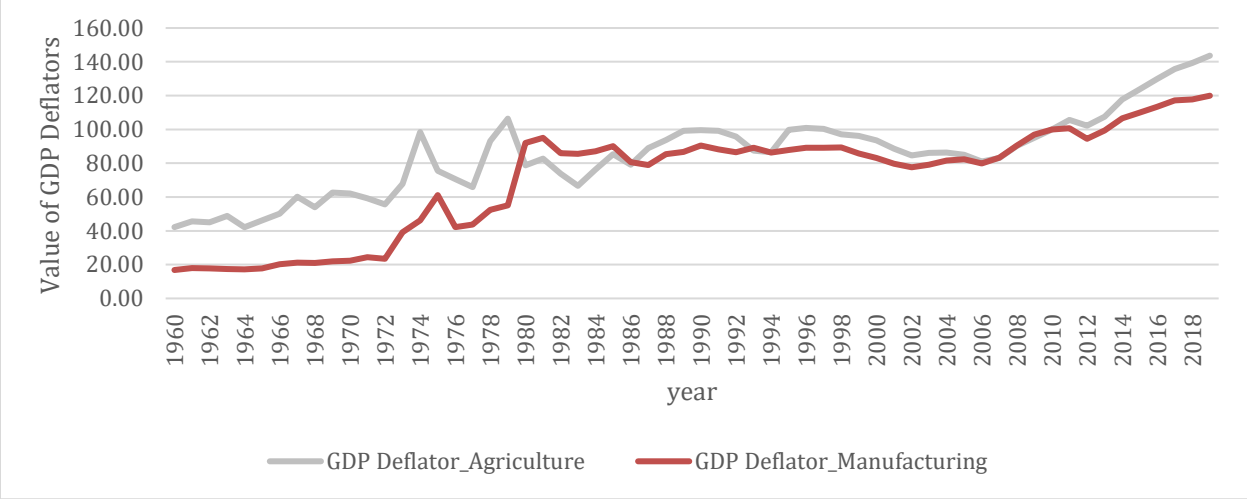
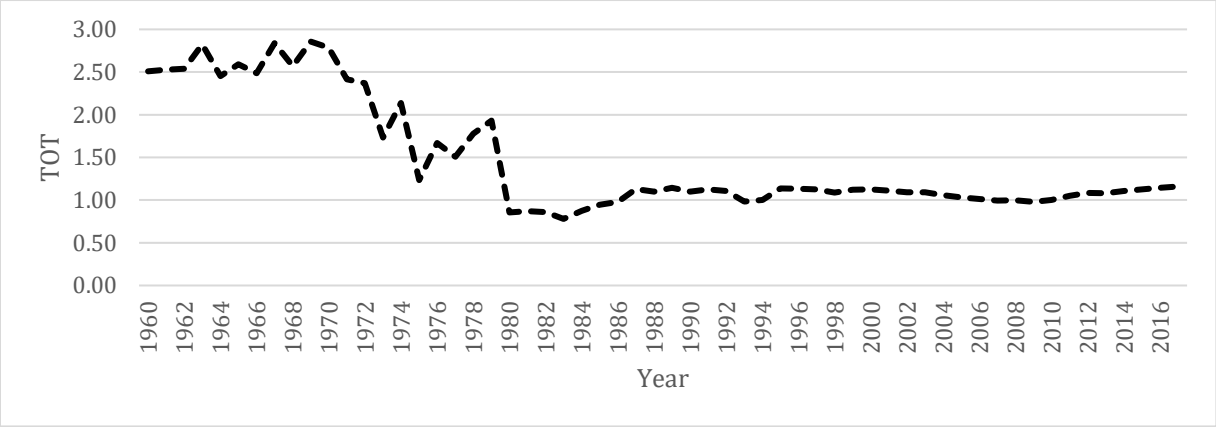


Figure 4.5: Trend of ToT of Agriculture against Manufacturing Sector

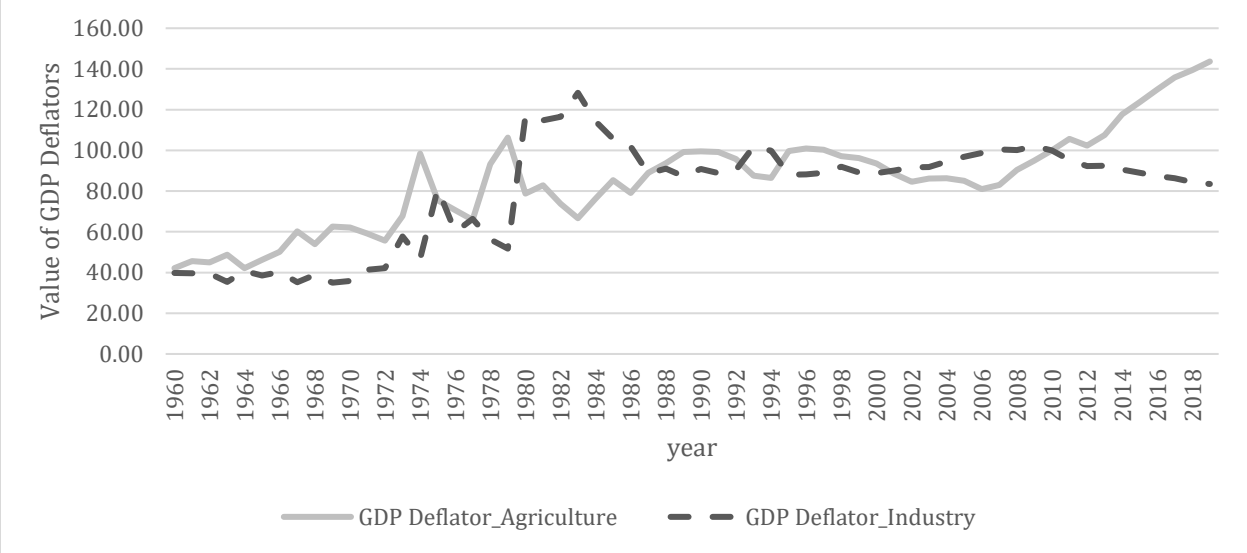


Source: Author's Calculation, WDI

As figure 21 shows, GDP deflators of agriculture was rising initially till 1974, then it spiraled and fall to its local bottom in 1983 along with a sharp rise in industrial GDP deflator in that

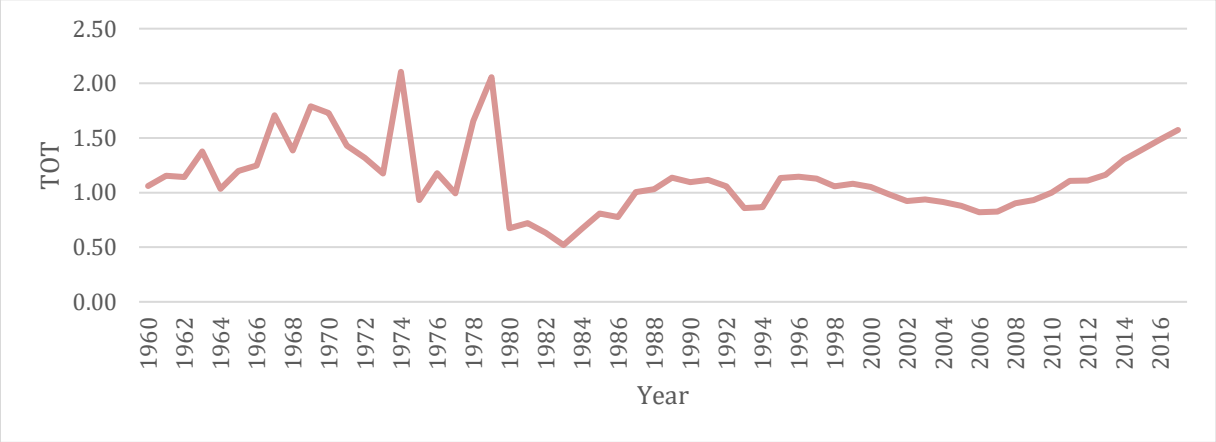
year. Both the GDP deflators move close to each other thereafter. There was a strong increase in agricultural GDP deflator since 2010. This change has been reflected in the improvement of ToT of agricultural sector against industrial sector which is shown in figure 22.

Figure 20: Trends of GDP Deflators in Agriculture and Industrial Sector



As figure 22 shows, for the first half of our reference period, 1995 to 2006, there was a fall in agricultural ToT against industrial sector. But for the last half of our reference period there was a slight improvement in ToT of agriculture against industrial sector. This improvement vanishes while we consider ToT of agriculture against service sector. This might be due to fact that service sector is dominant in Bangladesh and still provides major alternative opportunities for households who leaves from agriculture.

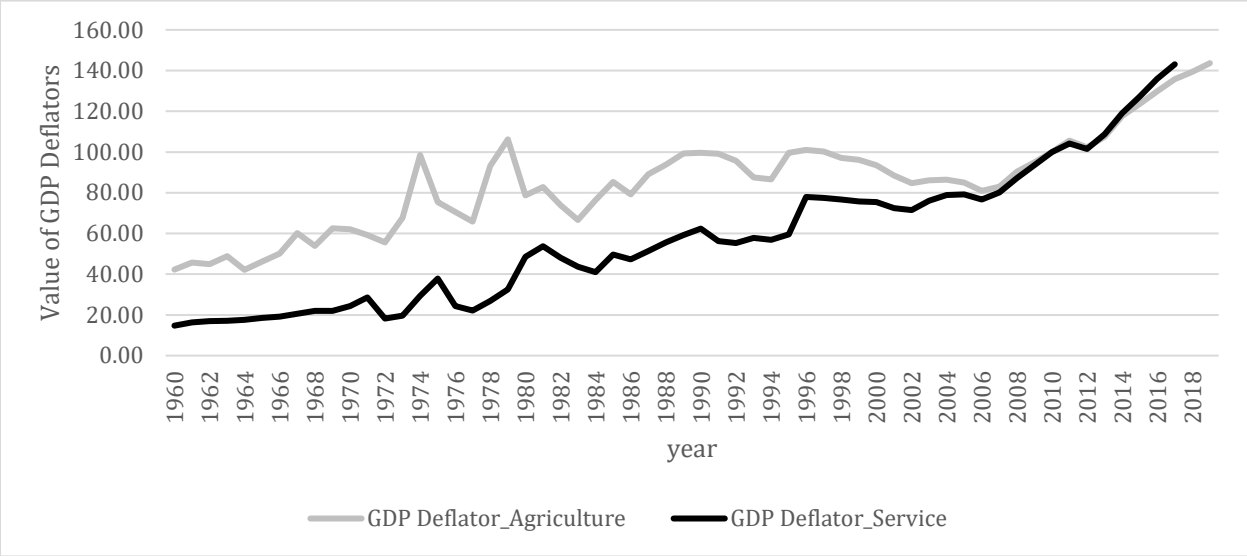
Figure 22: Trend of ToT of Agriculture against Industrial Sector



As figure 23 shows, GDP deflators of agriculture was rising faster than that of service sector till 1979, then it slowed down till 2006 when that of service sector grew faster at that time. Both the GDP deflators move close to each other thereafter even though the later surpassed the former

during the recent time. This change has been reflected in the fall of ToT of agricultural sector against service sector which is shown in figure 24.

Figure 23: Trends of GDP Deflators in Agriculture and Service Sector



As figure 23 shows, for the entire duration of our reference period, 1995 to 2006, there was a fall in agricultural ToT against service sector. This might be due to fact that service sector gained momentum during that period and thus non-agriculture gained expanded fast due to that change.

Figure 24:Trend of ToT of Agriculture against Service Sector

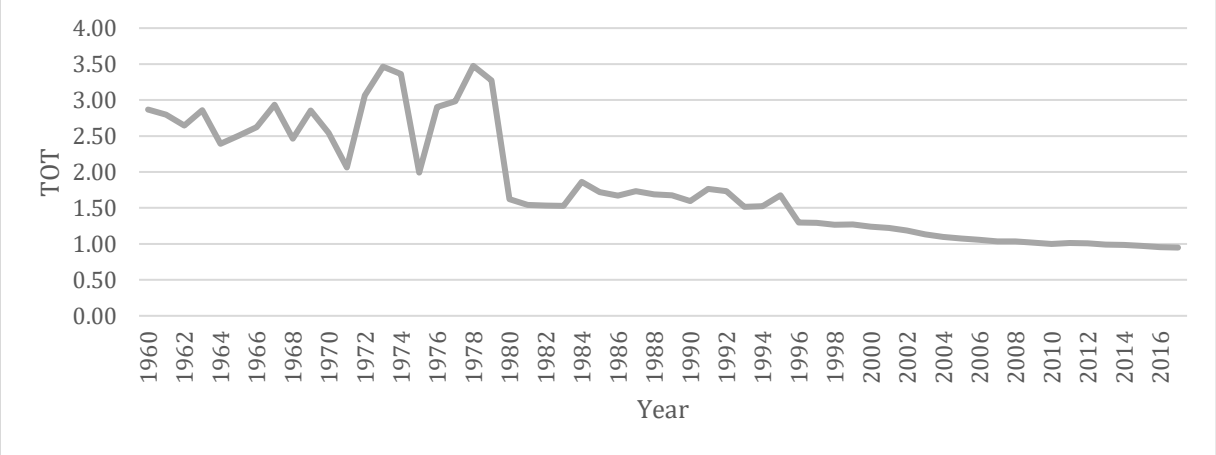
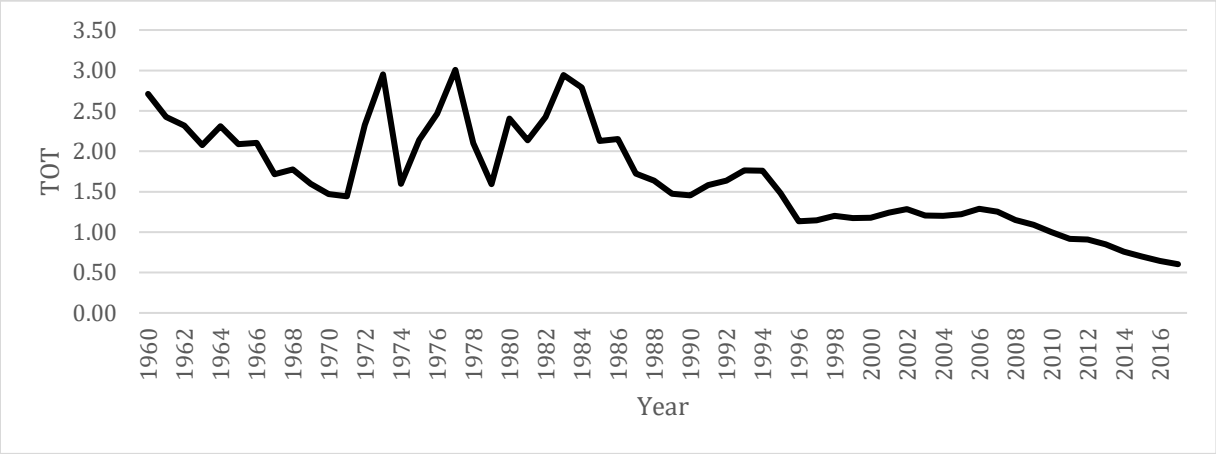


Figure 25 shows that TOT for agricultural sector against industry and service sector combined has declined over the year in Bangladesh. This implies Prebisch-Singer Hypothesis holds for Bangladesh. It is also important to note that switching out of agriculture happens strongly in industrial sector in urban areas especially in Garmentand service sectors in both rural and urban areas. This might be due to the fact that service sector is dominant in Bangladesh and still

provides major alternative opportunities for households who leaves from agriculture. As a result, this ToT seems more relevant for our context.

