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CROP DIVERSIFICATION FOR DIETARY DIVERSITY AND NUTRITION: EVIDENCE FROM BANGLADESHI FARM HOUSEHOLDS

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ACRONYMS

BDHS	Bangladesh Demographic and Health Survey
BIDS	Bangladesh Institute of Development Studies
BIHS	Bangladesh Integrated Household Survey
BMR	Basal Metabolic Rate
DDI	Dietary Diversity Index
EFI	Entropy Index
FAO	Food and Agriculture Organization
HDDS	Household Dietary Diversity Index
HPNSDP	Health, Population and Nutrition Sector Development Program
IFPRI	International Food Policy Research Institute
RI	Rice Share Index
SI	Simpson Index

FOREWORD

This study was undertaken as a contribution to the broader discussion of food and nutrition security. In a subsistence economy where peasants consume what they produce, one would expect a diverse cropping pattern to promote both food and nutritional security. This would occur mainly through the effect on production, and depending on the magnitude of the impact, this could have important implications for policy. However, if the farming sector has become more commercialised, the direct production-consumption effect would be weakened, and instead it would be mediated by the market. In such a case, it is not clear what the net effect might be on dietary diversity or per capita nutrient intake.

Mohammad Riaz Uddin explores this issue using panel data generated by the nationally representative, Bangladesh Integrated Household Survey (BIHS) generated by IFPRI for 2011-12 and 2015. He shows that diversification of production has no effect on dietary diversity or per capita nutrient intake, if controlled for incomes. It is really incomes that affect these outcome variables, probably suggesting that Bangladesh agriculture has actually moved away from the traditional, subsistence-type farming of earlier decades and has become much more commercialised.

I would like to congratulate Mohammad Riaz Uddin for this painstaking exercise, based on a large panel data set. His findings will be useful to development practitioners working in the area of food and nutrition security.

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October 2019

Khan Ahmed Sayeed Murshid
Director General

ABSTRACT

Using two rounds of nationally representative Bangladesh Integrated Household Survey (BIHS- 2011-12, 2015) data and a panel data model, this study explores the linkages, if any, among household crop diversification, household dietary diversity and per capita nutrients intake of the household. Over the years, Bangladesh has been improving in dietary diversity and vitamin A intake, but it has not improved in crop diversification, per capita calorie, iron and zinc intake. This study finds that households with less concentration on rice production are more likely to diversify their consumption. It is also found that there is no significant association between crop diversification and dietary diversity, but there is a negative and significant association between dietary diversity and per capita calorie intake among the farm households. On the other hand, diversity in dietary intake significantly increases per capita micro-nutrients intake (iron, zinc, vitamin-A). Moreover, household income is a strong determinant for both dietary diversity and nutrients intake. This study suggests that increasing per capita income of household increases diet diversity, per capita calorie, protein, iron, zinc and vitamin-A intake.

CHAPTER 1
INTRODUCTION

Bangladesh, as a developing country, has made substantial progress in providing better food security for its large population. Despite such progress, the country is still facing some challenges, especially in lessening gaps between peoples' daily food intake and the minimum requirement for balanced nutrition from the food intake. In Bangladesh, majority of the people, especially the poverty-stricken population, subsist on diets that consist of staple foods such as rice, wheat and maize (almost 70 per cent). As a result, research indicates that Bangladesh's food production is perhaps not diversified properly which could be considered a major barrier to acquiring a standard nutritional status for such a growing population. This lack of diversity might also be a cause behind micronutrient deficiencies. Moreover, crop diversification could have impact on food security, nutrition and health, secure source of income, employment and high-value products, and could be the resilience of farming systems and environments.

In this twenty-first century, it is crucial that nutrition security is given as much importance as food security, especially in the context of a developing country such as Bangladesh. Household nutrition security must come to mean a lot more than merely the avoidance of starvation (Aeri and Goplan 2001). A family's food intake must be adequate, that is, not just meet the bare energy requirement needed for survival, but must provide all the nutrients essential for proper growth and development. The time has come for much needed change in the way nutrition and food security approached and several factors would matter here. For the evolvement of nutritional-orientation focused food production programmes, it is important to examine and correct the mistakes of the past and use new knowledge and technologies to design and develop new strategies for combating under-nutrition.

Child and maternal mortality have reduced in Bangladesh. However, a large proportion of child and adult people still remain malnourished. Basically, under-nutrition encompasses protein-energy malnutrition and deficiency of micronutrients, including essential vitamins and minerals.

Bangladesh Demographic and Health Survey (BDHS) *2014* found that there has been some improvement in children's nutritional status over the past decade. For example, the level of stunting among children below 5 has declined from 51 per cent in 2004 to 36 per cent in 2014, and in the last three years it has declined by a further 5 per cent. On the other hand, wasting has increased to 17 per cent in 2007 from 15 per cent in 2004; it has then gradually declined to 14 per cent in 2014. Additionally, the level of underweight has declined from 43 per cent in 2004 to 33 per cent in 2014. The Health, Population and Nutrition Sector Development Program (HPNSDP) 2011-16 targets for 2016 were 38 per cent for stunting and 33 per cent for underweight; and the 2014 BDHS data show that these targets have been achieved. In general, Bangladesh's performance in tackling these nutrition related factors has been commendable, but there is still much to do. In comparison with neighbouring countries in South Asia, Bangladesh is doing better than some countries in some measures and lagging behind in most of the indicators. Table 1.1A (in Appendix) compares measures of child nutrition status among South Asian countries.

Therefore, nutritional security should remain a topmost priority for Bangladesh and get special priority in government policies. This research is based on the assumption that crop diversification could be a good solution to reducing nutrition deficiencies and explore how this could work. Thus, the main objective of this study is to understand how crop diversification could improve the nutritional status of adult and children in Bangladesh. Based on the assumption that crop diversification might improve nutritional status, this research explores the avenues of such improvement and contemplates whether it is most likely to occur through means of income or through means of production.

In general, agriculture contributes to 19.4 per cent of GDP. With nearly 43.5 per cent of labour force engaged in agriculture, 76.5 per cent of the total population have their livelihoods either fully or partially dependent on agriculture (Country Nutrition Paper, FAO and WHO 2014). So, agriculture might be used to handle the malnourishment issues.

Crop diversification could improve nutritional status in two ways: (1) production and (2) income. Due to an increase in crop diversification, farm households could get different types of crops, thus it is not necessary to increase amount of food consumption. However, consumption of nutritious food would increase due to diversity in crop production. In turn, such an increase in food intake would have a positive impact on nutrients intake. On the other hand, increase of individual/family income could happen due to crop diversification and the increase of income, in turn, would have a positive impact on nutrients intake. Then, increased family/ individual income would raise a family's expenditure on food and this might lead to improved nutritional status of a family/individual.

The three research questions addressed in this study are:

1. Does production diversity result in consumption or dietary diversity?
2. What are the factors of improving household dietary diversity?
3. Does dietary diversity result in better nutrients intake, both macro and micro nutrients?

CHAPTER 2

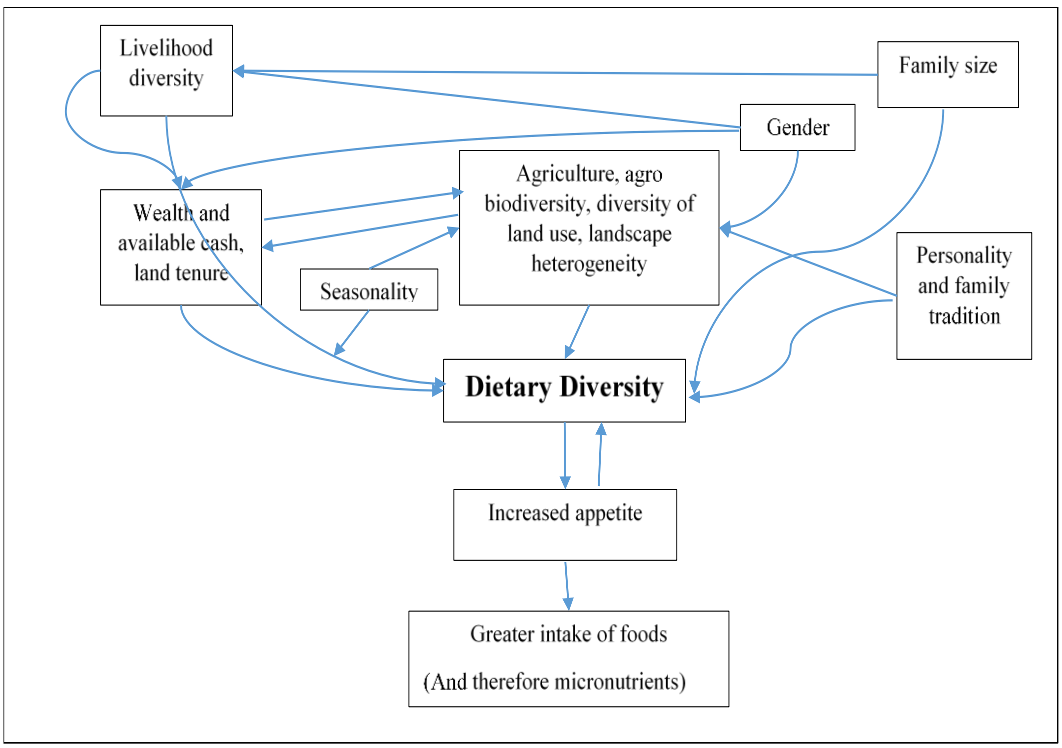
CONCEPTUALISATION AND LITERATURE

2.1 Conceptual Framework

Figure 2.1 shows the relationships between determinants and outcomes of dietary diversity, and an interpretation of how these factors interact within the socio-ecological system (The arrows indicate associations that can be either positive or negative; they are not meant to indicate causation).

The conceptual framework gives us an indication of how different factors could be associated with dietary diversity. For example, alongside agriculture and agro-biodiversity, other factors such as livelihood diversity, wealth, family size, etc. could be associated with dietary diversity, which in turn could lead to increased appetite, greater food intake and more micronutrients. While this framework is indicating the possible associations between different factors and dietary diversity, the motive of this research is to explore whether there could be causation between crop diversification and dietary diversity.

Figure 2.1: Conceptual Framework



2.2 Literature

Several studies have shed light on the issues of crop diversification, dietary diversity and nutrition intake, and these studies have helped in shaping an informed study based on the propositioned research questions. Focusing on the potentials and constraints of crop diversification in Bangladesh, Islam and Hossain (2014) demonstrated that diversification along the line of production of non-rice crops has implications for labour employment. Their research showed that some crops like oilseeds and pulses are less labour intensive and hence would have negative impact on employment generation. And potatoes, vegetables and spices being highly labour-intensive, expansion of area for the production of these crops would have positive impact on labour employment. The study further highlighted that crop diversification augments income and employment opportunities in the rural settings where roughly three fourths of gross crop area is engaged in producing a single crop.