Figure 25: Trend of ToT of Agriculture against Industry and Service Sector combined



However, it may be the case that though overall agricultural ToT declines in Bangladesh, non-crop ToT improves while crop terms of trade deteriorate in Bangladesh. But we cannot verify it from the aggregate data. We need price and value of crop and non-crop separately in order to calculate this and we leave it for further research. ToT have been found biased against agriculture since independence as outlined in Agricultural Sector Review of Bangladesh, 1989. As Bangladesh opted import substitution industrialization policy in late 70s, the prices of industrial sector were regulated around international price level. So, there was a very low chance for the price level of industrial commodities to deteriorate. This report noted that during some sub-periods TOT for agriculture improved but that improvement was entirely due to growth of non-crop agricultural commodities. So, cereal producers have unilaterally faced depressed ToT compared with non-crop producers. Furthermore, ToT may not expose real incentive received by farmers. Because, industrial price index may include the commodities never consumed by the farmers (e.g., automobile).

The findings of Agricultural sector review (1989) have outlined the existence of policy bias against agricultural as a whole. It also highlights the problem of cereal pricing policy compared with industry and ToT against agriculture may degenerate labor intensive employment opportunities. Therefore, the country may face stress in the avenue of creating more employment for the incoming labor force.

Other notable studies of agricultural ToT regarding Bangladesh are conducted by Rahman (1976), Hossain (1984) and Chowdhury (1992) and Akther Hossain (2008). Bangladesh faced unfavorable ToT since independence due to its heavy reliance on exporting agricultural commodities (Rahman, 1976). It had been identified in 80s that the growth of the price of agricultural commodities would be under pressure in future, therefore deterioration of agricultural ToT would be inevitable

(Hossain, 1984). So, it is well documented that ToT has been bias against agriculture in Bangladesh after economic transformation. It has been reported that ToT is in favor of industrial sector in Bangladesh and this sector has started domination due to higher price faced by that sector (Chowdhury, 1992).

However, it has been by found that TOT has been improving for agriculture in Bangladesh which is an opposite result (Akther Hossain, 2008). by using the BBS data from 1972 to 2006 it has been found that agricultural ToT against industry had been improving for Bangladesh. But those industrial wholesale price index had been constructed based on selected industrial goods.

Our result shows that TOT in Bangladesh is against agriculture means the rise of price of agricultural commodity is lower than the rise of the price of commodities produced in industry and service sector. It has far reaching implictions on the overall shape and size of the sectors in this economy. Therefore, it is almost instantaneous that as long as the cost of switching sectors is minimal, people will switch from a sector with lower reward to another sector where reward is higher. In Bangladesh a vast majority of the farmers holds a tiny piece of land which implies they are marginal farmers in terms of land ownership. So their cost of switching out of agriculture is not huge. Moreover, we see a movement of surplus labours from agriculture to rural non-agriculture as non-agriculture sector has been booming in recent recent years.

4.4 Role of Price Volatility and Production Shocks

It is important to realize that differential changes in price level is captured by the changes in ToT of a sector. But the level of price which determines the mean income of a household is one aspect of economic incentive. The variability of prices or the fluctuations in price level is another important aspect to consider when we discuss the issue of switching economic actors out of a sector. This variability is also important when we analyze crop diversification at the household level. Price level plays a crucial role to create incentive for the people working in any sector. Even the bumper harvest season can add risk to farmers income through reduced price and reduced revenue. As agricultural commodities are price inelastic in nature means when price falls their revenue declines. As a result, without storage infrastructure available in many geographical locations of Bangladesh, the producers of agricultural commodities have very little option except selling at a lower price during the harvest season. So, supply shock has been a serious problem for the primary commodity producers for years. Price fluctuation thus works as disincentive for the growers and this disincentive increase with the level of subsistence. Stable price works as insurance against income fluctuation for the farmers. Marginal farmers with a tiny landholding cannot bear shocks from systematic price depression and sometimes even forced to change occupation.

However, presence of fluctuation is almost universal irrespective of price elasticity of the good. Economic fluctuations and policy response require various safeguards due to differing degrees of price flexibility across sectors. Price volatility is not same in all sectors. For example, industrial

price is more stable compare agricultural price which reflects the volatility in agricultural prices (Han, Jensen and Penson, 1990). As agricultural commodities are inelastic in nature, shock in demand or supply or both play a critical role in price fluctuation of agricultural goods (Cairnes, 1965).

4.4.1 Measurement of Price Variability

Problems in market integration, uncertainty in the price formation process, barriers to participate in market directly and information asymmetry causes spatial and time specific price variations for agricultural commodities in Bangladesh (Mahmud et al., 1994). Year to year price variation is associated with the risk of farm income fluctuation, as a result, many farmers do not choose crop diversification. Besides, this study has also found the non-crop price variation is much higher than crop and it is abnormally high for some non-food grains.

Standard Deviation (SD) of price is a popular method to measures the variability of revenue and income earned by the people involved in any sector. We measure price volatility using standard deviation of price of the selected agricultural commodities. Standard deviation here is defined as square root of the sum of squared deviation of each price from mean price. We have applied following standard formula to calculate standard deviation-

$$\sigma = \sqrt{\frac{\sum(p_i - \overline{p})}{n}}$$

Where, σ measures standard deviation,
p_i=daily price of agricultural commodities
$\bar{p}$=mean of daily prices of agricultural commodities
n =no of observations*[2]

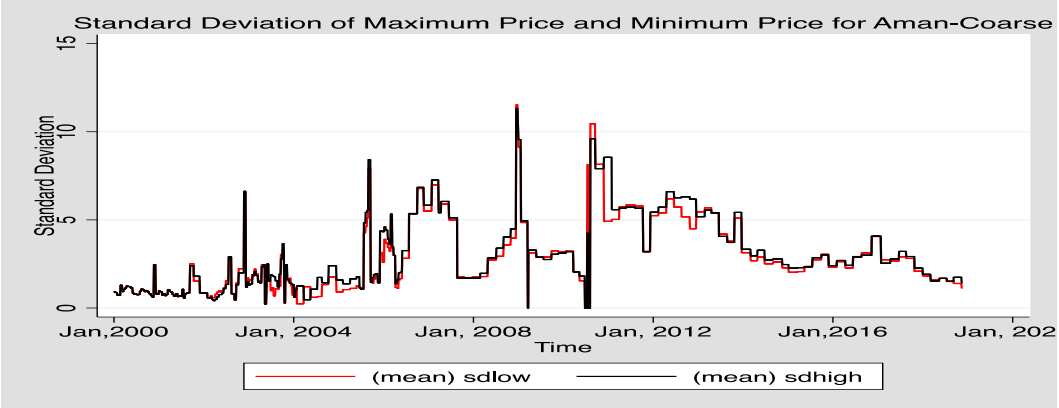
Higher standard deviation suggests higher variability and vice versa. Since it is defined as squared sum it cannot be negative. Using the daily price data from Department of Agricultural Marketing (DAM) of Bangladesh we find price of rice is relatively stable compare to wheat, potato, pulse, maize, tomato and onion. Among rice Aman fine, Aman Coarse and Aman medium have more variability in their prices compare to Aus and Boro. DAM database includes geographical variation of daily prices. DAM data has been collected from 64 district main markets and several selected markets of data city on daily basis.

Following graphs present the standard deviation of maximum and minimum daily price for various categories of rice, wheat, potato, pulse, maize, tomato and onion. In case of crops like wheat, maize, pulse, tomato, potato and onion we find both maximum daily price and minimum daily price have significant variability during a year and over the years. Our findings show that the daily price of Aman has more variability than the daily price of Boro rice. However, the daily price of

[2] In reality, while calculating sample mean we usually use $(n-1)$as degrees of freedom instead of n.

non-cereal exhibits higher variability compare to daily price variability of cereal. Figure 26 shows that the standard deviation of daily prices for Aman coarse was very high during 2005 to 2010. In other years price of Aman coarse remain more or less stable.

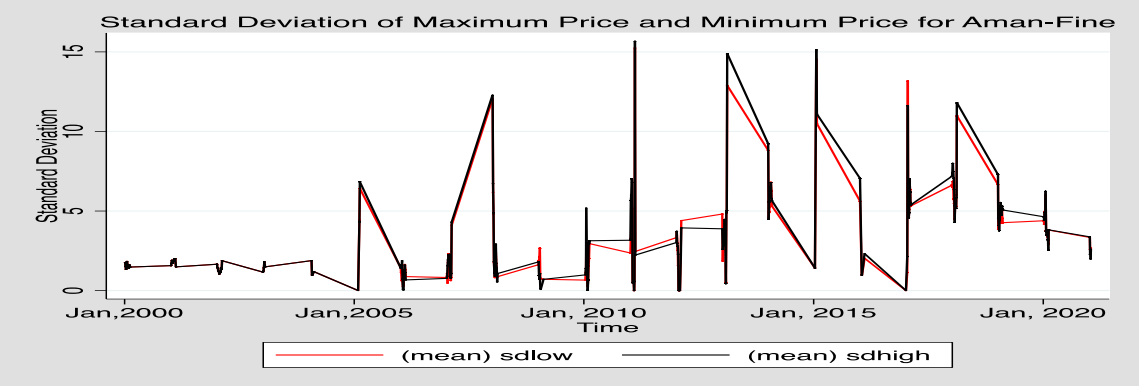
Figure 26: Standard Deviation of the Price of Aman Coarse:



Source: DAM Data, Bangladesh

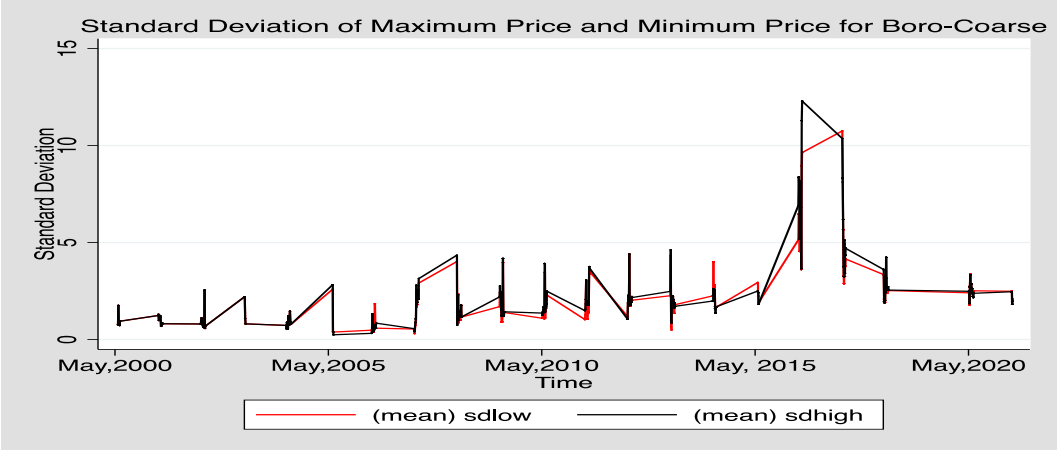
Figure 27 shows the standard deviation of maximum and minimum price of Aman fine fluctuates very often. The daily price variability of Aman fine is much higher than the price variability exists in Boro fine (shown in Graph C1 in Appendix). In general, the daily price variations of all three varieties of Aman (fine, medium and coarse) are much higher compared to similar categories of Boro. Aus is another category of rice but DAM data is infrequent for Aus rice, therefore, we cannot generate comparable graph for Aus.

Figure 27: Standard Deviation of the Price of Aman-Fine



Source: DAM, Bangladesh

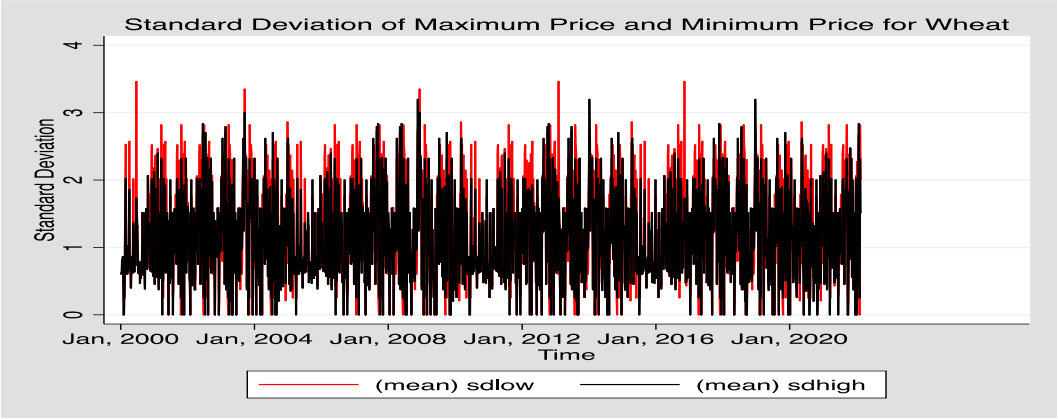
Figure 28: Standard Deviation of the Price of Boro-Coarse:



Source: DAM, Bangladesh

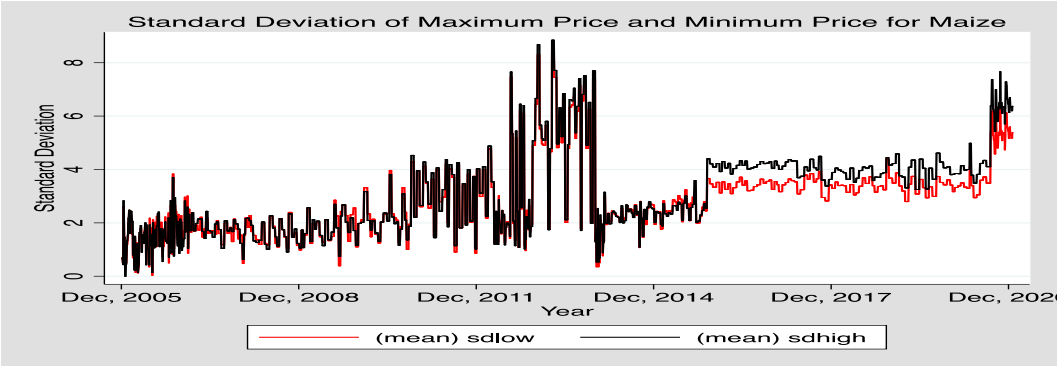
Unlike rice, non-rice crops display much more variability, therefore standard deviation is much higher for these crops. Figure 28 shows that there is significant variability in the standard deviation of the daily price of wheat during any year. However, the pattern of fluctuation is not symmetric each year, means price fluctuates not only in harvesting season but also it fluctuates in other occasions. In case of Maize, it's daily price fluctuation was much higher until 2013. After 2013, it becomes stable in terms of price fluctuation until the very recent year. The price of Maize once again started fluctuate in 2020.

Figure 29: Standard Deviation of the Price of Wheat:



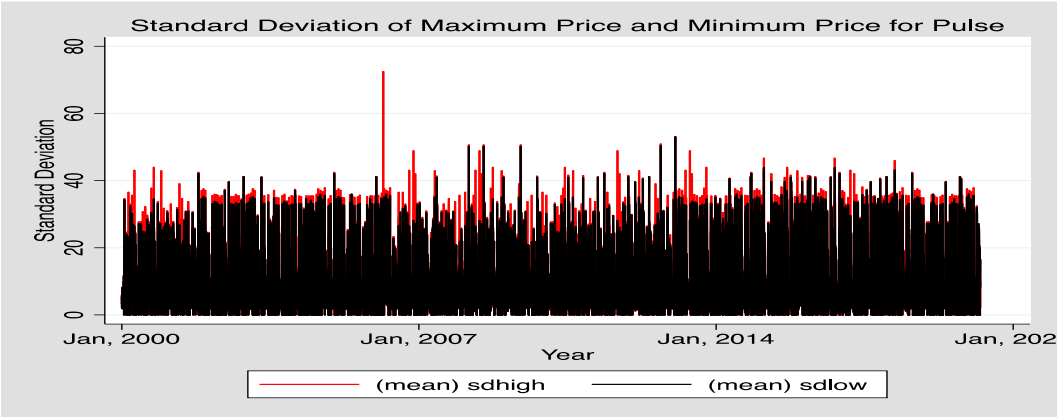
Source: DAM, Bangladesh

Figure 30: Standard Deviation of the Price of Maize



Source: DAM, Bangladesh

Figure 31: Standard Deviation of the Price of Pulse:



Source: DAM, Bangladesh

Figure 31 exhibits the standard deviation of the daily price of pulse and it shows the oscillation in the daily price of pulse. Price fluctuation pattern for pulse is irregular, therefore producers are unable to predict their future income generated from the production of Pulse accurately. Apart from these crops, the daily price of potato, onion and tomato also demonstrate the significant price variation compare to the price variation of cereal what are not shown here.

4.4.2 General Equilibrium Dynamics

As globally terms of trade are going against agricultural commodities, so when local price is determined on the basis of import parity price that also go down along with global trend. So, any policy to support price must serve the interest of both consumers and producers simultaneously. Since reduced price presume to benefit consumers through higher consumer surplus, support on inputs ensures that profit margin of farmers does not shrink. In fact, farmers do not worry about price level rather they worry about margins from agricultural production. Overtime, agricultural price reduced as well as input cost also reduced. But if the rate of the decline in input cost is less than the rate of the decline in output price, that can make agriculture nonattractive to farmers. As a result, farmers profit margin can shrink and thus induce agricultural households to become a non-agricultural entity.

There is a misalignment of economic incentives at the micro/household/farm level which causes the government's call for the changes in farmer's behavior not sensitizing enough to act on them. For similar reasons, the Government's call for a nutrition sensitized value chain might not have been successful. It is micro-level sensitivity towards the macro-level policies that makes the policies successful but is often missing in the Government's initiatives in Bangladesh's agricultural sector. Therefore, the Government policymakers need to set the parameters aligned with the general equilibrium framework for effective outcomes.

For example, falling ToT of agriculture against its competing sectors is reducing per capita income of agricultural household on the one hand. On the other hand, rising prices of the commodities produced in competing sectors are consumed by these households at higher prices. Both are going against them and thus they are indirectly pushed to go out of agriculture.

5. Achieving National Food and Nutrition Security Strategic Goals: Is there Any Strong Role for Rural Non-agriculture?

5.1 Background

Food security was a policy response in many countries including Bangladesh when there exists a nutritional deficiency related to malnutrition due to availability of insufficient food per capita. For a long time, the agri-food policy response to malnutrition was to strengthen the staple food production through price incentives, supplying high-yield varieties, promoting farm technologies, etc., to achieve self-sufficiency in major cereal production and energy availability (Pellegrini 2015). The focus was neither the entire agriculture nor the overall farming in general, not even the entire cereal sector especially. The focus was primarily on a narrow range of cereal crops, especially paddy, wheat, and maize. While this strategy has clearly helped to reduce hunger, it has also contributed to lower levels of agricultural diversity (Khoury et al., 2014).

Understanding the notion that more diversified agricultural and food systems may help to improve dietary quality and nutrition, food policy planning was revisited in many countries including Bangladesh to include agricultural diversity to achieve household consumption diversity. But empirical evidence found on the effects of crop and non-crop diversification strategies on dietary improvement in farm households is not robust (Webb and Kennedy 2014). Rather the policy lessons learned from various studies is that crop diversification has a double role: it has a non-negligible impact on households' diets and, other things being equal, it increases agricultural revenues (Pellegrini and Tasciotti 2014). Theil and Finke (1983) show that dietary diversity increases with per capita income irrespective of whether it is from agricultural or non-agricultural activities. As income rises, expenditure on food may increase because more food items are purchased or more expensive food is purchased or a combination of both. Therefore, incremental earnings and a reduction in income variability from agricultural and non-agricultural diversification may have the potential to secure access to sufficient food and thus improve household food security. However, the other dimension of food security i.e., food utilization – a cause of nutritional outcome remains to be a problem to integrate.

The regression results from many studies show a positive correlation between the number of crops cultivated, household income from crops and indicators of dietary diversity (**Pellegrini and Tasciotti 2014**). It is, however, interesting to see whether a non-agriculture income structure has any strong role on food consumption diversity. Moreover, whether non-agriculture has been given due importance in the food and nutrition polices of Bangladesh.

5.2 Policy Objectives in Agriculture, Food and Nutrition Security

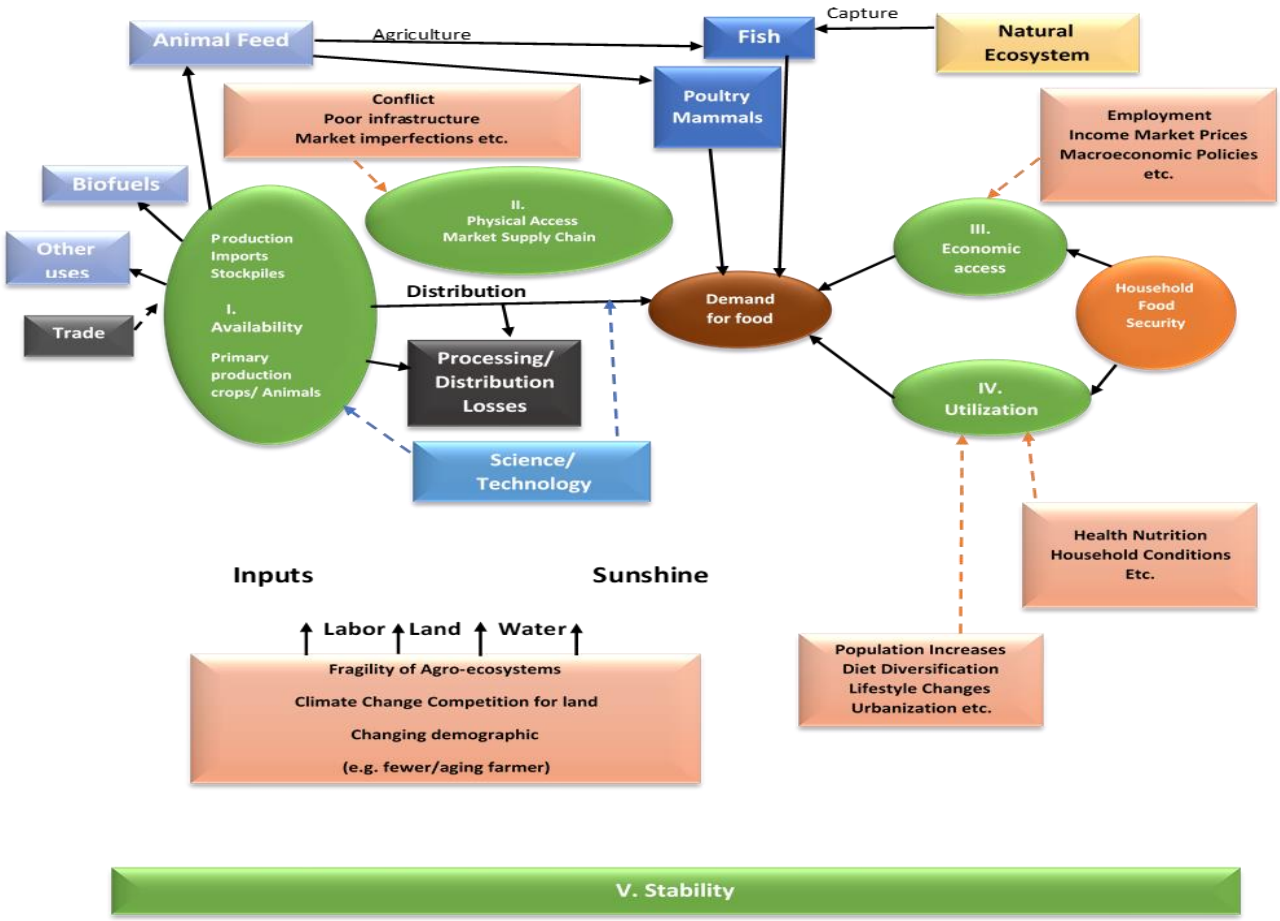
The Government of Bangladesh (GoB) adopted in 2007 a long-term development strategy (**Vision 2021**), which aims at transforming Bangladesh into a middle-income country by 2021. The implementation of Vision 2021 is being achieved through the **National Perspective Plan (2010-2021)**. In both documents, the *GoB has prioritized the attainment of self-sufficiency in food grain production and the achievement of nutritional requirement by 2021*. Vision 2021 is being implemented through medium term plans of 5 years. The **Sixth Five-Year Plan (6FYP 2011-2015)** aimed *at raising agricultural productivity, fostering diversification and boosting rural infrastructure* (**PCB 2013**) has been superseded by the **Seventh Five Year Plan (7FYP 2016-20)**, which has been approved by the end of 2015 and *focuses on developing the crop sub-sector to raise rural income and generate employment opportunities for poor rural people* (**FAOLEX. 2015**). The development vision for agriculture under the **7FYP 2016-20** aims at ensuring food and nutritional security, sustainable intensification and diversification of climate resilient agricultural production with increased commercialization and livelihood improvement through technological innovations and use, and linking farming community with markets, both national and international. Beside the 7FYP, the key guiding document for the development of the agriculture sector is the **National Agriculture Policy (NAP 2013)**, which aims to improve food and nutrition security for all and the quality of life for rural people through increased productivity and agricultural diversification. The **National Food Policy (NFP 2006)** mainly targeting women and children, aims to enhance purchasing power to increase access to food and to ensure adequate nutrition for all.