Dillon *et al*. (2014) found that a 10 per cent increase in agricultural revenues results in a 1.8 per cent increase in diet diversity and a 10 per cent increase in crop diversification results in a 2.4 per cent increase in diet diversity. They also explained that agricultural income growth or increased crop diversity may not be sufficient to ensure improved dietary diversity. However, increases in revenues from agriculture do change diet composition. It is shown that the effect of agricultural income on share of calories by food groups indicates relatively large changes in diet composition than direct impact on diet diversity. For a 10 per cent increase in agricultural revenue households are 7.2 per cent more likely to consume vegetables and 3.5 per cent more likely to consume fish, and it increases the share of tubers consumed by 5.2 per cent.

By using HIES 2000 and 2010 data, Hossain, Jimi and Islam found (2016) that one unit increase in the diversity index induces 0.03 unit increase in the average dietary diversity at both national and rural levels for the year 2000 and 0.01 and 0.02 at national and rural levels, respectively, for the year 2010. They divided both crops and consumption into 7 groups and put zero for non-producing household. Energy intake remained almost stagnant, but significant improvement in the intake of protein, vitamin A, and iron was found.

Taruvinga *et al*. (2013) found that household dietary diversity against dietary quantity presents an opportunity to estimate household food security. They used household cross-sectional survey data from rural communities in the Eastern Cape province of South Africa to estimate the determinants of rural household dietary diversity. Regression results show there is a positive influence of participation in irrigation schemes, gender, education, income, access to home gardens and ownership of small-livestock in achieving of high dietary diversity or diversity in dietary intake. They suggest government target the above variables through government policies and intervention programmes which may improve rural household dietary diversity and household food security.

Using two rounds (2013 and 2014) of nationally representative survey data (n = 5,978 observations), Mulmi *et al*. (2017) found significant associations between child dietary diversity and agricultural diversity in terms of diversity of food groups and of species grown, in particular for older children in poorer households, and in general for fruits and vegetables, dairy and eggs.

The agricultural interventions have the potential to influence nutritional outcomes in the South Asia; however, the available evidence regarding linking the agricultural interventions and their impact on the nutritional status of women and children is small (Pandey *et al*. 2016). They found that the diversification of agriculture towards fruits and vegetables and integrated agriculture-aquaculture can potentially promote dietary diversity and improve nutritional outcomes. With more favourable nutrition-sensitive agricultural policies and empowerment of women, it is possible to improve nutritional status.

IFPRI, BIDS and INFS (1998) conducted a study focusing on micronutrient deficiencies, which is a major topic of research in the field of studying nutrition, and showed how homestead gardening, as a form of diversified food production methods, could impact micronutrient deficiencies. Micronutrient deficiency is a serious issue because it negatively impacts health and could have dire consequences, especially in the case of pregnant women and infant children. The IFPRI, BIDS and INFS (1998) study highlighted that the main reason behind micronutrient deficiencies is low quality food intake; and that Vitamin A and iron deficiencies are the most common micronutrient deficiencies while zinc and iodine deficiencies are also common. The key highlight of this study was to demonstrate how such micronutrient deficiencies could potentially be reduced through food diversification. For example, the study indicates that vegetable gardening could be a promising strategy in improving vitamin A and iron deficiencies. According to this study, diversified fish production and vegetable gardening, if conducted in the proper way, could be very profitable in terms of food production methods because of the potential leading to increased household incomes. The potential profitability of these food production methods in this study was described through increased income, translating into possible increased household expenditure in vitamin A and iron-rich animal products and fruits, which in turn could be associated with lower morbidity, measured by prevalence and duration of sicknesses, especially in pre-school children. On the other hand, this study indicates the possibility of nutritional improvement through such diversified food production methods. For example, lower morbidity could be associated with higher energy and higher intakes of iron, and vitamin A and C. Among other studies that have been conducted on how diversified vegetable gardening could lead to improved nutritional status, Marsh (1998) used impact evaluation to show that the average vegetable consumption is higher for people who started homestead gardening compared to people who had not taken up homestead gardening. Cohen *et al*. (1985) showed that home gardening could have positive impact on reducing the risk of vitamin

A deficiency. Both of these studies were conducted by dividing the whole sample into two groups, the treatment group (people who started homestead gardening) and the control group (people who did not start homestead gardening).

The study most relevant to this research in terms of focusing on the factors that affect crop diversification is the study conducted by Ashfaq *et al*. (2008). Focusing on the factors affecting crop diversification, this study used a multiple regression model in which the values of the Entropy Index[1](EI) of crop diversification were taken as the dependent variable, and different factors affecting diversification were taken as independent variables. The study found that the size of land holding, age of respondents, education level of respondents, farming experience of respondents, off farm income of respondents, distance of farm from main road, distance of farm from main market and farm machinery are the main factors influencing crop diversification.

Crop diversification, which is in its essence an agricultural tool, could have potential effects on nutrition, and this is the premise of this research. The possible link between agriculture and nutrition is indeed a popular topic of research. To explore the existence and extent of a linkage between agriculture and nutrition, Kennedy and Bouis (1993) stated three ways through which agriculture policies and programmes could influence individuals' nutritional status: (1) increased income and lower food prices, which permit increased food consumption; (2) effects on health and sanitation environment at the household and community level, which may increase or reduce morbidity; and (3) effects on time allocation patterns, particularly of mothers, which may increase or reduce time spent on nurturing activities-time that is often related to women's control over household income and is an important determinant of women's nutritional status. Moreover, this study indicated that other factors such as sanitation, environment and birth weight are substantially important influencing factors of individual's nutritional status.

Examining food security, self-sufficiency and nutrition gap using both time series and cross sectional data, Talukder (2005) highlighted that despite average per capita calorie intake being higher than calorie intake norms, a large segment of the population still remains calorie deficient, even compared to the minimum per capita calorie intake of 1805 kcals per day, and hence remains under-nourished. In Bangladesh, approximately 40% people consume food below the absolute poverty line food intake. On the contrary, this study showed that in relation to standard nutritional norm of food intake, Bangladesh remains a surplus producer of food grains, but there is a nutritional gap of substantial magnitude. This study emphasized the adoption of appropriate food intervention measures based on critical analysis of existing food intervention programmes to bridge the prevalent nutritional gap in the country. According to this study, all available nutritional indicators suggest that Bangladeshi people should consume lesser food-grains than what they currently consume and that serious motivational efforts will be needed to raise people's alacrity to consume lesser food-grains. Additionally, congenial production

[1] $EI = \sum_{i=1}^{n} Pi * logPi$, where P_i stands for proportion of area under the i^{th} crop

and market environment will have to be ensured to induce people to diversify production and consumption of non-rice foods. This study suggests that cost-effective means for the elimination of nutrition gap needs to be devised and this should incorporate the proper identification of beneficiary groups, methods of handling grains, leakage of various kinds, valuation of benefits, people food preference and food related considerations.

Working on trends in consumption, nutrition and poverty, Ahmed (2000) showed that, with rising income, households tend to diversify food consumption to add higher-priced nutrients and also suggests that pre-school children, pregnant and lactating women face the most acute nutritional risks, which is consistent to nutrition studies conducted in low-income countries. Moreover, children of higher income groups are nutritionally better off than children belonging to lower income groups and this was found through measuring child nutrition by anthropometric data of children from different income groups. On the other hand, this study indicated that the consumption of food grains remains a major factor in controlling not only good-grain prices but also in influencing both nutrition and poverty. In Bangladesh, food grains dominate a major portion of food intake and nutrition, accounting for around 80 per cent of calorie consumed–73 per cent from rice and 6 per cent from wheat. This study highlighted nutritional status and intake in terms of household income, expenditure and food prices. For example, the study found that approximately 63 per cent of a household's total expenditure is spent on food; and as household income increases, the household's total share on food expenditure decreases in accordance with the theory of Engel's law. Moreover, while per capita intake of all the four main types of nutrients increases with increase in income, the intake of two of the nutrients, calorie and protein, are more responsive to change in income compared to the intake of the two nutrients, iron and vitamin A. In comparing nutrient intake of members within households, this study found that the intake of all four nutrients by female household members, in all expenditure groups, is consistently lower than that of the male household members. Based on calorie requirement measurement by basal metabolic rate (BMR), this study also found that the average calorie intake is far below the requirement level for all household members in case of the poorest 25 percent of rural households.

Murshid *et al*. (2008) conducted a study titled 'Determination of Food Availability and Consumption Pattern and Setting up of Nutritional Standard in Bangladesh', and highlighted the issues of consumption, food supply issues, the demand side of food, access to food, and perceptions of and knowledge about nutrition in their research. The study particularly focused on consumption and calorie-food intake in determining the calorie-nutrient needs of a highly growing population and also estimated nutritional requirements in a methodologically sound manner to determine nutritional standards. According to the findings of this study, people's diets are mostly based on cereals; averagely 74-76 per cent of calorie intake is still attained from cereals. Moreover, the contribution of animal-based foods to calorie intake is very low. On the other hand, the production of fish, meat and poultry has increased rapidly, but not at the pace required to make these products cheaper and affordable for the poverty-stricken portion of the population.

According to the IFPRI nutrition report (2015), if food availability and access to food increase, hunger may decrease, but malnutrition might not necessarily decrease. This report stated that a reason behind the persistent existence of malnutrition in Bangladesh may lie in the complex interaction between food intake and illnesses affecting the body's utilisation of food, which, in turn, is influenced by the overall health and caring environment. This relationship is often referred to as the "leaking bucket effect," wherein improvements in availability and access to foods that are important for good nutritional status might be offset by poor access to non-food inputs, such as quality health care facilities and services, education, sanitation and safe water, or perhaps ineffective mechanisms for delivering these services.

Exploring whether there could be a relationship between women's empowerment in agriculture and nutritional status, Sraboni *et al*. (2014) found that women's empowerment in agriculture has a positive association with calorie intake and dietary diversity, but it has no significant impact on adult nutritional status. This study suggests that household wealth, education and occupation are more important than women's empowerment in agriculture as determinants of adult nutritional status.

With an objective of ascertaining whether any increased diversity in production can raise dietary diversity or otherwise, Srinivasulu *et al*. (2014) used multiple linear regression models and used data from a primary survey of 300 households which were selected from 10 villages of Babati, Kongwa and Kiteto districts in Tanzania. This study found that there is no significant impact of farm diversity on dietary diversity after controlling for other covariates. In contrast, significant association was found between dietary diversity and other variables such as household size, level of education, monthly expenditure on food, irrigated area and proportion of vegetables consumed from own household production.

With an objective of investigating the effect of farm production diversity on households' dietary diversity and verifying the role of market access and other potential influencing factors on production and dietary diversity, Sibhatu, Krishna and Qaim (2015) carried out a study based on comprehensive datasets of market-oriented smallholder farm households from Indonesia and Kenya, and from subsistence farmers in Ethiopia and Malawi. The study found that farmers from the market-oriented production systems consume more diversified diets compared to farmers from the subsistence systems; and even among the subsistence farmers, the crucial role of farm diversity in augmenting dietary diversity is evident only among those who have limited access to food markets. Moreover, farm diversity enhances dietary diversity of Indonesian and Malawian households either through direct consumption and/or by increasing and stabilising farm income, which is also dependent on the type of crop on the farm. However, no meaningful connection could be found between the variables of interest in Kenya and Ethiopia, despite the controlling for market access and other factors. The study concludes that the linkage between farm production diversity and dietary diversity does not universally exist and that diversifying diets through farm diversification need not require subsistence production systems.