The Government adopted a **Plan of Action (NFP-PoA, 2008-2015)** which provides a programmatic guidance for the implementation of the NFP; identifies 26 strategic areas of interventions and more than 300 action agenda; identifies responsible actors (government and non-government) and suggests a set of priority targets and indicators for monitoring progress. Subsequently, the GoB adopted the **Country Investment Plan for Agriculture, Food Security and Nutrition (CIP1, 2011-2015)**, which plans and identifies 12 invest programmes to ensure implementation of the NFP PoA; mobilizes additional funds, monitors, evaluates investments in agriculture, food security and nutrition. The **CIP2 2016-2020** follows the **CIP1 2011-20151** whose development was prompted in response to a need to efficiently mobilize resources in the aftermath of the 2008 food price crisis. The overarching goal of the **CIP2 2016-2020** is *to achieve improved food security and nutrition for all at all times by making food systems nutrition-sensitive and sustainable*. Its strategic objective is to ensure availability, affordability and nutritional quality of foods, and that all people have access to a variety of safe and nutritious foods, and to the knowledge they need to make healthy diet choices.

5.3 Identifying Policy Gaps in CIP2

It would be helpful to invoke a standard food security model to assess if there is any gap in case of implementing NFP objectives in Bangladesh. Presented below is a flow chart of the food security model (Figure 32). It is borrowed from the APEC Policy Report, September 2012 who adapted it from Teng and Escaler, 2010b.

Figure 32: Circular flow of food security model



Source: APEC Policy Report, September 2012, (modified from Teng and Escaler, 2010b)

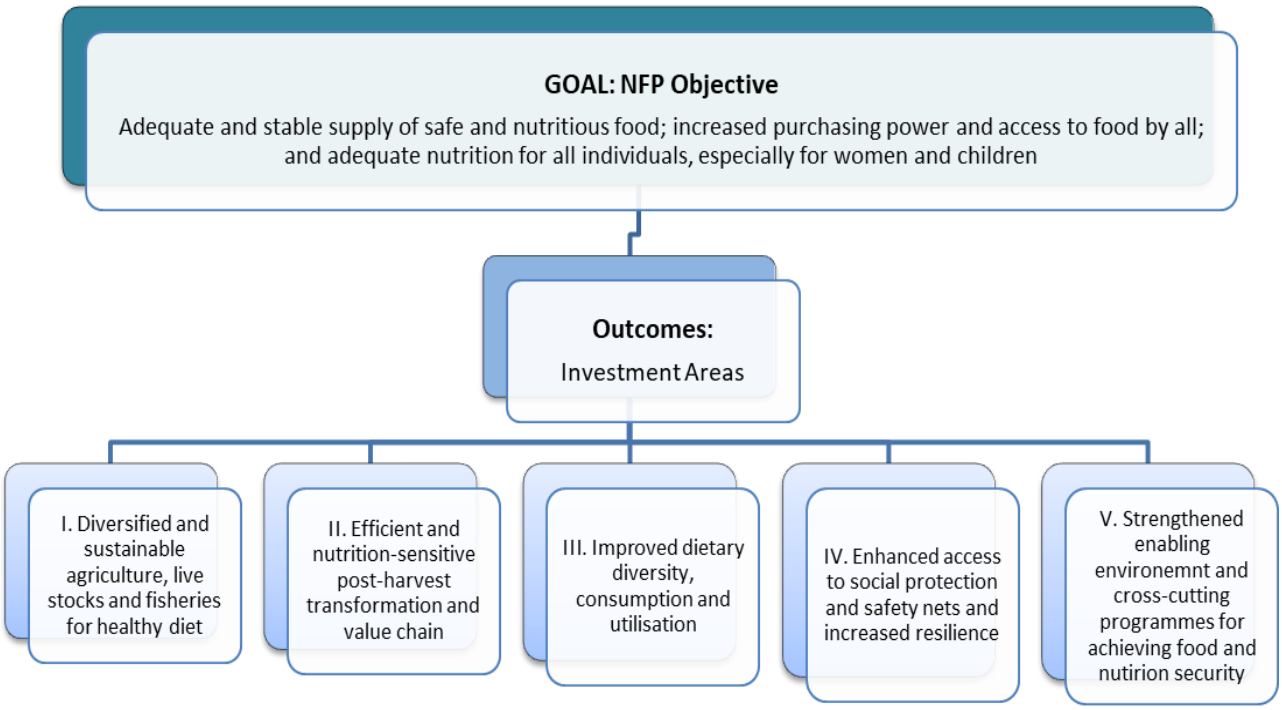
This conceptual model of food security explains the key elements to achieve food security in households - i. Availability, ii. Physical Access, iii. Economic Access, iv. Utilization. Additionally, a fifth element- stability- is also referred in the model to ensure 'stability' of the four primary elements of the food security model over time.

'Availability' of food addresses the 'supply side' of food security and is determined by the level of food production, stock levels, net trade, etc. The second dimension is 'Physical access' to food which is defined by the physical reach of adequate amount of food by the poor and vulnerable households. The third dimension 'Economic access' to food which is affordability for smallholders allowing them to generate more income and create more employment. Economic accessibility is the purchasing power of consumers or affordability which deals with the changes of incomes and food prices. The fourth dimension 'Utilization' means the ability to fully utilize the food that the household has purchased. All of these elements are interrelated, and are reflected on the NFP objectives.

The CIP2 framework for 2016-2020 states the goal of the NFP objectives. It is broken into three parts:

- adequate and stable supply of safe and nutritious food
- increased purchasing power and access to food by all
- adequate nutrition for all individuals, especially for women and children.

Figure 33: CIP2 Results framework



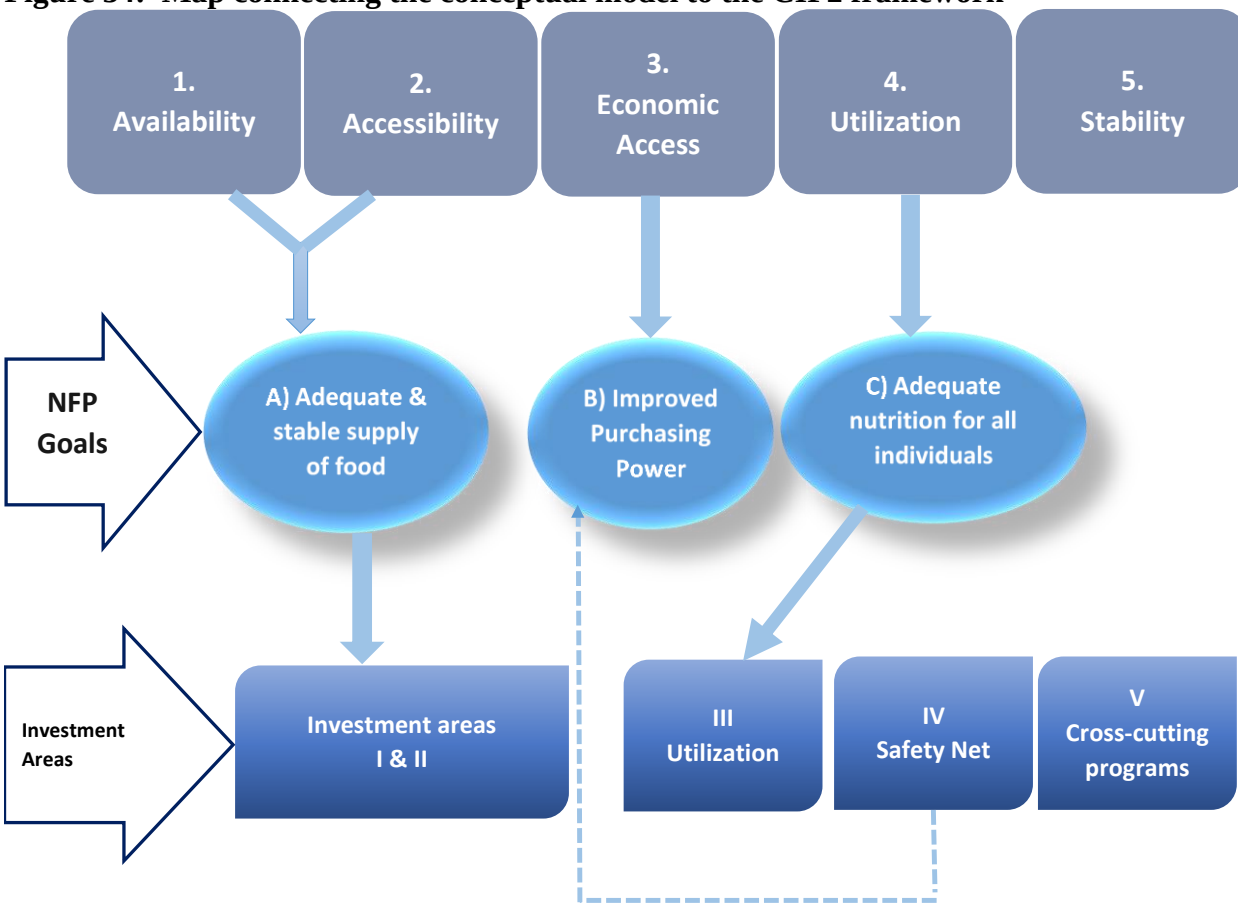
Source: FPMU, Ministry of food

The first NFS objective which is- ensuring adequate and stable food supply, deals with the supply side of the economy and is a blend of investment areas (I) & (II) (Figure 33). The second

objective focuses on increased purchasing power for all household dealings with the affordability. The third objective is about ensuring adequate nutrition and food utilization.

If we draw a map to depict how the conceptual model of food security is reflected on the CIP2 framework, we see that the issue of accessibility and availability are well addressed in the CIP2 investment areas with discussion and investment programs on utilization and stability. But none of the five investment areas in the CIP2 framework discusses the affordability issue directly and adequately from the income side (except the investment area on "social protection and safety net programs for targeted groups" that is for targeted groups).

Figure 34: Map connecting the conceptual model to the CIP2 framework



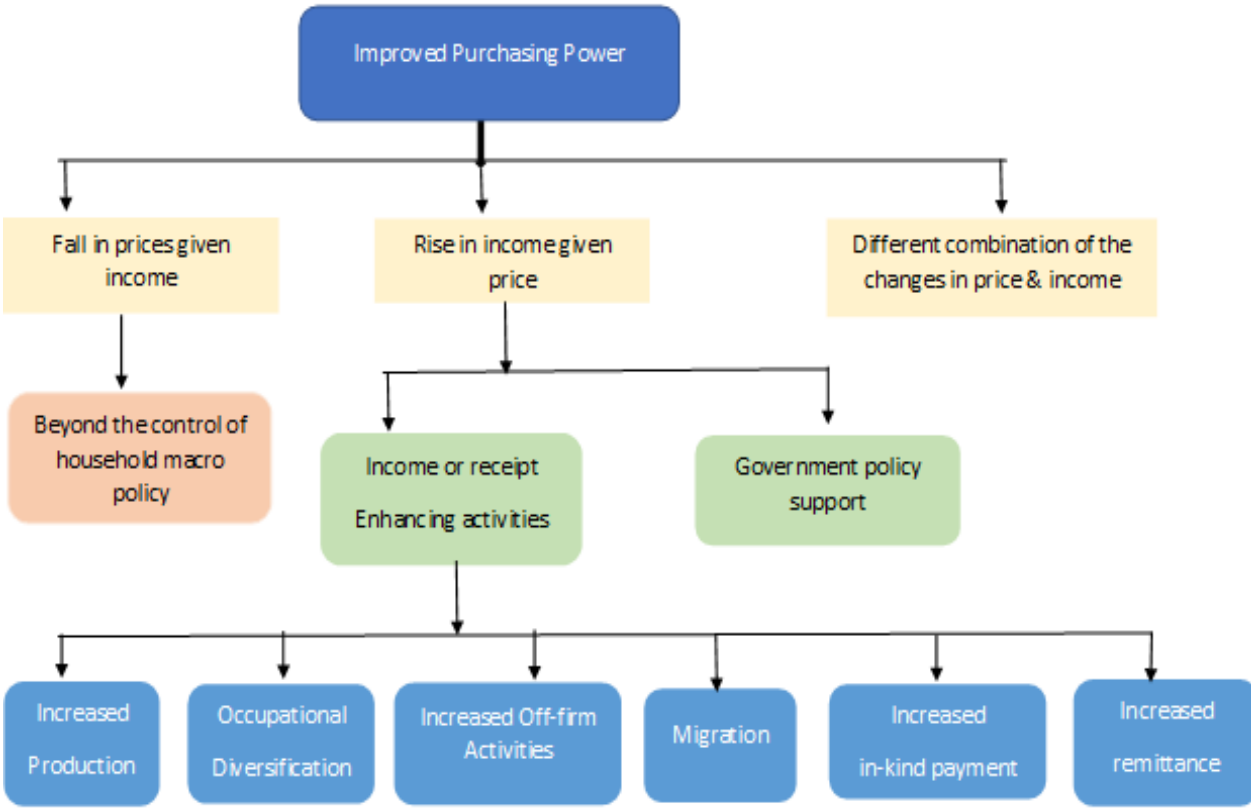
Source: Author's mapping of the Conceptual food security model & the CIP2 framework

We can see from the mapping that the issue of economic access is not adequately reflected in the investment plans (Figure 34). Here, the first two outcomes i. Diversified and sustainable agriculture, live stocks and fisheries for healthy diet, ii. Efficient and nutrition-sensitive post-harvest transformation and value chain goes in line with of the first goal of NFP. It might be inferred that agricultural production which will make food available will also provide agricultural households with adequate income in return to their factors such as land, labor, capital, and entrepreneurship, but the issue of 'economic access' is not exclusively dealt within in the 13 investment programs of the framework.

Besides, from our analysis of rural income decomposition in Section 2, we obtain that there is a significant drop in agriculture real income over time for the poor households at the bottom two income quintiles. It has been found that the increase in overall per capita real income of rural households grew very slowly compared with the national per capita real income of Bangladesh. The purchasing power of poor agriculture households have dropped significantly from the data analyzed over the period of 1991 to 2016 while non-agricultur households have seen an increase in both per capita real income and increase in the contribution of non-agriculture sector in the income growth. Therefore, it is pertinent that we revisit our investment section of the NFP objective which heavily relies on agriculture, and focuses on investment programs blending both agriculture and non-agriculture sectors.

The flow chart from Helal et al., 2009, below also emphasizes this issue (Figure 35). It depicts different set of activities through which purchasing power of the households can be enhanced. As depicted in the flow chart, fall in price can improve on purchasing power given a nominal income. But the price movement is a macro issue and it is beyond the control of an individual household. A household can raise its nominal income through enhancing economic activities and receiving money from different sources. One of the ways is increased production, but there has to be adequate economic incentives for an individual household to engage in such increased agricultural production. Decomposed real income in Section 2 shows lower economic incentive for agricultural production.

Figure 35: Income flow chart



Source: Uddin, Mohammed & Emran, Sheikh. (2019)

Another important fact is that we have estimated agricultural terms of trade against it competing sectors such as manufacturing, industry and service sector. We find a decreasing trend of agricultural terms of trade implying further depressed performance for agriculture in terms of providing improved purchasing power to the rural poor and low-income people. It is a global trend against agriculture and Bangladesh is no exception to that. In this case, farmers will not gain much from their production related activities due to suppressed prices of their produces, but they have to buy a sub set of their consumption basket manufactured outside agriculture at higher prices which will curb their real income further.

In this situation, still emphasizing agriculture's role in improving nutrition outcomes for the rural households is not well justified. There must other reasons to emphasize sustainable agriculture but not for this policy target on food and nutrition security. We do not have to withdraw any resource from the targeted investment programmes, but we need to place a renewed focus on non-agriculture as livelihood activities for the marginalized people. There are many options to focus on as shown in the income flow chart harness real income of the rural poor.

Last but not least, we need to reconsider the emphasis on the agricultural diversity at the household level. The presumed link between agricultural diversity and nutrition are yet to established. In fact, our estimated model of this link nullifies the positive impact of agricultural diversification on dietary diversity. We test if, and to what extent, diversity in food production affects dietary diversity, and whether controlling for covariates, especially income, sustains the results. A simple OLS fixed effects model indicates that diversity in food production does not necessarily affect household diversity in food consumption when household income and other variables are controlled for. The positive effects of agricultural diversity in food crops on the food diversity of households have originated from the simultaneity or omitted variables biases. The apparent positive association becomes negative once we control for the household's level of productivity with control function. After controlling all the confounding factors we find no significant impact agricultural diversity on dietary scores.

Then again, the question is why should we overemphasize agriculture in case of achieving better nutrition outcomes when there is no conclusive relation between two. Even if we find any positive correlation between them, we should not rely on agricultural diversity because rural households are not showing their preferences toward agricultural diversity. Rather they are keen to specialize and commercialize and that is how they can enhance their real income and reach a better nutrition outcome.

6. Conclusion

Undernutrition is still a problem for Bangladesh. Hence, the question of how rural households can be made more nutrition-sensitive is still has a relevance for the policy planners. Increasing farm production diversity may not help much to improve nutrition outcomes. Most existing studies, on average, found a positive but small effect of crop diversity on dietary diversity though many of them did not evaluated the underlying mechanisms in depth. Once total household income is controlled for the positive link goes away. This study finds a strong role of income in case of realizing better nutrition outcomes. Hence, strengthening income from non-agriculture should be a key strategy for rural farm and non-farm households to be more nutrition-sensitive. Since agriculture is not providing enough incentives to farmers, policies toward agriculture may force the rural poor to remain poor there, but with no significant improvement on nutrition outcomes.

We need to focus on livelihood activities that energize the real income of rural household which is off-farm activities in rural areas and other opportunities outside rural areas. We can focus on occupational diversification, minimum support price of agricultural produces, stabilization of agricultural prices. These factors combined can improve on nutrition outcome of the rural poor faster.

REFERENCE:

Adjimoti, G. O., & Kwadzo, G. T. M. (2018). Crop diversification and household food security status: evidence from rural Benin. Agriculture & Food Security, 7(1), 1-12.

AKHTAR HOSSAIN, A. K. H. A. N. D. (2008). The Agricultural Terms of Trade in Bangladesh: An Econometric Analysis of Trends and Movements, 1952–2006. Australian Economic Papers, 47(1), 38-52.

Akhter, M. 2009. An economic analysis of pond fish culture in some selected areas of Mymensingh district. MS Thesis submitted to the Dept. of Agril. Econ. BAU, Mymensingh.

Alam, J.; Yasmin, F.; Sayeed, M. A. and Rahman, S.M.A. 1995. Economics of mini dairy farms in selected areas of Bangladesh. Asia-Australian Journal of Animal Sciences, 8(1): 17-22.

Anderson, K. (1987). On why agriculture declines with economic growth. Agricultural economics, 1(3), 195-207.

Arezki, R., Hadri, K., Loungani, P., & Rao, Y. (2014). Testing the Prebisch–Singer hypothesis since 1650: Evidence from panel techniques that allow for multiple breaks. Journal of International Money and Finance, 42, 208-223.

Armar-Klemesu, M. (2000). Urban agriculture and food security, nutrition and health. Growing cities, growing food. Urban agriculture on the policy agenda, 99-118.

Bangladesh Second Country Investment Plan - Nutrition Sensitive Food Systems 2018.

Baree, M. A.; Rashid, M. H. A. and Qais, S. 2006. Profitability analysis of garlic production in Bangladesh. Progress. Agric. 17(1): 361-368.

BARI, 2004-2009. Annual Reports, Agricultural Economics Division, Bangladesh Agricultural Research Institute, Gazipur.

BBS HIES final reports 2010 (page 28) and 2016 (page 30)

Bhagowalia, P., Kadiyala, S., & Headey, D. (2012). Agriculture, income and nutrition linkages in India: Insights from a nationally representative survey.

BJRI, 2008. Annual research reports, Agricultural Economics Division, Bangladesh Jute Research Institute, Dhaka

Bloch, H., & Sapsford, D. (2000). Whither the terms of trade? An elaboration of the Prebisch-Singer hypothesis. Cambridge Journal of Economics, 24(4), 461-481.

Bokhtiar, M., Delowar, M., & Wahid, A. N. (2018). Application of Forward Contract and Crop Insurance as Risk Management Tools of Agriculture: A Case Study in Bangladesh. Asian Economic and Financial Review, 8(12), 1394-1405.

Bollerslev, T. 1986 Generalized autoregressive conditional heteroskediasticity. J. Econom. 31, 307 – 327. (DOI: 10. 1016/0304-4076(86)90063-1)

BRRI, 2004-2010. Annual research reports, Agricultural Economics Division, Bangladesh Rice Research Institute, Gazipur.

Cairnes, J. E. (1965). Essays on Political Economy: Theoretical and Applied. 1873. Reprint. New York: Kelley.

Cairnes, J. E. (1965). Essays on Political Economy: Theoretical and Applied. 1873. Reprint. New York: Kelley.

Carletto, G., Ruel, M., Winters, P., & Zezza, A. (2015). Farm-level pathways to improved nutritional status: introduction to the special issue. The Journal of Development Studies, 51(8), 945-957.

Chambers, R. G. (1992). On the design of agricultural policy mechanisms. American Journal of Agricultural Economics, 74(3), 646-654.

Chinnadurai, M., Karunakaran, K. R., Chandrasekaran, M., Balasubramanian, R., & Umanath, M. (2016). Examining linkage between dietary pattern and crop diversification: an evidence from Tamil Nadu. Agricultural Economics Research Review, 29(347-2016-17232), 149-160.

Chowdhury, K. 1992, 'Sectoral Lead and Economic Growth in Bangladesh: Evidence from Granger-Causality Test,' Bangladesh Development Studies, vol. 20, no. 1, pp. 109–116.

Crop Diversification Program (CDP) from 1987 to 2004 (Ministry of Agriculture)

Dawe, David 2015. Agricultural transformation of middle-income Asian economies: Diversification, farm size and mechanization. ESA Working Paper No. 15-04. Rome, FAO

De Pinto, A., Seymour, G., Bryan, E., & Bhandari, P. (2020). Women's empowerment and farmland allocations in Bangladesh: evidence of a possible pathway to crop diversification. Climatic Change, 163(2), 1025-1043.

Dizon, F., Wang, Z., & Mulmi, P. (2021). The Cost of a Nutritious Diet in Bangladesh, Bhutan, India, and Nepal.

Engle, R. F. 1982 Autoregressive conditional heteroscedasticity with estimates of variance of United Kingdom inflation. Econometrica 50, 987 – 1008. (DOI: 10.2307/ 1912773)

EPC, 1997. FAO, Horticulture baseline production and marketing survey, Vol. III. Annexure (part 1), Engineering and Planning Consultants Ltd., 43 Dilkusha C/A, Dhaka-1000.

Fanzo, J., Hunter, D., Borelli, T., & Mattei, F. (Eds.). (2013). Diversifying food and diets: using agricultural biodiversity to improve nutrition and health. Routledge.

FAOLEX database. FAO, 2015.

Feroz, A. N. M. W. 2009. An economic study on shrimp farming and its environmental effects in selected areas of Satkhira district. MS thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh.

Fleuret, P., & Fleuret, A. (1980). Nutrition, consumption, and agricultural change. Human organization, 250-260.

Fraval, S., Hammond, J., Bogard, J. R., Ng'endo, M., van Etten, J., Herrero, M., ... & van Wijk, M. T. (2019). Food access deficiencies in sub-Saharan Africa: prevalence and implications for agricultural interventions. Frontiers in Sustainable Food Systems, 3, 104.

Gilbert, C. L. & Morgan, C. W. 2010.Has food price volatility risen? Discussion Paper 2/2010. Trento, Italy: Dipartimento di Economia, Universita` degli Studi di Trento.

Gisser, M. (1993). Price support, acreage controls, and efficient redistribution. Journal of Political Economy, 101(4), 584-611.

Haggblade, S., Hazell, P., & Reardon, T. (2010). The rural non-farm economy: Prospects for growth and poverty reduction. World development, 38(10), 1429-1441.

Han, D. B., Penson, J. B., & Jansen Jr, D. W. (1990). Variance of agricultural prices, industrial prices, and money. American Journal of Agricultural Economics, 72(4), 1066-1073.

Han, D. B., Penson, J. B., & Jansen Jr, D. W. (1990). Variance of agricultural prices, industrial prices, and money. American Journal of Agricultural Economics, 72(4), 1066-1073.

Hardaker, J. B. (Ed.). (2004). Coping with risk in agriculture. Cabi.

Harvey, C. A., Rakotobe, Z. L., Rao, N. S., Dave, R., Razafimahatratra, H., Rabarijohn, R. H., ... & MacKinnon, J. L. (2014). Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. Philosophical Transactions of the Royal Society B: Biological Sciences, 369(1639), 20130089.

Harvey, C. A., Rakotobe, Z. L., Rao, N. S., Dave, R., Razafimahatratra, H., Rabarijohn, R. H., ... & MacKinnon, J. L. (2014). Extreme vulnerability of smallholder farmers to agricultural risks and

climate change in Madagascar. Philosophical Transactions of the Royal Society B: Biological Sciences, 369(1639), 20130089.

Helal, Uddin and Nurul Islam 2019. Decomposing Rural Income into Sectors to Identify Their Likely Contributions to Rural Poverty Reduction in Bangladesh. Asia-Pacific Journal of Rural Development, 29(2), 224-246.

Helal, Uddin and Nurul Islam 2015. Decomposition of Rural Poverty Reduction in Bangladesh: The Recent Trend - funded by USAID, 2016

Helal, Uddin, Deen Islam and S. Badruddoza. 2009. Impact of Price Hike on Poor Household and Children Wellbeing (Save the Children, UK- funded

Holden, S., & Shiferaw, B. (2004). Land degradation, drought and food security in a less-favoured area in the Ethiopian highlands: a bio-economic model with market imperfections. Agricultural Economics, 30(1), 31-49.

Hossain, M. 1984, 'Agricultural Development in Bangladesh: A Historical Perspective', Bangladesh Development Studies, vol. 12, December, pp. 31–57.

Hossain, M. A. Hasan, M. K. and Nahar, Q. 2008. Assessment of technical efficiency of potato producers in some selected areas of Bangladesh. J. Agric. Rural Dev 6(1&2): 113-118, June 2008.

Huq, S., Reid, H., Konate, M., Rahman, A., Sokona, Y., & Crick, F. (2004). Mainstreaming adaptation to climate change in least developed countries (LDCs). Climate Policy, 4(1), 25-43

IFPRI- International Food Policy Research Institute. 2020. Bangladesh Integrated Household Survey (BIHS). DOI: httpes://doi.org/10.7910/DVN/NXKLZJ Available https://www.ifpri.org/publication/bangladesh-integrated-household-survey-bihs-2018-2019, Accessed May 20.

Immink, M. D., & Alarcon, J. A. (1991). Household food security, nutrition and crop diversification among smallholder farmers in the highlands of Guatemala. Ecology of food and nutrition, 25(4), 287-305.

Islam MM, Hossein E (2015) Crop diversification in Bangladesh: constraints and potentials. Bangladesh economic association conference paper. Available at: https://bea-bd.org/site/images/pdf/057.pdf. Accessed: December 12, 2019

Islam, A.H.M.S., von Braun, J., Thorne-Lyman, A.L. and Ahmed, A.U., 2018. Farm diversification and food and nutrition security in Bangladesh: empirical evidence from nationally representative household panel data. Food security, 10(3), pp.701-720.