To estimate the effect of crop diversification on child health, Stefania Lovo and Marcella Veronesi (2015) used Tanzania National Panel Survey and Fixed Effect estimation method. The study used fixed effects panel estimation to control for unobserved heterogeneity; and several robustness checks were performed, including placebo tests, to test the validity of the findings. The study found a positive and significant effect of crop diversification on long-term child nutritional status, in particular for very young children and children living in households with limited market access.

CHAPTER 3
METHODOLOGY

3.1. Measurement of Crop Diversification and Dietary Diversity

Crop diversification has been measured in three ways: (1) Rice Share Index (RI), (2) Simpson Index (SI) and (3) Entropy Index (EI). To measure consumption diversity, the Household Dietary Diversity Score (HDDS) is usually used, but the HDDS cannot differentiate among weights or actual quantity of the consumption of different food groups. Thus, along with HDDS a new index similar to the Herfhindahl Hirschman Index of crop diversification has been used in this study, which is called Dietary Diversity Index (DDI).

3.1.1. Rice Share Index (RI)

Rice share index (RI) refers to the proportion of different rice production to gross crop production. In terms of consumption, the index refers to the proportion of rice consumption to total consumption. The mathematical expression of RI is as follows:

$$RI = \sum_{i=1}^{n} \frac{r_i}{A}.$$

Here, RI = rice share index, r_i= total production of rice and A = amount of all crop products. The value of RI lies between zero and one, whereas RI tends to zero means more diversification and vice versa. RI has limitation that it cannot exactly tell about crop diversification rather than concentration on rice production. Low concentration on rice production can imply high crop diversification and high concentration on rice production can imply low crop diversification.

3.1.2. Simpson Index (SI)

Simpson Index of crop diversification is the difference between the value one and the sum of squares of all the proportion of a particular crop involved in a particular household. The index is represented as:

$$SI = 1 - HHI = 1 - \sum_{i=1}^{n} P^2$$

where we can define,

$$p = \sum_{i=1}^{n} \frac{a_i}{A}$$

Here, ai = amount of land involved in a particular crop item produced by household in a given time period, and A= total land operated by household in a given time period. The value of SI lies between zero and one, where zero means zero diversification and one means perfect diversification, of course, in terms of crop production.

3.1.3. Entropy Index (EI)

Entropy Index is an inverse measure of concentration and has been widely used to measure diversification (Shiyani and Pandya 1998).

The formula for computing Entropy index is as

$$EI = \sum_{i=1}^{n} P_i * log P_i$$

where, P_i stands for proportion of area under i^{th} crop. The index would increase with increase in diversification and the upper value of index can exceed on, when the number of total crops is higher than the value of logarithmic base i.e. 10. The value of index approaches Zero when there is complete concentration. When the number of crops is less than the value of logarithmic base, the value of index varies between Zero and One.

3.1.4. Household Dietary Diversity Score (HDDS)

In measuring dietary diversity, the number of different food groups consumed would be calculated rather than the number of different foods consumed. This is based on the assumption that a household's consumption from six different food groups is better than the consumption of six different foods from the same food group, for example: consumption of different types of cereals. According to the U.N. Food and Agriculture Organization (FAO), there are twelve food groups. Additionally, another food group (leafy vegetable) which is used as 13th food group to calculate HDDS:

A. Cereals
B. Roots and tubers
C. Vegetables
D. Leafy vegetables
E. Fruits
F. Meat and poultry
G. Eggs
H. Fish and seafood
I. Pulses/nuts
J. Milk and milk products
K. Oil/fats
L. Sugar and honey
M. Miscellaneous

The value of HDDS varies from 0 to 13; 13 means maximum diversity and 0 means no diversity.

3.1.5. Dietary Diversity Index (DDI)

Dietary Diversity Index (DDI) is the deviation of the sum of squares of the entire proportion of consumption items in a particular household from the value one. DDI is exactly similar to Herfhindahl Index. The index is represented as

$$\mathrm{DDI} = 1 - \sum_{\mathrm{i}=1}^{\mathrm{n}} C_i^2$$

where we can define,

$$C_i = \frac{a_i}{A}$$

Here, a_i= amount of particular food item consumed by household in a given time period, and A= total amount of food consumed by household in a given time period. The value of DDI lies between zero and one; where zero means zero diversity and one means perfect diversity, of course, in terms of food intake.

3.2. Data and Limitations

Data from two rounds of the *Bangladesh Integrated Household Survey (BIHS)* 2011-12 and 2015 have been used to conduct this study. It is a household survey conducted by Data Analysis and Technical Assistance Limited (DATA) under the supervision of International Food Policy Research Institute (IFPRI). This BIHS survey is statistically representative of the following levels:

i. Nationally representative of rural Bangladesh

ii. Representative of rural areas of each of the seven divisions in Bangladesh

A sound and appropriate statistical method was used to calculate the total BIHS sample survey of 6,503 households in 325 primary sampling units (i.e. villages). The sample size was selected in two ways: first, by selecting primary sampling units (PSUs) and second, by selecting households from the PSUs. Among the 6,500 and households, 4,423 and 4,619 households are “nationally representative (representative of rural Bangladesh)” respectively in 2011-12 and 2015 at the division level and the remaining households fall under a different stratum referred to as the “Feed the Future Zone.” These households falling under the FTF zone have not been considered in this study. Additionally, households which are not involved in the production system have not been included in this study either, as crop diversification in case of these households cannot be measured. Therefore, we have smaller sample size than original BIHS data- 1,697 (3,394 for 2 rounds) out of 2,200 farm households. A point to note is that, research based on this survey data cannot be considered to be nationally representative, because it is representative of only rural Bangladesh. This could be considered one of the main limitations of this study.

3.3. Econometrics' Specification

Now, we have two nationally representative survey data available for rural Bangladesh to analyse the impact of independent variables on dependent variable. Since this data are panel, we can use fixed effects or random effects model. Two models are given below:

Fixed-Effects Model (FE): When using FE, we assume that something within the individual may impact or bias the predictor or outcome variables and we need to control for this. This is the rationale behind the assumption of the correlation between entity's error term and predictor variables. FE removes the effect of those time-invariant characteristics, so we can assess the net effect of the predictors on the outcome variable.

Random-Effects Model (RE): The rationale behind the random effects model is that, unlike the fixed effects model, the variation across entities is assumed to be random and uncorrelated with the predictor or independent variables included in the model. RE allows to generalise the inferences beyond the sample used in the model.

Since there are some unobservable time invariant characteristics among households in rural Bangladesh, we want to control for these factors. So, to control for the unobservable time invariant factors we have used fixed effects model.

The main regression measures the impact of crop diversification on consumption diversification, and then we would like to analyse the impact of dietary diversity on macro and micro nutrients intake of the farm households.

Thus, the model is going to be estimated- the model would incorporate household dietary diversity as the dependent variable and other household characteristics as explanatory variables.

Model 1:

$$Y_{it} = \beta_0 + \beta_1 * (SI \ or \ EI\ )_{it} + \beta_2 * I_{it} + \beta_3 * Crop_{it} + \beta_4 * X_{it} + \alpha_{it} + u_{it}$$

Where,

Y_i= Dietary Diversity Index for household i (HDDS or DDI)

SI= Simpson index

EI= Entropy index

I_i= Income of household i

$Crop_i$= Crop production of household i

α_{it} = Household fixed effect

μ_{it} = Error term

t= Time variable

X_i= Vector of other household characteristics, such as number of international/domestic migrants, gender of household head, family size, education of household head, etc.

Model 2:

$Y_{it} = \beta_0 + \beta_1 * (DDI)_{it} + \beta_2 * I_{it} + \beta_3 * Crop_{it} + \beta_4 * X_{it} + \alpha_{it} + u_{it}$

where,

Y_i= Log of nutrients intake such as per capita kcal/protein/iron/zinc/vitamin A

DDI= Dietary diversity Index

I_i= Income of household i

$Crop_i$= Crop production of household i

α_{it} = Household fixed effect

μ_{it} = Error term

t= Time variable

X_i= Vector of other household characteristics, such as number of international/domestic migrants, gender of household head, family size, education of household head, etc.

CHAPTER 4

CROP DIVERSIFICATION AND DIETARY DIVERSITY

This study postulates that crop diversification or diversity in crop production may have significant impact on improving diversity in food intake or dietary diversity. Dietary diversity could be considered an indicator of food quality in a household. Both descriptive and inferential analysis are needed to explore the causation or association, if any, properly between the dependent variable and independent variables. Before doing econometric analysis, descriptive analysis is conducted to know about the nature and pattern of the data.

4.1. Descriptive Statistics

Table 4.1 shows how dietary diversity or number of households consuming different food groups changes over two rounds of surveying. The changes of household dietary diversity score (HDDS) 11, 12 and 13 over 4 years show that the number of households falling under these three HDDS is higher than the previous round of surveying. Except these three HDDS, the number of households is lower in the second round than those of the first round. So, it can be said that, over the four years, households have earned higher dietary diversity in terms of the thirteen food groups developed by FAO under the FANTA-II project.

Table 4.1: Number of Households Consuming Different Food Groups Over the Years

Year	Number of food groups									
	5	6	7	8	9	10	11	12	13	Total
2011-12	3	30	100	192	279	302	351	289	151	1,697
2015	4	7	23	90	177	266	370	478	282	1,697

Source: BIHS 2011-12 and 2015.

Simpson Index (SI) and Entropy Index (EI) of crop diversification have increased nationally in rural Bangladesh over the period of four years, but this positive change is not significant. In terms of the divisional estimates of SI and EI, crop diversification has not changed significantly across 7 administrative divisions of Bangladesh, except for Sylhet division. In Sylhet division, EI or crop diversification has decreased significantly, from 0.11 to 0.07. However, changes are very small in crop diversification (Table 4.2).