Islam, M. S. and Rahman K. M. M. 2011. Impact of spices research and extension in Bangladesh. Research report-2011, Krishi Gobasona Foundation (KGF), BARC, Farmgate, Dhaka.

Islam, M. T., Omori, K., & Yoshizuka, T. (2005). Rural Development Policy and Administrative Patterns in Bangladesh: A Critical Review. 島根大学生物資源科学部研究報告, 10, 19-26.

Islam, Q.M.S. 2008. Adoption of BARI chickpea and the profitability of chickpea cultivation in some selected areas of Bangladesh. Economic Affairs, 53 (Qr-1): 7-14, March 2008.

Islam, Q.M.S.; Karim, M.R.; Hossain, M.S. and Haque, A.K.M. 2000. Economics of chickpea cultivation in high barind tract of Bangladesh. Bangladesh J. Agril. Res. 25(2): 293-298.

Islam, Q.M.S; Kundu, T.K; Hossain, M.S. and Karim, M.R. 2000. Assessment of improved technology for lentil production in Bangladesh. Economic Affairs, 45(2): 95-104.

Islam, R.; Islam, M.N. and Alam, Q.M. 2006. Economic performance and efficiency of BARI maize sheller in two districts of Bangladesh. Annual Research Report, Agricultural Economics Division, BARI, Gazipur.

John Baffes, B., & Etienne, X. L. (2016). Analysing food price trends in the context of Engel's Law and the Prebisch-Singer hypothesis. Oxford Economic Papers, 68(3), 688-713.

Jones, A. D. (2017). Critical review of the emerging research evidence on agricultural biodiversity, diet diversity, and nutritional status in low-and middle-income countries. Nutrition reviews, 75(10), 769-782.

Jones, A. D., Shrinivas, A., & Bezner-Kerr, R. (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. Food Policy, 46, 1-12.

Karim, M.R.; Moniruzzaman and Alam, Q.M. 2010. Economics of hybrid maize production in some selected areas of Bangladesh.

Kazal, M.M.H., S. Rahman, Md. Jahangir Alam and S. Tanveer Hossain (2013) Financial and Economic Profitability of Selected Agricultural Crops in Bangladesh, FAO NFPCSP Report

Keding, G. B., Msuya, J. M., Maass, B. L., & Krawinkel, M. B. (2012). Relating dietary diversity and food variety scores to vegetable production and socio-economic status of women in rural Tanzania. Food Security, 4(1), 129-140.

Keleman, A., Hellin, J., & Flores, D. (2013). Diverse varieties and diverse markets: scale-related maize "profitability crossover" in the central mexican highlands. Human Ecology, 41(5), 683-705.

Kennedy, G., Ballard, T., & Dop, M. (2013). FAO guidelines for measuring household and individual dietary diversity. Rome, Italy: Food and Agriculture Organization of the United Nations.

Khoury CK, Bjorkman AD, Dempewolf H et al. (2014) Increasing homogeneity in global food supplies and the implications for food security. Proc Natl Acad Sci USA 111, 4001–4006.

Komarek, A. M., De Pinto, A., & Smith, V. H. (2020). A review of types of risks in agriculture: What we know and what we need to know. Agricultural Systems, 178, 102738.

Kumar, M. A. N. O. J., Kumar, R. A. K. E. S. H., Rangnamei, K. L., Das, A., Meena, K. L., & Rajkhowa, D. J. (2019). Crop diversification for enhancing the productivity for food and nutritional security under the Eastern Himalayas. Indian Journal of Agricultural Sciences, 89(7), 1157-61.

Lanjouw, J. O., & Lanjouw, P. (2001). The rural non-farm sector: issues and evidence from developing countries. Agricultural economics, 26(1), 1-23.

Lunven, P. (1982). The nutritional consequences of agricultural and rural development projects. Food and Nutrition Bulletin, 4(3), 1-6.

MacDonald, J., Perry, J., Ahearn, M., Banker, D., Chambers, W., Dimitri, C., ... & Southard, L. (2004). Contracts, Markets, and Prices. USDA, Economic Research Service, Ag Economic Report, (837).

Mahmud, W., Rahman, S. H., & Zohir, S. (1994). Agricultural growth through crop diversification in Bangladesh (No. BOOK). Washington: IFPRI.

Mango, N., Makate, C., Mapemba, L., & Sopo, M. (2018). The role of crop diversification in improving household food security in central Malawi. Agriculture & Food Security, 7(1), 1-10.

Masuku, M. B., & Sithole, M. M. (2009). The impact of HIV/AIDS on food security and household vulnerability in Swaziland. Agrekon, 48(2), 200-222.

Mazunda, J., Kankwamba, H., & Pauw, K. (2015). Food and nutrition security implications of crop diversification in Malawi's farm households. Mapping the linkages between agriculture, food security and nutrition in Malawi, 44-49.

Miah, M. A. M. 2002. Production and marketing of livestock and livestock products in selected periurban areas of Bangladesh. Ph.D. Dissertation submitted to the Dept. Of Agricultural Economics, Bangladesh Agricultural University, Mymensingh.

Miah, M. M., Haque, A. E., Hossaim, T. M. B., Hossain, S., & Rahman, M. S. (2013). Policy options for supporting agricultural diversification in Bangladesh. National Food Policy Capacity Strengthening Programme (NFPCSP), Food Planning and Monitoring Unit (FPMU), Ministry of Food, FAO_Bangladesh

Miah, M.A.M., Hassan, M. K. and Akter, M.S. 2005. Comparative economic performance of improved pulse production in Bangladesh: Technical efficiency and related issues. The Agriculturists, 3 (1&2): 104-116.

Mian, M. R. U.; Rahman, M. O. and Ahmed, A. U. 2006. Pangas mono culture and carp-pangas polyculture: An economic analysis of pond fish production in two areas of Bangladesh. Progress. Agric. 17(2): 107-114, 2006.

Ministry of Food and Disaster Management of Bangladesh. 2008. National Food Policy Plan of Action (2008-2015).
www.gafspfund.org/sites/gafspfund.org/files/Documents/NationalFoodPolicyPlanofActionFINAL.pdf

Mitra, A. (2005). Terms of Trade and Class Relations: An Essay in Political Economy. Orient Blackswan.

Mitra, A. (2005). Terms of Trade and Class Relations: An Essay in Political Economy. Orient Blackswan.

Murendo, C., Gwara, S., Mazvimavi, K., & Arensen, J. S. (2019). Linking crop and livestock diversification to household nutrition: Evidence from Guruve and Mt Darwin districts, Zimbabwe. World Development Perspectives, 14, 100104.

Murendo, C., Nhau, B., Mazvimavi, K., Khanye, T., & Gwara, S. (2018). Nutrition education, farm production diversity, and commercialization on household and individual dietary diversity in Zimbabwe. Food & nutrition research, 62.

Naik, G., & Jain, S. K. (2002). Indian agricultural commodity futures markets: A performance survey. Economic and Political weekly, 3161-3173.

National Agricultural Policy 2018

National Agriculture Policy 2013 (NAP 2013)

National Food Policy 2006: Section 1.1.4. Agriculture diversification and improved agricultural technology (NFP 2006)

National Nutrition Policy 2015 (NNP 2015)

National Social Security Strategy 2015 and its Plan of Action 2018

Nielsen, J., Haselow, N., Osei, A., & Talukder, Z. (2013). Diversifying diets: using agricultural biodiversity to improve nutrition and health in Asia. Diversifying Food and Diets: Using Agricultural Biodiversity to Improve Nutrition and Health, 303.

Nurunnahar, M.; Jahan, H.; Asaduzzaman, M. and Rahman, M. H. 2006. A socio-economic study on carp fish farms under poly culture management in Kushtia district. Progress. Agric. 17(1): 395-403, 2006.

Parvin, H. 1. 2010. A comparative economic study of potato and tomato production in selected areas of Bogra district. MS thesis, Dept. of Agricultural Economics, BAU, Mymensingh. Agriculturists, 3 (1 &2): 104-116.

Passarelli, S., Mekonnen, D., Bryan, E., & Ringler, C. (2018). Evaluating the pathways from small-scale irrigation to dietary diversity: evidence from Ethiopia and Tanzania. Food Security, 10(4), 981-997.

Prebisch, R. 1950, The Economic Development of Latin America and its Principal Problems, United Nations, New York, reprinted in: Economic Bulletin for Latin America vol. 7, no. 1, 1962, pp. 1–22.

Prebisch, R. 1950, The Economic Development of Latin America and its Principal Problems, United Nations, New York, reprinted in: Economic Bulletin for Latin America vol. 7, no. 1, 1962, pp. 1–22.

Quddus, A., & Kropp, J. D. (2020). Constraints to Agriculture Production and Marketing in the Lagging Regions of Bangladesh. Sustainability, 12(10), 3956.

Rahman, M. S. 2009. An economic analysis on dairy cow rearing under Rangpur Dairy and Food Products Limited in Rangpur district. MS thesis, Department of Agricultural Economics,

Rahman, M.S; Hossain, M. A.; Sarker, M. J. U. and Bakr, M. A. 2012. Adoption and profitability of BARI lentil in some selected areas of Bangladesh. Bangladesh j. agril. res. 37 (4): 593-606.

Rahman, S.H. 1976, ‘An Analysis of Terms of Trade of Bangladesh, 1959/60 to 1974/75’, Bangladesh Development Studies, vol. 4, no. 3, pp. 375–398.

Rajendran, S., Afari-Sefa, V., Shee, A., Bocher, T., Bekunda, M., & Lukumay, P. J. (2017). Does crop diversity contribute to dietary diversity? Evidence from integration of vegetables into maize-based farming systems. Agriculture & Food Security, 6(1), 1-13

Rasul, G., & Thapa, G. B. (2003). Sustainability analysis of ecological and conventional agricultural systems in Bangladesh. World development, 31(10), 1721-1741.

Rezvi, M. R. (2018). The Factors of Declining Agricultural Growth in Bangladesh and Its Impact on Food Security. South Asian Journal of Social Studies and Economics, 1-9.8.

Ruel, M. T. (2003). Operationalizing dietary diversity: a review of measurement issues and research priorities. The Journal of nutrition, 133(11), 3911S-3926S.

Sen, B., Dorosh, P., Ahmed, M., & Van Asselt, J. (2021). Moving out of agriculture in Bangladesh: The role of farm, non-farm and mixed households, World Development, DOI 10.1016/j.worlddev.2021.105479.

Shukla, S. K., Singh, K. K., Pathak, A. D., Jaiswal, V. P., & Solomon, S. (2017). Crop diversification options involving pulses and sugarcane for improving crop productivity, nutritional security and sustainability in India. Sugar Tech, 19(1), 1-10.

Sibhatu, K. T., Krishna, V. V., & Qaim, M. (2015). Production diversity and dietary diversity in smallholder farm households. Proceedings of the National Academy of Sciences, 112(34), 10657-10662.

Sibhatu, K. T., Krishna, V. V., & Qaim, M. (2015). Production diversity and dietary diversity in smallholder farm households. Proceedings of the National Academy of Sciences, 112(34), 10657-10662.

Singer, H. W. (1950), “U.S. Foreign Investment in Underdeveloped Areas: The Distribution of Gains between Investing and Borrowing Countries,” American Economic Review, Papers and Proceedings, 40, 473-485.

Singer, H. W. (1950). The distribution of gains between borrowing and investing countries. American Economic Review, 40(2), 473-485.

Singer, H. W. (1950). The distribution of gains between borrowing and investing countries. American Economic Review, 40(2), 473-485.

Spatafora, N., & Tytell, I. (2009). Commodity terms of trade: The history of booms and busts.

Spatafora, N., & Tytell, I. (2009). Commodity terms of trade: The history of booms and busts.

Sultana, A. 2009. An economic analysis of broiler production in some selected areas of Mymensingh district. MS Thesis submitted to the Dept. of Agricultural Economics, BAU, Mymensingh. July-December, 2009.Bangladesh Agricultural University, Mymensingh.

Table production and socio-economic status of women in rural Tanzania. Food Security. 2012; 4:129–40.

Taufique, K. A., & Turton, C. (2003). Hands not lands: an overview of how livelihood is changing in rural Bangladesh. Dhaka: DFID.

Tesfaye, W. (2020). Crop diversification, household nutrition and child growth: Empirical evidence from Ethiopia.

Thamarajakshi, R (1969): "Intersectoral Terms of Trade and Marketed Surplus of Agricultural Produce, 1951-52 to 1965-66", Economic and Political Weekly (Review of Agriculture), 28 June.

Thamarajakshi, R (1969): "Intersectoral Terms of Trade and Marketed Surplus of Agricultural Produce, 1951-52 to 1965-66", Economic and Political Weekly (Review of Agriculture), 28 June.

The Eighth five-year plan, FY2016-FY2020, GED, Planning Commission, Government of Bangladesh.
Tisdell C, Alauddin1 M, Md. Sarker AR, and Kabir MA. Agricultural Diversity and Sustainability: General Features and Bangladeshi Illustrations. Sustainability 2019; 11: 6004; doi:10.3390/su11216004

Tripathi, A. K. (2012). Agricultural price policy, output, and farm profitability—Examining linkages during post-reform period in India. Asian Journal of Agriculture and Development, 10(1362-2016-107639), 91-111.

Van Winsen, F., de Mey, Y., Lauwers, L., Van Passel, S., Vancauteren, M., & Wauters, E. (2016). Determinants of risk behaviour: effects of perceived risks and risk attitude on farmer's adoption of risk management strategies. Journal of Risk Research, 19(1), 56-78.

Varangis, P. (1999). Dealing with commodity price uncertainty. The World Bank.

Vittal, N. (1988). Inter-Sectoral Terms of Trade in India: Reality and Hype. Economic and Political Weekly, A133-A140.

Vittal, N. (1988). Inter-Sectoral Terms of Trade in India: Reality and Hype. Economic and Political Weekly, A133-A140.

Wani, M. H., Baba, S. H., Hussain, M., Yousuf, S., Mir, S. A., & Kubravi, S. S. (2012). Food and nutritional security in the frame of crop diversification in the temperate region of Jammu and Kashmir. Indian Journal of Agricultural Economics, 67(902-2016-67838).

Wooldridge, J. M. (2015). Control function methods in applied econometrics. Journal of Human Resources, 50(2), 420-445.

Wright, B. D. (2011). The economics of grain price volatility. Applied Economic Perspectives and Policy, 33(1), 32-58.

Appendix A:

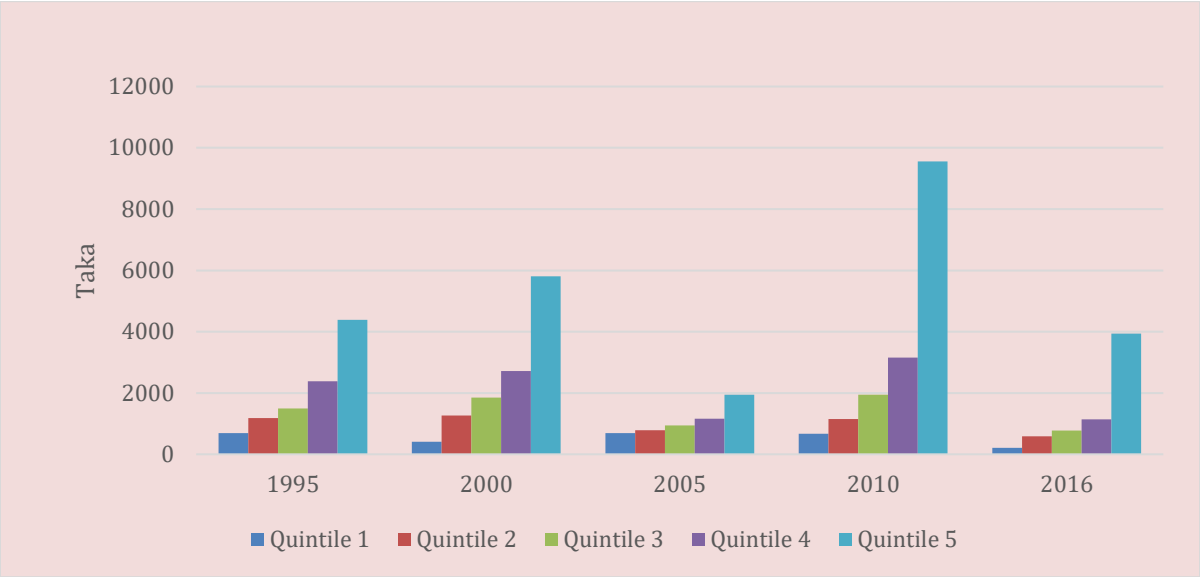
Appendix A1: BIHS Round 2 (2015): Non-agri (1) Vs. Agri (2) households

	obs1	obs2	Mean1	Mean2	diff	p value
HDDS	3421	3015	8.45	8.37	.079	.019
HFVS	3421	3015	34.44	33.34	1.097	0
WDDS	3406	3010	12.15	12.12	.024	.849
CDDS	1493	1195	9.71	9.59	.12	.516
MDDS	3175	2795	11.86	12.02	-.156	.226
Crop VS	3420	3015	1.92	3.07	-1.149	0
Monthly income	3420	3015	9394	6531	2862.64	0
Household Size	3420	3015	5.05	4.86	.191	0

Appendix A2: BIHS Round 3 (2018/19): Non-agri (1) Vs. Agri (2) households

	obs1	obs2	Mean1	Mean2	diff	p value
HDDS	3090	2514	8.68	8.53	.15	0
HFVS	3090	2514	38.76	36.22	2.537	0
WDDS	3076	2507	10.42	10.24	.186	.007
CDDS	1359	953	8.53	8.55	-.025	.854
MDDS	2846	2276	10.29	10.30	-.014	.852
Crop VS	3090	2514	1.88	2.89	-1.002	0
Monthly income	3090	2514	12174	8488	3686.10	0
Household Size	3090	2514	5.88	5.63	.249	0

A3: Per Capita Real Income from Farming at Different Quintiles



Appendix B: Impact of agricultural diversity on dietary diversity by subsamples

Table B1. Impact of agricultural diversity in food crop on women's food consumption
Dependent variable: Number of food items consumed by household women

	Endogenous			Endogeneity-controlled		
Variables	OLS	Poisson	NB	OLS	Poisson	NB
Agricultural diversity (food crop)	-0.152***	-0.0137***	-0.00763***	-0.772***	-0.0697***	-0.0504***
	(0.0164)	(0.00146)	(0.00107)	(0.0437)	(0.00382)	(0.00336)
HH income in thousand BDT	0.0158**	0.00137***	0.000611	0.0298***	0.00264***	0.00149***
	(0.00615)	(0.000532)	(0.000376)	(0.00632)	(0.000544)	(0.000389)
Agri. HH dummy	0.187	0.0165	-0.0112*	0.793***	0.0711***	0.0218***
	(0.117)	(0.0106)	(0.00671)	(0.122)	(0.0109)	(0.00702)
HH has any female earner	0.104	0.00948	0.0165**	0.482***	0.0445***	0.0360***
	(0.107)	(0.00970)	(0.00715)	(0.107)	(0.00959)	(0.00709)
Age of HH head	0.00148	0.000128	0.000274	0.00712	0.000637	0.000584***
	(0.00475)	(0.000420)	(0.000172)	(0.00473)	(0.000418)	(0.000173)
HH head is male	0.583	0.0526	0.00921	-0.163	-0.0166	-0.0184*
	(0.758)	(0.0681)	(0.0109)	(0.766)	(0.0685)	(0.0110)
Classes passed by HH head	-0.0760*	-0.00686*	0.00217**	-0.0476	-0.00401	0.00477***
	(0.0394)	(0.00354)	(0.000951)	(0.0391)	(0.00349)	(0.000958)
Avg. class passed by HH women	-0.144***	-0.0129***	0.000356	-0.136***	-0.0123***	0.00283
	(0.0496)	(0.00444)	(0.00228)	(0.0493)	(0.00438)	(0.00226)
Avg. age of HH women	-0.00970	-0.000885	0.000663*	-0.00711	-0.000683	0.000937**
	(0.00926)	(0.000840)	(0.000394)	(0.00930)	(0.000842)	(0.000394)
HH size	-0.187***	-0.0168***	-0.000912	-0.192***	-0.0176***	5.46e-05
	(0.0555)	(0.00503)	(0.00167)	(0.0551)	(0.00500)	(0.00167)
Farm land owned by HH	0.00205***	0.000193***	7.60e-05***	0.00251***	0.000232***	0.000172***
	(0.000689)	(6.07e-05)	(2.55e-05)	(0.000670)	(6.07e-05)	(2.59e-05)
Village has market	0.0319	0.00303	-0.00381	-0.0320	-0.00204	-0.0108*
	(0.116)	(0.0104)	(0.00636)	(0.113)	(0.00996)	(0.00627)
BIHS survey round	-0.186***	-0.0169***	-0.0168***	-1.295***	-0.117***	-0.0916***
	(0.0609)	(0.00552)	(0.00355)	(0.0923)	(0.00811)	(0.00644)

Control function residual				1.778***	0.161***	0.113***
				(0.105)	(0.00919)	(0.00757)
Constant	12.91***		2.416***	16.58***		2.656***
	(0.421)		(0.0170)	(0.483)		(0.0251)
Observations	13,050	11,727	13,050	13,050	11,727	13,050
R-squared	0.016			0.057		
Number of HH	5,809	4,486	5,809	5,809	4,486	5,809

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table B2. Impact of agricultural diversity in food crop on women's food category consumption
Dependent variable: Number of food groups consumed by household women

	Endogenous			Endogeneity-controlled		
Variables	OLS	Poisson	NB	OLS	Poisson	NB
Agricultural diversity (food crop)	0.0195***	0.00543***	0.00673***	0.0971***	0.0270***	0.0408***
	(0.00527)	(0.00152)	(0.00137)	(0.0107)	(0.00322)	(0.00305)
HH income in thousand BDT	-0.00309**	-0.000859*	-0.00119***	-0.00485***	-0.00134***	-0.00187***
	(0.00153)	(0.000493)	(0.000432)	(0.00155)	(0.000495)	(0.000426)
Agri. HH dummy	0.0532	0.0133	-0.00614	-0.0227	-0.00818	-0.0332***
	(0.0335)	(0.0107)	(0.00785)	(0.0342)	(0.0109)	(0.00810)
HH has any female earner	0.0281	0.00927	-0.0234***	-0.0193	-0.00421	-0.0397***
	(0.0309)	(0.00953)	(0.00800)	(0.0315)	(0.00974)	(0.00810)
Age of HH head	-0.000629	-0.000634	-0.00241***	-0.00134	-0.000820*	-0.00266***
	(0.00155)	(0.000481)	(0.000240)	(0.00155)	(0.000479)	(0.000239)
HH head is male	-0.394	-0.121	-0.126***	-0.300	-0.0978	-0.102***
	(0.355)	(0.127)	(0.0143)	(0.346)	(0.124)	(0.0143)
Classes passed by HH head	-0.0167	-0.00389	0.0135***	-0.0202	-0.00503	0.0114***
	(0.0130)	(0.00402)	(0.00121)	(0.0130)	(0.00403)	(0.00122)
Avg. class passed by HH women	-0.381***	-0.144***	-0.101***	-0.382***	-0.144***	-0.103***
	(0.0160)	(0.00518)	(0.00336)	(0.0159)	(0.00515)	(0.00332)
Avg. age of HH women	-0.0492***	-0.0186***	-0.0136***	-0.0496***	-0.0187***	-0.0139***
	(0.00329)	(0.00109)	(0.000552)	(0.00325)	(0.00108)	(0.000547)
HH size	-0.370***	-0.140***	-0.0775***	-0.369***	-0.140***	-0.0784***
	(0.0204)	(0.00613)	(0.00400)	(0.0204)	(0.00611)	(0.00398)
Farm land owned by HH	-6.99e-05	-5.83e-06	4.43e-05	-0.000127	-1.57e-05	-2.41e-05
	(0.000158)	(5.08e-05)	(2.89e-05)	(0.000159)	(5.13e-05)	(2.98e-05)
Village has market	-0.0797**	-0.0217**	-0.0104	-0.0717**	-0.0196*	-0.00468
	(0.0330)	(0.0101)	(0.00750)	(0.0330)	(0.0101)	(0.00748)
BIHS survey round	0.0157	0.00528	-0.00477	0.155***	0.0451***	0.0558***
	(0.0219)	(0.00662)	(0.00522)	(0.0265)	(0.00827)	(0.00676)
Control function residual				-0.223***	-0.0624***	-0.0911***
				(0.0284)	(0.00875)	(0.00766)
Constant	6.503***		1.990***	6.043***		1.796***
	(0.146)		(0.0253)	(0.152)		(0.0289)
Observations	13,050	11,727	13,050	13,050	11,727	13,050
R-squared	0.235			0.241		
Number of HH	5,809	4,486	5,809	5,809	4,486	5,809

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table B3. Impact of agricultural diversity in food crop on men's food consumption
Dependent variable: Number of food items consumed by household men

	Endogenous			Endogeneity-controlled		
Variables	OLS	Poisson	NB	OLS	Poisson	NB
Agricultural diversity (food crop)	-0.109***	-0.00969***	-0.00430***	-0.715***	-0.0641***	-0.0452***
	(0.0176)	(0.00155)	(0.00111)	(0.0452)	(0.00397)	(0.00340)
HH income in thousand BDT	0.00815	0.000714	0.000640*	0.0219***	0.00193***	0.00150***
	(0.00641)	(0.000566)	(0.000376)	(0.00641)	(0.000562)	(0.000387)
Agri. HH dummy	0.226*	0.0206*	-0.000345	0.835***	0.0751***	0.0313***
	(0.122)	(0.0111)	(0.00711)	(0.127)	(0.0115)	(0.00747)
HH has any female earner	0.234**	0.0215**	0.00719	0.607***	0.0547***	0.0258***
	(0.112)	(0.0102)	(0.00738)	(0.114)	(0.0102)	(0.00740)
Age of HH head	0.0131**	0.00122**	0.00117***	0.0194***	0.00179***	0.00150***
	(0.00551)	(0.000510)	(0.000203)	(0.00548)	(0.000510)	(0.000206)
HH head is male	0.217	0.0179	-0.0652***	-0.509	-0.0483	-0.0925***
	(0.775)	(0.0669)	(0.0142)	(0.790)	(0.0702)	(0.0142)
Classes passed by HH head	-0.0269	-0.00259	-0.000125	0.00108	2.21e-05	0.00242**
	(0.0470)	(0.00429)	(0.000982)	(0.0464)	(0.00423)	(0.000995)
Avg. class passed by HH women	0.190***	0.0165***	0.0193***	0.194***	0.0168***	0.0216***
	(0.0575)	(0.00504)	(0.00262)	(0.0565)	(0.00495)	(0.00260)
Avg. age of HH women	0.00824	0.000753	0.00204***	0.00415	0.000403	0.00210***
	(0.0123)	(0.00111)	(0.000534)	(0.0122)	(0.00110)	(0.000532)
HH size	0.0331	0.00295	0.000410	0.0222	0.00202	0.00130
	(0.0567)	(0.00507)	(0.00176)	(0.0558)	(0.00500)	(0.00177)
Farm land owned by HH	0.00249***	0.000224***	5.77e-05**	0.00301***	0.000271***	0.000153***
	(0.000670)	(5.58e-05)	(2.73e-05)	(0.000652)	(5.53e-05)	(2.80e-05)
Village has market	0.0903	0.00824	0.00250	0.0258	0.00317	-0.00391
	(0.124)	(0.0112)	(0.00679)	(0.122)	(0.0108)	(0.00671)
BIHS survey round	-0.403***	-0.0365***	-0.0257***	-1.498***	-0.135***	-0.0981***
	(0.0656)	(0.00594)	(0.00388)	(0.0986)	(0.00879)	(0.00680)
Control function residual				1.744***	0.157***	0.108***
				(0.111)	(0.00979)	(0.00791)
Constant	10.39***		2.333***	14.07***		2.565***
	(0.448)		(0.0180)	(0.499)		(0.0258)
Observations	12,346	10,958	12,346	12,346	10,958	12,346
R-squared	0.012			0.050		
Number of HH	5,612	4,226	5,612	5,612	4,226	5,612