Table 4.2: Average Crop Diversification and Dietary Diversity by Administrative Division

Indicators		Barisal	Chittagong	Dhaka	Khulna	Rajshahi	Rangpur	Sylhet	National
Sl	2011-12	0.25	0.18	0.16	0.49	0.28	.020	0.06	0.18
	2015	0.32	0.20	0.18	0.55	0.29	0.21	0.04	0.19
	Difference	0.07	0.02	0.02	0.06	0.01	0.01	-0.02	0.01
	P-value	0.37	0.37	0.20	0.26	0.80	0.80	0.11	0.21
El	2011-12	0.38	0.31	0.27	0.92	0.50	0.34	0.11	0.32
	2015	0.51	0.36	0.30	0.97	0.49	0.35	0.07	0.34
	Difference	0.13	0.05	0.03	0.05	-0.01	0.01	-0.04	0.02
	P-value	0.33	0.28	0.20	0.60	0.83	0.91	0.08	0.32
HDDS	2011-12	10.05	10.50	10.19	10.09	10.14	9.82	10.21	1017
	2015	10.95	11.26	11.08	10.47	10.86	10.80	10.99	11.00
	Difference	0.90	0.76	0.89	0.38	0.72	0.98	0.78	0.83
	P-value	0.05	0.00	0.00	0.39	0.00	0.00	0.00	0.00
DDI	2011-12	0.75	0.81	0.78	0.80	0.77	0.75	0.78	0.78
	2015	0.83	0.85	0.82	0.78	0.81	0.79	0.82	0.81
	Difference	0.08	0.04	0.03	-0.03	0.03	0.04	0.03	0.03
	P-value	0.01	0.00	0.00	0.19	0.00	0.00	0.00	0.00

Source: BIHS 2011-12 and 2015.
Note: SI= Simpson Index; EI= Entropy Index; HDDS= Household dietary diversity score; DDI= Dietary diversity index.

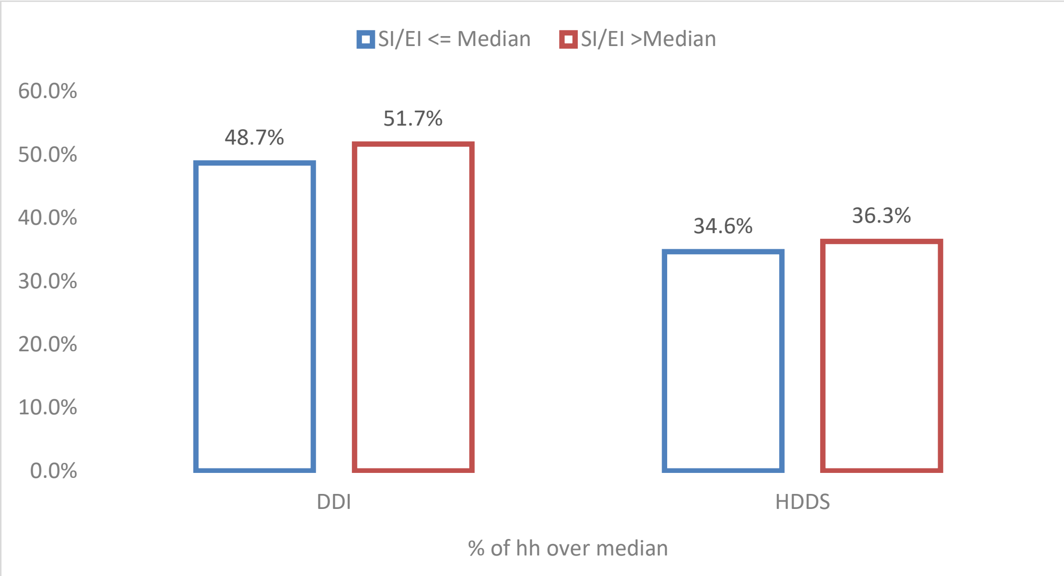
HDDS and DDI have significantly increased nationally in rural Bangladesh over the period of four years. Accordingly, in terms of the divisional estimates of HDDS and DDI, dietary diversity has changed significantly across 7 administrative divisions of Bangladesh except for Khulna. In Khulna division, HDDS has increased and DDI has decreased, but both are insignificant (Table 4.2).

Bangladesh has experienced an increase in dietary diversity, but no changes in crop diversification, both nationally and across administrative divisions, among farm households. However, there is some exception in Sylhet division about crop diversification, and in Khulna division about dietary diversity, both of which have been mentioned earlier.

Number of crops produced and quantity of crop production both decreased from 2011-12 to 2015 (Table 4.1A and Table 4.1B in appendix). The quantity of crop production had been 11895.7994 metric tonnes in 2011-12 and it was decreased to 10231.5605 metric tonnes in 2015.

How many of the households belong to the above median of dietary diversity (DDI/HDDS) according to their crop diversification status is shown in Figure 4.1. It shows that 48.7 per cent of the households with below median of SI/EI have DDI of the above median DDI, and it is 52 per cent for the households with above median SI/EI. Now, if we use HDDS instead of DDI, the percentage of higher dietary diversified households is higher for the higher crop diversified households and vice versa. Since incidence of dietary diversity is higher among the higher crop diversified households, there is a positive relationship between dietary diversity and crop diversification. However, the difference between the changes is not very high.

Figure 4.1: Percentage of the Households according to their Crop Diversification and Dietary Diversity Status



Mean dietary diversity (DDI, HDDS) of the households according to their crop diversification status as below or above median is shown in Table 4.3. Average DDI of the HHS with the above median SI is 0.008 unit higher than that of the HHS with the below median SI. The difference is also significant at 1% significance level. Accordingly, if we use HDDS in terms of DDI, the difference is also significant at 1% level. Therefore, we can conclude that households with the above median SI is more dietary diversified

Table 4.3: Mean Dietary Diversity according to Crop Diversification Status

Crop Diversification (SI)	DDI	HDDS
Lower (below median)	0.795	10.465
Higher (above median)	0.803	10.791
Difference	0.008	0.326
P-value	0.009	0.000

Source: BIHS 2011-2, 2015.

Table 4.4 shows the percentage of the households with and without median dietary diversity according to their income status. Both in terms of DDI and HDDS, the percentage of above median is higher for the higher income households and lower for the lower income households. In contrast, the percentage of the below median households is higher for the lower income households and lower for the higher income households. So, as income increases, incidence of falling above median dietary diversity also increases.

Table 4.4: Percentage of the Households according to their Dietary Diversity and Income

Income Percentiles	DDI		HDDS	
	<=Median	>Median	<=Median	>Median
Bottom 20%	87.6	12.4	92.2	7.8
Q2	70.2	29.8	79.6	20.4
Q3	21.1	47.9	67.7	32.3
Q4	32.8	67.2	53.7	46.3
Top 20%	16.8	83.2	36.4	63.6

Source: BIHS 2011-12, 2015.

Average crop diversification and dietary diversity of the households according to their income are shown in Table 4.5. Average SI does not show any clear difference because of household income, but HDDS and DDI show the differences. In terms of HDDS and DDI, the average number is higher for the higher income level and lower for the lower income level. So, there is seen a positive relationship between household income and diversity in dietary intake.

Table 4.5: Average Crop Diversification and Dietary Diversity according to Income

Income Percentiles	DDI		HDDS
	Sl	HDDS	DDI
Bottom 20%	0.19	9.16	0.72
Q2	0.18	10.04	0.76
Q3	0.19	10.57	0.80
Q4	0.20	11.08	0.83
Top 20%	0.20	11.70	0.83
Total	0.19	10.58	0.80

Source: BIHS 2011-12, 2015.

The relationship between household head and his/her spouse’s educational qualification and their dietary diversity is similar to the previous relationship of dietary diversity and crop diversification with income (Table 4.6). There is no clear relationship between household head’s educational qualification and crop diversification, but the relationship is positive between head’s educational qualification and dietary diversity (HDDS, DDI). HDDS and DDI are higher for the higher household head’s qualifications and vice versa. Accordingly, the relationship of dietary diversity with household head’s educational qualification is similar to that with educational qualifications of the head’s spouse except higher-secondary completion. The relationship between educational qualification (for both household head and his/her spouse) and crop diversification or dietary diversity is similar to the relationship between literacy and diversity. That relationship of literacy with crop diversification or dietary diversity is shown in appendix Table 4.3C.

Table 4.6: Average Crop Diversification and Dietary Diversity according to Educational Qualifications

Education of the:		Crop Diversification and Dietary Diversity		
		Sl	HDDS	DDI
Household Head	Less than primary	0.19	10.34	0.78
	Primary completed	0.19	10.89	0.81
	Secondary completed	0.22	11.19	0.82
	Higher-secondary	0.17	11.49	0.84
	Graduate	0.14	11.86	0.88
Household head's spouse	Less than primary	0.19	10.37	0.78
	Primary completed	0.18	10.94	0.81
	Secondary completed	0.22	11.55	0.84
	Higher-secondary	0.14	11.33	0.85
	Graduate	0.19	12.09	0.87

Source: BIHS 2011-12, 2015.

Table 4.7 shows the mean crop diversification and dietary diversity in terms of gender of household head. There is no significant difference between crop diversification (SI) and DDI due to the gender of head. However, male-headed households consume significantly from more food groups than that of female-headed households.

Table 4.7: Average Crop Diversification and Dietary Diversity according to the Household Head's Gender

Gender of the head	Sl	HDDS	DDI
Female	0.18	10.28	0.80
Male	0.19	10.60	0.80
Difference	-0.01	-0.33	0.00
P-Value	0.555	0.005	0.611

Source: BIHS 2011-12, 2015.

The estimates on percentage of the households with less than median and above median according to gender of the head are shown in Table 4.8. Among the 232 female-headed households, 53 per cent have DDI above the median, and among the 3,156 male-headed households, it is 49.8 per cent. Accordingly, among the 232 female-headed households, 30 per cent have HDDS above median, and among the 3,156 male-headed households, it is 36 per cent. So, male-headed households have the higher probability of having DDI above the median than that of female-headed households, and female-headed households have the higher probability of having higher HDDS than that of male-headed households.

Table 4.8: Percentage of the Households according to the Gender of the Head

Gender of the head	DDI		HDDS		Total
	<=Median	>Median	<=Median	>Median	
Female	46.98	53.02	69.83	30.17	232
Male	50.25	49.75	64.32	35.68	3,156

Source: BIHS 2011-12, 2015.

Estimates of the SI, HDDS and DDI according to household size are shown in Table 4.9. Average crop diversification (SI) and dietary diversity (DDI) are significantly higher for the households with size below the median and vice versa. In contrast, dietary diversity in terms of HDDS is significantly higher for the households with size above the median and vice versa.

Table 4.9: Average Crop Diversification and Dietary Diversity according to the Household Size

Household Size	Crop Diversification or Dietary Diversity		
	Sl	HDDS	DDI
<=Median	0.21	10.40	0.80
>Median	0.17	10.80	0.79
Difference	-0.04	0.40	-0.01
P-value	0.000	0.000	0.023

Source: BIHS 2011-12, 2015.

Table 4.10: Percentage of the Households according to the Gender of Household Size

Household size	DDI		HDDS		Total
	<=Median	>Median	<=Median	>Median	
<=Median	48.41	51.59	68.30	31.70	1855
>Median	51.92	48.08	60.23	39.77	1539
All	50.00	50.00	64.64	35.36	3394

Source: BIHS 2011-12, 2015.

The estimates on percentage of the households with less than median and above median according to gender of household size are shown in Table 4.10. Among the 1,855 below median household size, 52 per cent have DDI above the median, and among the 1,539 above the median households, it is 48 per cent. Accordingly, among the 1,855 below the median size households, 32 per cent have HDDS above median, and among the 1,539 above the median households, it is 40 per cent. So, households with lower size have the higher probability of having DDI above the median than that of households with higher size, and households with higher size have the higher probability of having higher HDDS than that of households with lower size. Relationship of household size with DDI and HDDS is not the same.

Simpson Index (SI) is highest for small farmer and lowest for big farmers (Table 4.11). In contrast, DDI and HDDS are highest for big farmer and lowest for small farmers. So, there is a positive relationship between farmer's land ownership and diversity in dietary intake among the farm households. However, there is a negative relationship between farmer's land and crop diversification, which implies that the smaller farmers are more diversified in crop production than the bigger farmers.

Table 4.11: Average Crop Diversification and Dietary Diversity Intake by Farmer's Land Ownership

Farmer's Category	Sl	HDDS	DDI
Small	0.19	10.52	0.79
Medium	0.16	11.24	0.82
Big	0.14	11.50	0.84
All	0.19	10.58	0.80

Source: BIHS 2011-12, 2015.

4.2. Inferential Statistics

In this study, panel data models have been used to analyse the association between crop diversification and dietary diversity or impact of crop diversification of the households on dietary diversity. Simpson Index (SI) and Entropy Index (EI) are used to measure crop diversification, while Household Dietary Diversity Score (HDDS) and Dietary Diversity Index (DDI) are used to measure the dietary diversity of the households.

Table 4.12: Regression Results on Dietary Diversity of the Household

VARIABLES	DDI (1)	HDDS (1)	DDI(2)	HDDS(2)
Simpson Index (SI)	0.002	-0.368*		
	(-0.0115)	(-0.222)		
Rice Share Index (RI)	-0.0223***	-0.504***	-0.0224***	-0.495***
	(-0.00838)	(-0.162)	(0.008)	(0.161)
Gender of the head: Male	-0.009	-1.309	-0.009	-1.318
	(-0.0453)	(-0.876)	(0.045)	(0.876)
Age of the head	0.000	-0.001	0.000	-0.001
	(0.001)	(0.016)	(0.001)	(0.016)
Age of the spouse of head	0.001	0.019	0.001	0.019
	(0.001)	(0.017)	(0.001)	(0.017)
Education of the spouse:				
Primary	0.006	0.097	0.006	0.097
	(0.010)	(0.194)	(0.010)	(0.194)
Secondary	0.001	-0.306	0.001	-0.325
	(0.032)	(0.622)	(0.032)	(0.622)
Higher-secondary	0.022	3.433*	0.022	3.428*
	(0.094)	(1.817)	(0.094)	(1.817)
Graduation	0.023	1.633	0.023	1.633
	(0.093)	(1.796)	(0.093)	(1.796)
HH size	0.00551**	0.364***	0.00551**	0.364***
	(0.002)	(0.042)	(0.002)	(0.042)
International migrants Dummy	0.004	0.106	0.004	0.105
	(0.009)	(0.178)	(0.009)	(0.178)
Domestic Migrants Dummy	0.008	-0.059	0.008	-0.059
	(0.006)	(0.117)	(0.006)	(0.117)
Land Holding:				
2.5 acres <= Land <7.5 acres	-0.0424***	-0.447	-0.0424***	-0.447
	(0.014)	(0.274)	(0.014)	(0.274)
Land>=7.5 acres	0.021	-0.597	0.021	-0.599
	(0.034)	(0.654)	(0.034)	(0.654)
Income	0.100***	2.297***	0.100***	2.298***
	(0.006)	(0.111)	(0.006)	(0.111)
Entropy Index			0.001	-0.189
			(0.006)	(0.124)
Constant	-0.053	-8.451***	-0.053	-8.455***
	(0.067)	(1.287)	(0.067)	(1.287)
Observations	3,051	3,051	3,051	3,051
R-squared	0.228	0.299	0.228	0.299
Number of hhsid	1,589	1,589	1,589	1,589

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Since we have panel data, we used panel data models in our regression. We have used Fixed Effects (FE) and discussed the results of FE as we are more interested to control for the time invariant factors.

The second model from Table 4.12 is the panel fixed effects model, where we have used HDDS as dependent variable. It shows that the coefficient of the concentration on rice ratio (RI), household and household income is significant at 1% significance level. Accordingly, coefficients of the crop diversification (SI) and household head's spouse with higher-secondary completed are significant at 10% level. And all other variables are insignificant such as gender of the household head, age of the household head and head's spouse, land holding and migration dummy (both domestic and international).

There is a negative impact of the Simpson Index (SI) of crop diversification on dietary diversity among the farm households. However, the coefficient is only significant at 10% significance level.

Everything's remaining constant and for a given household, as SI increases across time by one unit, HDDS decreases by 0.368 unit. This implies that, as crop diversification increases, dietary diversity among those households decreases. However, the impact is very small and only significant at 10% level.

Other things remaining constant and for a given household, as rice concentration (RI) increases across time by 1unit, dietary diversity (HDDS) decreases by 0.50 unit. In other words, we can say decreasing the proportion of rice production significantly increases the diversity in dietary intake. Households with lower concentration on rice production consume more food groups.

Everything's remaining constant and for a given household, one member increasing leads to 0.36 unit increase in dietary diversity and households with higher secondary completed head are 3.43 food groups consume more than the uneducated head. So, household size and education of the head are two of the determinants of household diversity in dietary intake.

For a given household, as income increases across time by 100%, HDDS of the household increases by 2.3 units. The increase in HDDS is highly significant. Increasing in household income encourages to diversify the food intake among the members. A 100 per cent increase in household leads to 2.3 more food groups in the diet.

Since HDDS has its limitation, we are using DDI instead of HDDS to measure the dietary diversity of the households (Table 4.12, column 1).

The first model from Table 4.12 is the panel fixed effects model, where we have used DDI as dependent variable. It shows that the coefficient of the concentration on rice ratio (RI) is significant at 1% significance level. Accordingly, coefficients of the hhs income and medium farmer (2.5acres<= land <7.5acres) are significant at all 1%, 5% and 10% significance level, while coefficient of the household size is significant at 5% level. And all other variables are insignificant such as gender of the household head, age of the household head and head's spouse, educational qualification of the household head, and migration dummy (both national and international). Big farmer (land holding >= 7.5 acres) is not significantly better than the small farmer in terms of dietary diversity.

There is a positive impact of the Simpson Index (SI) of crop diversification on dietary diversity among the farm households. However, the coefficient is not significant, which is contradictory with the coefficient of DDI.

Everything's remaining constant and for a given household, as SI increases across time by 1unit, DDI increases by 0.002 unit. This implies that, as crop diversification increases, dietary diversity among the households also increases. However, the impact is very small and insignificant.

Other things remaining constant and for a given household, as rice concentration (RI) increases across time by 1unit, dietary diversity (DDI) decreases by 0.012 unit. In other words, we can say decreasing the proportion of rice production significantly increases diversity in dietary intake. Everything's remaining constant and for a given household, one member increasing leads to 0.006 unit increase in dietary diversity index.

For a given household, as income increases across time by 100%, DDI of the households increases by 0.10 unit. The increase in DDI is highly significant. Increasing in household income encourages to diversify the food intake among the members.

Households with medium land (2.5 acres<=land<7.5 acres) are worse than the small households (land<2.5). For a given household, as it has more land than a small household, DDI decreases by 0.04 unit for this household than the household with small land. Smaller land holding households are significantly more diversified in dietary intake than bigger land holding households.

In columns 3 and 4 of the Table 4.12, Entropy Index (EI) is used instead of SI of crop diversification. EI is not significant for any of the HDDS or DDI. And coefficients of the other variables are similar to corresponding column 1 and 2.

There is a positive impact of crop diversification on dietary diversity among the farm households through increasing the availability of the different fruits and vegetables. However, that impact on dietary intake is not always significant. Similarly, if we consider concentration on rice production as crop diversification, then crop diversification has always positive and significant impact. Other three most important determinants of the dietary diversity among farm households are income, household size and farmers land holding.

CHAPTER 5

NUTRIENTS INTAKE

This chapter discusses the changes of some macro and micro nutrients intake over the period of time among farm households of rural Bangladesh and across the seven administrative divisions. There might be changes in the number of households consuming recommended level of nutrients intake in that period. Also, we are going to link those nutrients intake with household dietary diversity- relationship between dietary diversity and nutrients intake. Recommended level of nutrition developed by World Health Organization (WHO) and Food and Agriculture Organization of United Nations (FAO) in 2004 is used in the analysis.

5.1. Descriptive Statistics

5.1.1. Nutrients Intake among the Farm Households

Table 5.1 shows the changes of average per capita calorie and protein intake among the farm households nationally as well as across the 7 administrative divisions of Bangladesh. Average per capita calorie intake has decreased from 3,465 kilocalorie to 3,347 kilocalorie and average protein intake decreased from 89.7 grams to 89.2 grams. Average per capita kilocalorie and protein intake have decreased over the years, but both the changes are not significant. Reduction of the average per capita calorie intake is significant but reduction of the per capita protein intake is not significant.

Table 5.1

Average Per Capita Calorie and Protein Intake by Administrative Division

Per capita intake		Division							National
		Barisal	Chittagong	Dhaka	Khulna	Rajshahi	Rangpur	Sylhet	
Kilocalorie	2011	3557.2	3228.4	3571.1	3866.0	3428.7	3317.9	3555.2	3465.2
	2015	3169.8	3204.6	3437.3	3219.8	3318.8	3405.0	3242.6	3346.8
	Diff.	-387.4	-23.8	-133.8	-646.2	-110.0	87.1	-312.9	-118.4
	P-Value	0.195	0.806	0.041	0.010	0.137	0.277	0.000	0.001
Protein	2011	92.9	85.6	94.1	97.4	85.3	82.0	94.2	89.7
	2015	79.6	89.7	92.4	78.2	88.1	87.0	85.5	89.2
	Diff.	-13.2	4.1	-1.6	-19.2	2.8	4.9	-8.7	-0.5
	P-Value	0.140	0.166	0.424	0.009	0.197	0.028	0.004	0.652

Source: BIHS 2011-12 and 2015.

In 2011-12, among the households across divisions, average per capita calorie intake is highest in Khulna (3866 kcal) and average per capita protein intake is highest in Sylhet (94.2 grams) division. In 2015, among the households across divisions, average per capita calorie intake is highest in Dhaka (3437 kcal) and average per capita protein intake is also highest in Dhaka (92.4 grams) division.

Average calorie intake has decreased significantly in Dhaka, Khulna and Sylhet divisions; however, changes is not significant in other divisions. While average protein intake has decreased significantly in Sylhet and Khulna division, it has increased significantly in Rangpur division.

Table 5.2 shows the changes of average per capita iron, zinc and vitamin A intake among the farm households nationally as well as across the 7 administrative divisions of Bangladesh. Average per capita iron intake has increased from 15.5 mg to 15.9 mg, average per capita zinc intake increased from 10.5mg to 10.8 and average per capita vitamin A intake increased from 334.3 RAE to 464 RAE. Average per capita iron, zinc and vitamin A intake has increased significantly over the years.

In 2011-12, among the households across divisions, average per capita intake of iron, zinc and vitamin A is 18.6 mg, 11.9 mg and 453 RAE respectively in Khulna. In 2015, among the households across divisions, average per capita iron intake is highest in Rangpur (16.5 mg), average per capita zinc intake is highest in Rajshahi (11.4 mg), and average per capita vitamin A intake is highest in Chittagong (404 RAE) division.

Average iron intake has decreased significantly in Khulna and Sylhet divisions and increased significantly in Rajshahi and Rangpur divisions. However, changes are not significant in other divisions. Average zinc intake has decreased significantly in Barisal, Sylhet and Khulna divisions, and increased significantly in Rangpur and Rajshahi divisions. Average per capita vitamin A intake has increased significantly in Chittagong, Dhaka, Rajshahi, Rangpur and Sylhet divisions, and significantly decreased only in Khulna division.

Table 5.2
Average Per Capita Iron, Zinc and Vitamin A Intake by Administrative Division

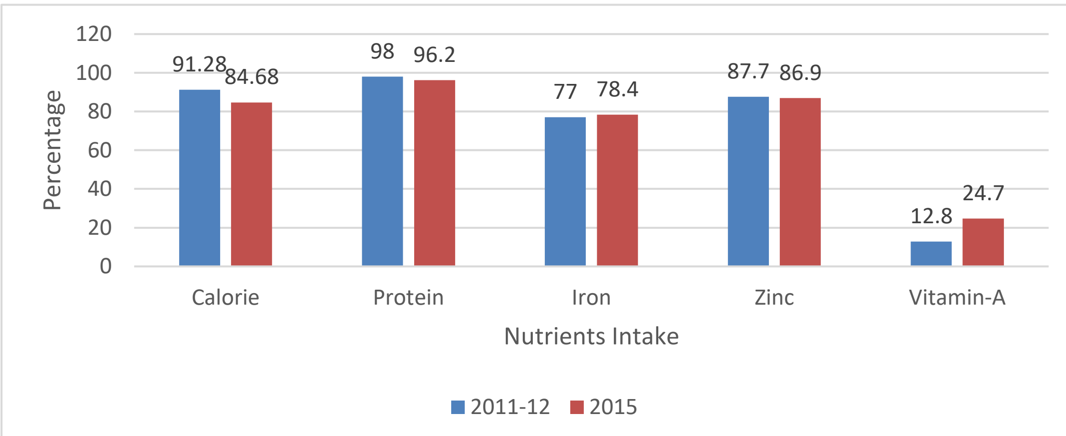
Per capita intake		Division							National
		Barisal	Chittagong	Dhaka	Khulna	Rajshahi	Rangpur	Sylhet	
Iron	2011	16.6	15.2	16.2	18.6	14.4	14.4	15.9	15.5
	2015	14.9	16.0	16.1	13.9	16.3	16.5	14.7	15.9
	Diff.	-1.7	0.8	-0.1	-4.7	1.9	2.1	-1.2	0.4
	P-Value	0.306	0.158	0.783	0.002	0.000	0.000	0.017	0.044
Zinc	2011	11.4	10.2	10.8	11.9	10.1	9.5	11.3	10.5
	2015	9.3	10.7	11.1	9.3	11.4	10.6	10.0	10.8
	Diff.	-2.1	0.5	0.3	-2.6	1.3	1.1	-1.3	0.3
	P-Value	0.073	0.158	0.203	0.009	0.000	0.000	0.000	0.013
Vitamin A	2011	381.7	404.0	326.4	452.6	302.0	263.8	383.9	334.3
	2015	407.2	567.2	461.3	239.4	369.4	456.7	545.6	464.8
	Diff.	25.5	163.2	134.9	-213.2	67.3	192.9	161.7	130.5
	P-Value	0.816	0.000	0.000	0.023	0.008	0.000	0.000	0.000

Source: BIHS 2011-12 and 2015.

5.1.2. Households with Consuming Required Amount of Nutrition

Consumption of the adequate level of micro and macro nutrients among the farm households of rural Bangladesh is shown in Figure 5.1. Percentage of the households consuming adequate level of iron and vitamin A intake have increased from 2011-12 to 2015, but that of calorie, protein and zinc have decreased in that period. Percentage of the households consuming recommended level of per capita calorie, protein and zinc have decreased from 91.3 to 85 per cent, 98 to 96 per cent and 88 to 87 per cent respectively. On the other hand, percentage of the households consuming recommended level of per capita iron and vitamin A intake have increased from 77 to 78.4 per cent and 13 to 25 per cent respectively. In terms of growth, vitamin A has the highest percentage growth. It is alarming that still only 25 per cent of the farm households consume recommended level of per capita vitamin A. They are might be unaware of the micro nutrition like vitamin A and also might have less knowledge about micro nutrients enriched food.

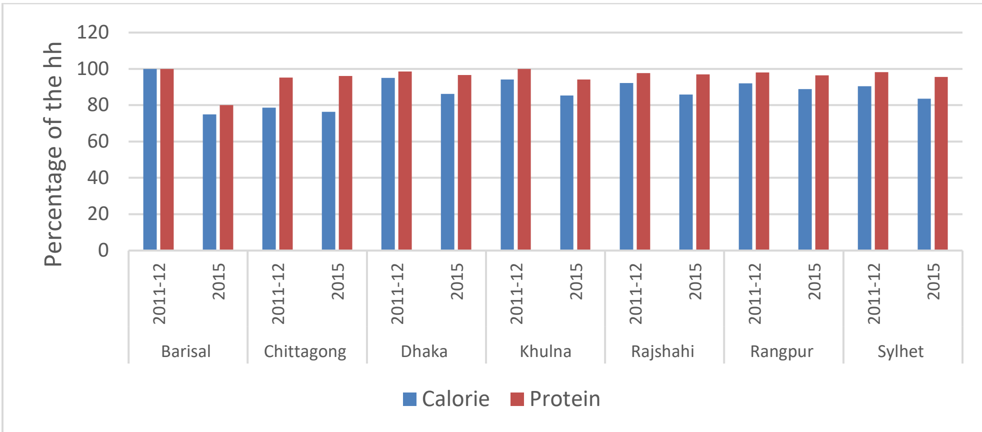
Figure 5.1: Percentage of the Household Consuming Required Amount of Nutrients



Percentage of the households consuming required level of calorie and protein intake has changed for all of the 7 divisions of Bangladesh (Figure 5.2). Percentage of the households consuming recommended level of these two nutrients is highest (100%) in Barisal division, which means in 2011-12 almost all of the farm households in this division consume required amount. But, in 2015, the percentage for calorie and protein intake is highest in Dhaka and Rajshahi divisions respectively. In terms of calorie intake, the percentage has decreased in all seven divisions. So, over the years, across all divisions, households with consuming required amount of calorie have decreased, which implies that households are becoming worse day by day in terms of having calories.

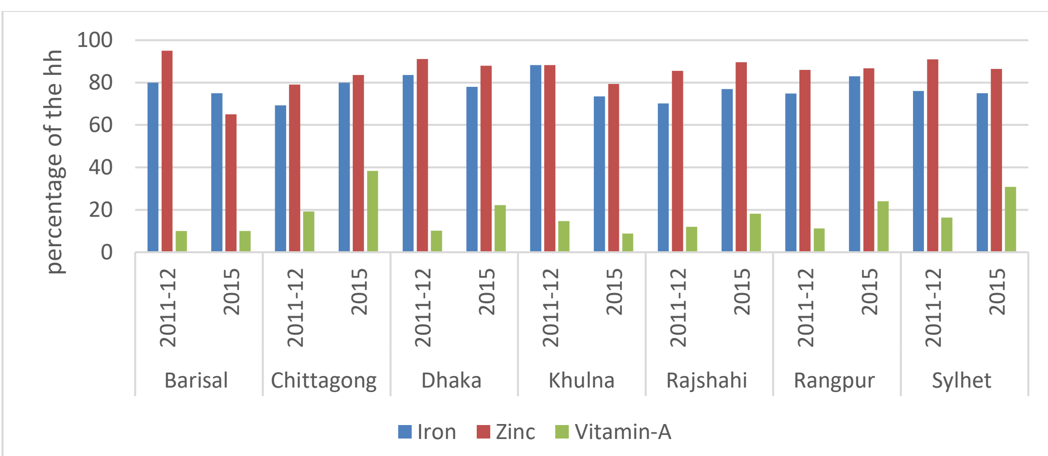
Although in terms of protein intake, the percentage has decreased in Barisal, Dhaka, Khulna, Rajshahi, Rangpur and Sylhet divisions, it has only increased in Chittagong division. So, over the years, across all divisions except for Chittagong, households with consuming required amount of protein have decreased, which implies that households are becoming worse day by day in terms of having protein.

Figure 5.2: Percentage of the Households Consuming Required Amount of Calorie and Protein by Administrative Division



Percentage of the households consuming required level of per capita iron, zinc and vitamin A intake has changed for all of the 7 divisions of Bangladesh except for Barisal (Figure 5.3). Percentage of the households consuming recommended level of iron, protein and zinc is highest in Khulna (88 per cent), Barisal (96 per cent) and Chittagong (19 per cent) divisions respectively in 2011-12. But, in 2015, the percentage for iron, zinc and vitamin A intake is highest in Rangpur, Rajshahi and Sylhet divisions respectively. In terms of zinc and iron, the percentage has decreased in Barisal, Dhaka, Khulna and Sylhet divisions and increased in Chittagong, Rajshahi and Rangpur divisions. So, over the years, across most of the divisions, households with consuming required amount of iron and zinc have decreased. While, in terms of vitamin A intake, the percentage has decreased in Dhaka, Khulna and Sylhet divisions, it has increased in Chittagong, Rajshahi and Rangpur divisions and it is stable at 10 per cent in Barisal division.

Figure 5.3: Percentage of the Household Consuming Required Amount of Iron, Zinc and Vitamin-A by Administrative Division



5.1.3. Dietary Diversity and per capita Nutrients Intake

How many of the HHs with less or equal to median dietary diversity index (DDI) and greater than median DDI consume required per capita nutrients intake are shown in Table 5.3. The percentage of the households with less or equal to median DDI is 87, 96, 66, 82 and 8.4 per cent respectively in consuming recommended level of calories, protein, iron, zinc and vitamin A. However, the percentage of the households with less or equal to median DDI is 89, 98, 90, 93 and 29 per cent respectively in consuming recommended level of calories, protein, iron, zinc and vitamin A. It means among the high dietary diversified households, the consequence of consuming required level of nutrition is higher than that of low dietary diversified households.

Table 5.3

Percentage of the Households Consumed Required Level of Nutrients according to their Dietary Diversity

		DDI		Total
		<=Median	>Median	
% of the HHs Consumed Required Calorie	No	13.1	10.9	12.0
	Yes	86.9	89.1	88.0
% of the HHs Consumed Required Protein	No	3.7	2.2	3.0
	Yes	96.3	97.8	97.0
% of the HHs Consumed Required Iron	No	34.0	10.5	22.3
	Yes	66.0	89.5	77.7
% of the HHs Consumed Required Zinc	No	18.3	7.0	12.7
	Yes	81.7	93.0	87.3
% of the HHs Consumed Required Vitamin A	No	91.6	71.0	81.3
	Yes	8.4	29.0	18.7

Source: BIHS 2011-12, 2015.

Table 5.4 shows the average nutrients intake by the households with less than median DDI and above the median DDI. It also describes their difference between means and their P-values. Average nutrients (calories, protein, iron, zinc and vitamin A) intake by the households with the above median DDI is significantly higher than those households with less than median DDI. Diversity in dietary intake has a positive and significant correlation with per capita macro and micro nutrients of the households.

Table 5.4

Average Nutrients Intake of the Households according to their Dietary Diversity

DDI	Calorie	Protein	Iron	Zinc	Vitamin A
<=Median	3244.89	79.85	13.31	9.32	282.06
>Median	3567.47	98.98	18.12	12.01	516.87
Difference	322.59	19.13	4.81	2.69	234.81
P-Value	0.000	0.000	0.000	0.000	0.000

Source: BIHS 2011-12, 2015.

5.1.4. Household Income and per capita Nutrients Intake

Among the farm households of Bangladesh, 69 per cent of the bottom 20 per cent income group consume recommended level of calories (Table 5.5). While it is 97 per cent for the top 20 per cent income group, and the percentage is between 69 per cent and 97 per cent among other income quintiles. In terms of protein consumption, 89 per cent of the bottom 20 per cent income group consume recommended level of calories, while it is 99.8 per cent for the top 20 per cent income group, and the percentage is between 89 per cent and 99.8 per cent among other income quintiles. Accordingly, the percentage of the households consuming recommended level of iron, zinc and vitamin A is higher for the higher income quintiles and vice versa. Therefore, income and per capita required amount of nutrients intake have a positive relationship.

Table 5.5

Percentage of the Households Consuming Recommended Level of Nutrients according to their Income Status

		% of the households consuming recommended level of nutrients				
		Calorie	Protein	Iron	Zinc	Vitamin A
Income Percentiles	Bottom 20%	68.9	89.2	44.0	63.2	9.2
	Q2	86.4	96.8	71.7	82.9	11.0
	Q3	89.2	97.9	79.6	89.6	17.7
	Q4	92.9	99.1	88.5	95.3	21.2
	Top 20%	96.9	99.8	95.1	98.3	32.7

Source: BIHS 2011-12, 2015.

Among the farm households of Bangladesh, bottom 20 per cent of the income group consume 2759 kcal on an average (Table 5.6). It is 4242 kcal for the top 20 per cent income households and these percentages are between previous two for the other income quintiles. In terms of protein, top 20 per cent income households consume 67 grams on an average and it is 119 grams for the top 20 per cent income households. Accordingly, the average nutrients intake of the households in terms of iron, zinc and vitamin A is higher for the higher income quintiles and vice versa. Therefore, income and average per capita nutrients intake have a positive relationship.

Table 5.6

Average Per Capita Nutrients Intake of the Households according to Their Income Status

	% of the households consuming recommended level of nutrients				
	Calorie	Protein	Iron	Zinc	Vitamin A
Bottom 20%	2759.2	67.4	11.6	8.0	266.4
Q2	3068.5	77.1	13.6	9.2	320.8
Q3	3267.7	84.2	14.8	10.0	388.5
Q4	3567.7	95.4	16.7	11.3	425.1
Top 20%	4242.2	118.9	21.1	14.2	569.1
Total	3406.1	89.4	15.7	10.7	399.4

Source: BIHS 2011-12, 2015.

5.1.5. Household Size and Nutrients Intake

The households with size greater than the median consume less per capita calorie, protein, iron, zinc and vitamin A than that of the households with size less than the median (Table 5.7). Differences in average intake are all significant except vitamin A. Smaller size households consumes higher per capita nutrients than the bigger size households. So, household size has a negative relationship with nutrients. The lesser the household size, the more the per capita nutrients intake among the household members.

Table 5.7

Average Per Capita Nutrients Intake of the Households according to the Size

Household Size	Average nutrients intake				
	Calorie	Protein	Iron	Zinc	Vitamin A
<=Median	3525.29	92.54	16.59	11.09	403.59
>Median	3261.85	85.61	14.65	10.16	394.33
Difference	-263.44	-6.93	-1.94	-0.93	-9.26
P-Value	0.000	0.000	0.000	0.000	0.438

Source: BIHS 2011-12, 2015.

5.1.6. Household Head's and His/Her Spouse's Characteristics and Nutrients Intake

Table 5.8 shows the average per capita nutrients intake of the households according to the gender of their head. The households with female head consume more of 154 kcal, 6 grams protein, 1.4 mg iron, 0.6 mg zinc and 82 RAE vitamin A than the male-headed households. All of the differences are significant. In the farm households of Bangladesh, people consume significantly more nutrients in the female-headed households than the male-headed households.

Table 5.8

Average Per Capita Nutrients Intake of the Households according to the Gender of Household Head

Gender of the head	Average nutrients intake				
	Calorie	Protein	Iron	Zinc	Vitamin A
Female	3549.445	94.94401	17.05316	11.22103	475.5019
Male	3395.547	88.99805	15.61647	10.62401	393.8015
Difference	153.898	5.94596	1.43669	0.59702	81.7004
P-value	0.0286	0.0065	0.0008	0.0329	0.0005

Source: BIHS 2011-12, 2015.

The relationship between educational qualification of the household head and per capita nutrients intake of the households is shown in Table 5.9. Average per capita intake of calorie, protein, iron and zinc is higher for the households with higher educational qualification. Per capita vitamin A intake is also higher for the higher educational qualification of the head except the higher secondary level. However, we cannot see any relationship between educational qualification of the spouse of household head and per capita nutrients intake.

Table 5.9

Average Per Capita Nutrients Intake according to the Educational Qualification of the Head and of the Head's Spouse

Education of the Head	Average nutrients intake				
	Calorie	Protein	Iron	Zinc	Vitamin A
Less than primary	3378.86	87.93	15.44	10.47	398.77
Primary completion	3435.09	90.73	15.97	10.85	393.78
Secondary completion	3435.00	93.21	16.02	11.06	410.20
Higher-secondary	3483.23	95.86	17.02	11.56	362.01
Graduate	3936.71	110.25	20.83	13.18	617.93
All	3405.87	89.40	15.71	10.66	399.44
Education of the head's spouse:					
Less than primary	3401.13	88.17	15.45	10.51	394.18
Primary completion	3367.88	89.37	15.64	10.67	383.64
Secondary completion	3382.64	94.31	16.84	11.44	379.27
Higher-secondary	3219.84	86.64	16.56	10.57	533.12
Graduate	3552.81	99.33	19.24	12.64	610.15
All	3388.11	88.73	15.57	10.59	392.21

Source: BIHS 2011-12, 2015.

5.2. Inferential Statistics

Before this section, we have discussed about descriptive statistics related to per capita kilocalorie, protein, iron, zinc and vitamin A intake of the Bangladeshi farm households. Here we would like to enunciate the impact of explanatory variables on nutrients intake. More importantly, we want to find the impact of household dietary diversity on nutrients intake among households. As there are some time invariant unobservable characteristics among households and we want to control for it, we have used panel fixed effect (FE) model. Regression results are shown in Table 5.10.

Table 5.10

Regression Results on Per Capita Nutrients Intake

Variables	Calorie (kcal)	Protein (grams)	Iron (mg)	Zinc (mg)	Vitamin-A (rae)
DDI	-0.517***	0.12	1.074***	0.514***	3.821***
	(0.08)	(0.09)	(0.10)	(0.10)	(0.26)
Gender of the head	0.06	0.07	0.07	0.05	-0.51
	(0.15)	(0.16)	(0.18)	(0.17)	(0.45)
Age of the head	-0.0094***	-0.01***	-0.01***	-0.01***	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Age of the spouse of head	0.00	0.00	0.00	0.00	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Literacy-head dummy	-0.0281*	-0.039**	-0.0305*	-0.0313*	-0.04
	(0.02)	(0.02)	(0.02)	(0.02)	(0.05)
Literacy of the spouse of head dummy	-0.0438***	-0.04***	-0.033**	-0.0245*	0.03
	(0.01)	(0.01)	(0.02)	(0.01)	(0.04)
hh size	-0.016**	-0.02***	-0.03***	-0.02***	0.0486**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Land Holding:					
2.5 acres <= Land <7.5 acres	-0.07	-0.108**	-0.08	-0.107**	-0.08
	(0.05)	(0.05)	(0.06)	(0.05)	(0.14)
Land>=7.5 acres	0.05	0.01	0.05	0.04	0.12
	(0.11)	(0.12)	(0.13)	(0.13)	(0.34)
International migrants dummy	0.03	0.02	0.0548**	0.04	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.06)
Domestic Migrants Dummy	0.00	-0.02	-0.05	-0.03	-0.14
	(0.03)	(0.03)	(0.04)	(0.04)	(0.09)
Income	0.378***	0.417***	0.380***	0.418***	0.614***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.06)
Crop production	0.0171**	0.0178**	0.0200**	0.0163**	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Constant	6.033***	1.618***	-0.674**	-0.94***	-2.26***
	(0.21)	(0.23)	(0.26)	(0.25)	(0.66)
Observations	3062.00	3062.00	3062.00	3062.00	3062.00
R-squared	0.23	0.29	0.32	0.29	0.31
Number of hhsid	1591.00	1591.00	1591.00	1591.00	1591.00

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Since we have panel data, we used panel data models in our regression. We have used Fixed Effects (FE) and discussed the results of FE as we are more interested to control for the time factors. Dependent variables in the Table 5.10 all are shown in the logarithmic form. Income and crop production are also shown in logarithmic form.

Among the explanatory variables, coefficients of dietary diversity (DDI), age of the household head, literacy dummy of the spouse of head and log of income are significant at 1% significance level for all five nutrients intake except for protein.

Everything's remaining constant and for a given household, as DDI increases by 0.10 unit, per capita calorie intake decreases by 5.2 per cent, which implies that more diversified in household means lower per capita calorie intake. For a given household and other things remaining constant, as DDI increases by 0.01 (unit), per capita protein, iron, zinc and vitamin A intake increases by 1.2, 11, 5 and 38 per cent respectively. There is a positive and significant impact of dietary diversity on nutrients intake except for calorie intake. The impact of dietary diversity on calorie intake is negative and that impact on protein intake is not significant. More diversified in diet leads to more intake of micro-nutrients than macro nutrients.

For a given household and everything's remaining constant, as age of the household head increases by one year, per capita calorie, protein, iron, zinc and vitamin A decrease by 0.9, 1, 1, 1 and 0.3 per cent respectively. So, the impact of the age of household head is negative for all five micro and macro nutrients. If age of the head increases, the household is less likely to consume more nutrients.

Surprisingly, the impact of the literacy of household head and head's spouse is negative and significant on nutrients intake. Everything's remaining constant and for a given household, as the head is literate, the members consume 3, 4, 3, 3, and 4 per cent less amount of calorie, protein, iron, zinc and vitamin A respectively than the households with illiterate head. For a given household and other things remaining constant, as the head's spouse is literate, the members consume 4.4, 3.7, 3.3, 2.5, and 3 per cent less amount of calorie, protein, iron, zinc and vitamin A respectively than the households with illiterate head's spouse. Therefore, members of the households with illiterate head and/or illiterate head's spouse consume more nutrition than the members of the households with literate head and/or head's spouse.

For a given household and everything's remaining constant, as household increases by one member, per capita calorie, protein, iron, zinc and vitamin A decrease by 1.6, 2.2, 2.7, 2.2 and 4.9 per cent respectively. So, the impact of household size is negative on all five micro and macro nutrients. If size of the household increases, the members are less likely to consume more nutrients and vice versa.

The coefficient of the medium farmers (2.5>=land holding<7.5) is negative and significant for protein and zinc intake. While the coefficient of higher farm is positive but insignificant. Everything's remaining constant and for a given household, as it has land below 7.5 acres and above 2.5 acres, the members consume 10.8 and 10.7 per cent less amount of protein and zinc than the households with land below 2.5 acres. Medium land holding households consume less and big households consume more nutrients than the small households.

Households with at least one domestic migrated member consume more nutrients. More specifically, members of households with at least one or more domestic migrated member consume significantly more iron than the households with no domestic migrated households. Everything's remaining constant and for a given household, as there is at least one domestic migrant member, members consume 54 per cent more iron than the members of households with no domestic migrants.

The coefficients of the income are elasticity of nutrients intake. Everything's remaining constant and for a given household, as income increases by 10 per cent, per capita calorie, protein, iron, zinc and vitamin-A intake increases by 3.8, 4.2,3.8, 4.2 and 6.1 per cent respectively. All of the coefficients are highly significant, which means that, as income increases in a household per capita nutrients intake is also increases significantly. Higher income households are more likely to consume more per capita calorie, protein, iron, zinc and vitamin-A.

The coefficients of the household total crop production are also elasticity of nutrients intake. Everything's remaining constant and for a given household, as crop production increases by 100 per cent, per capita calorie, protein, iron, zinc and vitamin-A intake increases by 1.7, 1.8, 2, 1.6 and 1.34 per cent respectively. All of the coefficients are significant at 5% level except that of the vitamin-A, which means that as crop production increases in a household, per capita nutrients intake is also increases significantly. Household with higher amount of production is more likely to consume more per capita calorie, protein, iron, zinc and vitamin-A.

Diversity in dietary intake has positive and significant impact on micro nutrients intake such as per capita iron, zinc and vitamin-A intake, and the impact is negative in per capita calorie intake. So, diversity in dietary intake means more per capita micro nutrients intake and less macro nutrients intake.

In essence, both in terms of micro and macro nutrients intake and over the period of four years, percentage of the households having required nutrients has decreased except vitamin-A intake. Percentage of the households having required per capita calorie, protein, iron and zinc intake has increased from 2011-12 to 2015. However, percentage of the households consuming required level of vitamin A intake has increased over the period of four years, from 2011-12 to 2015. Most importantly, for all the micro and macro nutrients-calorie, protein, iron, zinc and vitamin A, higher dietary diversified households are more likely to consume per capita required nutrients than low dietary diversified households. Crop diversification through increasing dietary diversity has positive impact on per capita calorie, protein, iron, zinc and vitamin A intake. So, diversity in dietary intake is not only good for macro nutrients intake but also for micro nutrients intake.

CHAPTER 6

SYNTHESIS OF FINDINGS, CONCLUSION AND POLICY IMPLICATIONS

In this study, BIHS 2011-12 and BIHS 2015 data have been used to construct panel data so that we can conduct analysis and address the research questions. The main aim of this study was to explore the linkages, if any, among household crop diversification, household dietary diversity and per capita nutrients intake of the household. For the purpose of analysis, various observations were dropped since they did not hold any relevance to the issues at hand in this study.

Over the years, households have been getting more diversified in favour of non-rice crop production; however, in terms of actual crop diversification they are getting less diversified day by day. Households were found to be less concentrated on rice and more diversified in 2015 than in 2011-12. Households which are more diversified in crop production have the probability of having more diversity in dietary intake compared to households with lower crop diversification. Although different measurements of dietary diversity (in the form of Household Dietary Diversity Score and Dietary Diversity Index) were used in this study, the findings from the analysis are similar to the findings from previous research related to dietary diversity. The analysis indicates that we have not been improving our situation to achieve higher diversity in crop production and we have been improving as less concentration on rice production.

There is a positive impact of crop diversification on dietary diversity among the farm households through increasing the availability of the different fruits and vegetables. However, that impact on dietary intake is not always significant. Similarly, if we consider concentration on rice production as crop diversification, then crop diversification has always positive and significant impact. Other three most important determinants of the household dietary diversity among farm households are income, size and farmers land holding.

Increasing household income significantly influences the increasing of both dietary diversity and nutrients intake in a household. This implies that if income increases in households, the households are more likely to have increased dietary diversity and attain better per capita micro nutrients intake. Therefore, increasing income is definitely a good tool to raise diversity in food intake and to improve the nutrition of households.

Over the period of four years, both in terms of micro and macro nutrients intake, percentage of the households having required nutrients has decreased except vitamin A intake. Percentage of the households having required per capita calorie, protein, iron and zinc intake has decreased from 2011-12 to 2015. However, percentage of the households consuming required level of vitamin A intake has increased over the period of four years. Importantly, for all the micro and macro nutrients- calorie, protein, iron, zinc and vitamin

A, higher dietary diversified households are more likely to consume per capita required nutrients than low dietary diversified households. Crop diversification through increasing dietary diversity has positive impact on per capita calorie, protein, iron, zinc and vitamin A intake. So, diversity in dietary intake is not only good for macro nutrients intake but also for micro nutrients intake.

If the years of education of the household head and of his/her spouse are considered as awareness indicator of food quality and nutrition, it could be claimed that such awareness helps to increase dietary diversity. When years of education of the household head increase, households are more likely to have higher diversity in food intake. It might be because such awareness helps people take the right decisions and do the right things.

There is no significant difference between gender of the household head and dietary diversity or nutrients intake of the members. Whether it is female household head or male household head, it does not have any significant impact on diet diversity and nutrients intake.

Regarding land holding of the farmers, medium land holding households (2.5 acres<=land <7.5 acres) are worse for both dietary diversity and nutrients intake. Medium land holding households are significantly less diversified in dietary intake and per capita nutrients intake is also less than the small land holding (land<2.5 acres) households. Higher land holding households are more diversified in dietary intake and per capita nutrients intake is also higher than small land holding households. However, this relationship is not significant though.

It was expected that the impact of family size or the number of family members would be negative on both dietary diversity and nutrients intake because of less per capita resources in larger families. Accordingly, the results of the analysis in this study indicate a significant negative relationship between dietary diversity and family size. Therefore, encouraging family planning or controlling child-birth would be a good tool in improving nutrition through diversity in dietary intake.

Therefore, the analyses in this study lead us to conclude that there is a positive relationship between dietary diversity and nutrients intake. Now, if Bangladesh wants to reduce the gap between Bangladeshi child nutrition indicators and the world standards, more focus should be given to raising dietary diversity and household income; also, more incentives should be given for increased crop production and homestead gardening.

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Appendix

Table 1.1A: Measures of Child Nutrition in South Asia

Country	Stunting	Wasting	Under-weight	Survey Year
Bangladesh	36.1	14.3	32.6	2014
India	38.7	15.1	29.4	2013-14
Pakistan	45	10.5	31.6	2012-13
Nepal	37.4	11.3	30.1	2014
Bhutan	33.6	5.9	12.8	2010
Sri Lanka	14.7	21.4	26.3	2012
Maldives	20.3	10.2	17.8	2009
Afghanistan	40.9	9.5	25	2013

Source: World Bank, UNICEF and WHO (2014).

Table 4.1A: Quantity of Crop Production, 2011-12

2011-12					
Crop	Quantity (MT)	Crop	Quantity (MT)	Crop	Quantity (MT)
Aush (local)	34.69	Bitter gourd	13.023	Other fruits	4.371
AushL local (deve)	27.18	Arum	22.965	Boroi(bitter plum	13.969
Aush (hyv)	117.163	Ash gourd	60.93	Rose apple	0.075
Aman (local)	231.347	Cucumber	27.137	Wood apple	3.9255
B. aman (l)	32.145	Cow pea	6.913	Ambada/hoq plum	2.8595
Aman (hyv)	1172.687	Snake gourd	11.481	Pomegranate	0.182
Aman (hybrid)	22.079	Danta	4.474	Bilimbi	0.029
Ropa Aush (hyv)	21.32	Green banana	1.895	Chalta	1.66
Boro (hyv)	2787.31	Cauli flower	28.62	Tamarind(pulp)	0.873
Boro (hybrid)	366.0195	Water gourd	48.4225	Olive(wild)	5.003
Wheat (local)	10.316	Sweet gourd	18.3205	Coconut/green coconut	53.337
Wheat (hyv)	41.948	Tomato	28.337	Potato	681.271
Maize	56.646	Raddish	40.371	Sweet potato	25.284
Barley	0.56	Shalgom	0.067	Sugar cane	130.514
Job	0.03	Green papaya	4.963	Date (date Palm)	0.219
Cheena	0.7	Kakrol	7.06	Palm (taal)	3.978
Kaun(italian millet)	0.82	Yam stem	2.4655	Juice	0.64
Joar(great millet)	9.58	Other green Vege	9.334	Tobacco	9.98
Other	25.58	Drumstick	1.457	Betel nut	15.48075
Dhaincha	17.02	Bean	40.0556	Betel leaf	11.271
Jute	95.544	Coriander leaf	1.97925	Other tobacco	0.236
Cotton	0.15	Pui shak	7.0045	Paddy seedling	523.218
Bamboo	301.721	Palang shak (spi	2.9605	Tomato Seedling	0.003
Lintel	5.669	Lal shak	7.059	Brinjal seedling	0.26
Mung	1.6115	Kalmi shak	1.019	Cauliflower Seed	0.002
Black gram (mash)	11.212	Danta shak	1.4495	Tobacco Seedling	0.105
Vetch(khesari)	10.85	Kachu shak	0.056	Other seedling	0.12
chick pea	0.14	Lau shak	3.808	Jute stick	136.377
Field pea (motor	0.225	Mula shak	0.567	Straw	3441.27
Motor kalai	0.99	Other green leaf	1.2595	Others (by Product)	100.634
Others1	1.358	Potato leaves	0.031	Others	31.911

2011-12					
Crop	Quantity (MT)	Crop	Quantity (MT)	Crop	Quantity (MT)
Oil seeds	5.082	Cabbage	12.265	Total	11895.7994
Mustar	32.489	Banana	110.321		
Ground nut/pea n	13.273	Mango	89.5785		
Soybean	4.606	Pineapple	6.735		
Chili	31.13985	Jack fruit	117.135		
Onion	96.767	Papaya