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table B4. Impact of agricultural diversity in food crop on men's food category consumption
Dependent variable: Number of food groups consumed by household men

	Endogenous			Endogeneity-controlled		
Variables	OLS	Poisson	NB	OLS	Poisson	NB
Agricultural diversity (food crop)	0.0277***	0.00778***	0.00340**	0.106***	0.0311***	0.0349***
	(0.00574)	(0.00170)	(0.00144)	(0.0118)	(0.00367)	(0.00318)
HH income in thousand BDT	-0.00663***	-0.00303***	-0.00368***	-0.00840***	-0.00356***	-0.00433***
	(0.00156)	(0.000555)	(0.000483)	(0.00156)	(0.000551)	(0.000466)
Agri. HH dummy	0.0963***	0.0331***	0.0243***	0.0180	0.0104	-0.000986
	(0.0356)	(0.0113)	(0.00798)	(0.0369)	(0.0116)	(0.00824)
HH has any female earner	0.0609*	0.0197*	0.00229	0.0130	0.00501	-0.0126
	(0.0322)	(0.0101)	(0.00793)	(0.0326)	(0.0102)	(0.00798)
Age of HH head	-0.0121***	-0.00408***	-0.00629***	-0.0129***	-0.00431***	-0.00654***
	(0.00166)	(0.000526)	(0.000223)	(0.00166)	(0.000524)	(0.000222)
HH head is male	-0.132	-0.0523	-0.0147	-0.0391	-0.0208	0.00705
	(0.388)	(0.105)	(0.0143)	(0.386)	(0.106)	(0.0144)
Classes passed by HH head	-0.0279*	-0.00722	-0.00364***	-0.0315**	-0.00824*	-0.00560***
	(0.0159)	(0.00485)	(0.00122)	(0.0158)	(0.00484)	(0.00123)
Avg. class passed by HH women	0.119***	0.0357***	0.0635***	0.118***	0.0357***	0.0617***
	(0.0195)	(0.00552)	(0.00292)	(0.0194)	(0.00550)	(0.00291)
Avg. age of HH women	0.0658***	0.0194***	0.0197***	0.0663***	0.0195***	0.0197***
	(0.00472)	(0.00143)	(0.000633)	(0.00470)	(0.00142)	(0.000628)
HH size	-0.0424**	-0.0166**	-0.0424***	-0.0410**	-0.0160**	-0.0431***
	(0.0201)	(0.00656)	(0.00261)	(0.0200)	(0.00653)	(0.00259)
Farm land owned by HH	1.08e-05	-3.55e-08	-0.000155***	-5.61e-05	-1.38e-05	-0.000220***
	(0.000158)	(5.38e-05)	(2.97e-05)	(0.000156)	(5.29e-05)	(3.00e-05)
Village has market	-0.0842**	-0.0234**	-0.0166**	-0.0760**	-0.0211*	-0.0116
	(0.0344)	(0.0108)	(0.00753)	(0.0343)	(0.0108)	(0.00752)
BIHS survey round	-0.347***	-0.108***	-0.0803***	-0.206***	-0.0648***	-0.0242***
	(0.0222)	(0.00711)	(0.00526)	(0.0285)	(0.00916)	(0.00707)
Control function residual				-0.224***	-0.0674***	-0.0840***
				(0.0303)	(0.00951)	(0.00773)
Constant	3.435***		1.428***	2.962***		1.247***
	(0.153)		(0.0240)	(0.164)		(0.0289)
Observations	12,346	10,962	12,346	12,346	10,962	12,346
R-squared	0.164			0.170		
Number of HH	5,612	4,228	5,612	5,612	4,228	5,612

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table B5. Impact of agricultural diversity in food crop on children's food consumption
Dependent variable: Number of food items consumed by household children

	Endogenous			Endogeneity-controlled		
Variables	OLS	Poisson	NB	OLS	Poisson	NB
Agricultural diversity (food crop)	-0.0902**	-0.0123**	-0.00117	-0.717***	-0.0900***	-0.0440***
	(0.0424)	(0.00549)	(0.00285)	(0.102)	(0.0127)	(0.00849)
HH income in thousand BDT	0.0222*	0.00268*	0.000527	0.0345***	0.00426***	0.00134*
	(0.0125)	(0.00154)	(0.000767)	(0.0126)	(0.00154)	(0.000781)
Agri. HH dummy	0.130	0.0158	-0.00193	0.710***	0.0868***	0.0314*
	(0.252)	(0.0312)	(0.0153)	(0.261)	(0.0320)	(0.0163)
HH has any female earner	0.271	0.0287	0.0434***	0.650***	0.0786***	0.0602***
	(0.239)	(0.0298)	(0.0167)	(0.246)	(0.0305)	(0.0170)
Age of HH head	-0.00891	-0.00134	-0.00218***	-0.00294	-0.000556	-0.00189***
	(0.0128)	(0.00162)	(0.000411)	(0.0131)	(0.00166)	(0.000412)
HH head is male	-2.337	-0.261	-0.0262	-3.085	-0.355	-0.0509**
	(2.019)	(0.272)	(0.0243)	(2.120)	(0.279)	(0.0248)
Classes passed by HH head	-0.0241	-0.00367	0.00602***	-0.0270	-0.00345	0.00844***
	(0.0845)	(0.0101)	(0.00204)	(0.0842)	(0.0101)	(0.00207)
Avg. class passed by HH women	-0.360**	-0.0462**	-0.0268***	-0.386**	-0.0502**	-0.0231***
	(0.183)	(0.0231)	(0.00743)	(0.181)	(0.0229)	(0.00742)
Avg. age of HH women	0.0634*	0.00782*	0.000808	0.0437	0.00586	0.000626
	(0.0379)	(0.00470)	(0.00142)	(0.0375)	(0.00461)	(0.00141)
HH size	-1.186***	-0.150***	-0.0238***	-1.171***	-0.148***	-0.0227***
	(0.139)	(0.0179)	(0.00341)	(0.138)	(0.0181)	(0.00343)
Farm land owned by HH	0.00184	0.000259*	-3.45e-05	0.00280**	0.000373***	7.90e-05
	(0.00130)	(0.000137)	(6.12e-05)	(0.00124)	(0.000133)	(6.19e-05)
Village has market	-0.358	-0.0378	-0.0132	-0.317	-0.0335	-0.0196
	(0.259)	(0.0317)	(0.0148)	(0.256)	(0.0314)	(0.0148)
BIHS survey round	2.036***	0.249***	0.0609***	0.902***	0.110***	-0.0115
	(0.172)	(0.0215)	(0.00988)	(0.237)	(0.0291)	(0.0165)
Control function residual				1.749***	0.217***	0.110***
				(0.242)	(0.0298)	(0.0189)
Constant	11.58***		2.204***	15.60***		2.442***
	(1.094)		(0.0381)	(1.252)		(0.0605)
Observations	5,461	3,566	5,461	5,461	3,566	5,461
R-squared	0.094			0.119		
Number of HH	3,463	1,576	3,463	3,463	1,576	3,463

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table B6. Impact of agricultural diversity in food crop on children's food category consumption
Dependent variable: Number of food groups consumed by household children

	Endogenous			Endogeneity-controlled		
Variables	OLS	Poisson	NB	OLS	Poisson	NB
Agricultural diversity (food crop)	0.0457***	0.0119***	0.0120***	0.0741***	0.0192***	0.0221***
	(0.0131)	(0.00326)	(0.00201)	(0.0274)	(0.00698)	(0.00471)
HH income in thousand BDT	0.00422	0.00120	0.000429	0.00367	0.00105	0.000240
	(0.00369)	(0.000985)	(0.000533)	(0.00374)	(0.000995)	(0.000540)
Agri. HH dummy	0.0802	0.0187	0.00824	0.0539	0.0121	0.000443
	(0.0767)	(0.0200)	(0.0103)	(0.0798)	(0.0207)	(0.0107)
HH has any female earner	0.110	0.0309	0.0288***	0.0931	0.0263	0.0246**
	(0.0723)	(0.0190)	(0.0111)	(0.0737)	(0.0194)	(0.0113)
Age of HH head	0.000996	0.000179	-0.000480*	0.000726	1.00e-04	-0.000550**
	(0.00407)	(0.00104)	(0.000266)	(0.00406)	(0.00104)	(0.000267)
HH head is male	-0.890	-0.260	-0.0537***	-0.856	-0.250	-0.0475***
	(0.803)	(0.195)	(0.0168)	(0.804)	(0.195)	(0.0170)
Classes passed by HH head	-0.0256	-0.00635	0.00153	-0.0255	-0.00631	0.000969
	(0.0289)	(0.00713)	(0.00144)	(0.0288)	(0.00711)	(0.00146)
Avg. class passed by HH women	0.0666	0.0161	0.0187***	0.0678	0.0163	0.0178***
	(0.0591)	(0.0146)	(0.00452)	(0.0593)	(0.0147)	(0.00453)
Avg. age of HH women	0.0490***	0.0130***	0.00590***	0.0499***	0.0132***	0.00597***
	(0.0102)	(0.00263)	(0.000939)	(0.0102)	(0.00264)	(0.000939)
HH size	-0.552***	-0.164***	-0.0323***	-0.552***	-0.164***	-0.0326***
	(0.0508)	(0.0157)	(0.00277)	(0.0510)	(0.0158)	(0.00278)
Farm land owned by HH	0.000583	0.000168	-1.37e-05	0.000540	0.000156	-3.97e-05
	(0.000446)	(0.000112)	(3.70e-05)	(0.000449)	(0.000113)	(3.93e-05)
Village has market	-0.0801	-0.0191	-0.00658	-0.0820	-0.0196	-0.00516
	(0.0825)	(0.0213)	(0.0100)	(0.0822)	(0.0212)	(0.0100)
BIHS survey round	0.322***	0.0945***	-0.0445***	0.373***	0.108***	-0.0270***
	(0.0580)	(0.0161)	(0.00745)	(0.0726)	(0.0198)	(0.0102)
Control function residual				-0.0792	-0.0203	-0.0258**
				(0.0689)	(0.0178)	(0.0109)
Constant	5.668***		1.493***	5.486***		1.435***
	(0.348)		(0.0281)	(0.377)		(0.0367)
Observations	5,461	3,581	5,461	5,461	3,581	5,461
R-squared	0.125			0.125		
Number of HH	3,463	1,583	3,463	3,463	1,583	3,463

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix C:

Table C1: No of People Engaged in Agriculture of Bangladesh

Year	LFP	Population	Employment in Agriculture	No of People Engaged in Agriculture
1991	57.81	105599127	69.51	42433671
1992	57.8	107983704	68.90	43003647
1993	57.81	110350639	68.12	43456274
1994	57.84	112737683	67.22	43832466
1995	57.88	115169930	66.03	44015833
1996	57.81	117649932	64.63	43957076

1997	57.76	120160564	64.86	45015915
1998	57.72	122682815	64.93	45978571
1999	57.68	125189651	64.94	46892780
2000	57.65	127657854	64.81	47696759
2001	57.59	130088702	62.39	46741392
2002	57.55	132478086	59.90	45668443
2003	57.52	134791603	57.19	44340624
2004	57.49	136986432	54.30	42763151
2005	57.45	139035505	51.17	40872496
2006	57.34	140921167	48.08	38850660
2007	57.22	142660376	47.85	39060082
2008	57.11	144304167	47.67	39285852
2009	57.01	145924797	47.53	39541026
2010	56.92	147575430	47.31	39740369
2011	56.85	149273778	46.55	39503326
2012	56.79	151007807	45.76	39242555
2013	56.73	152764676	45.01	39007195
2014	56.69	154520167	44.27	38779405
2015	56.64	156256276	43.46	38463644
2016	56.6	157970840	42.66	38142943
2017	58.86	159670593	40.60	38156736
2018	59.01	161356039	39.39	37505659
2019	59.12	163046161	38.30	36918476

Source: WDI, World Bank

Table C2: Trend in GDP to Employment Ratio in Bangladesh

	Ratio of GDP to Employment	
Year	Agriculture	Non-Agriculture
1991	0.46	2.24
1992	0.44	2.23
1993	0.40	2.28
1994	0.40	2.24
1995	0.41	2.14
1996	0.36	2.17
1997	0.36	2.18
1998	0.35	2.21
1999	0.35	2.21
2000	0.35	2.20
2001	0.35	2.08
2002	0.34	1.98
2003	0.35	1.87
2004	0.35	1.77
2005	0.36	1.67
2006	0.38	1.58
2007	0.37	1.58

2008	0.37	1.57
2009	0.36	1.58
2010	0.36	1.57
2011	0.36	1.56
2012	0.35	1.55
2013	0.34	1.54
2014	0.35	1.52
2015	0.34	1.51
2016	0.33	1.50
2017	0.33	1.46
2018	0.33	1.43
2019	0.33	1.42

Source: WDI

Graph C1: Standard Deviation of the Price of Boro-Fine: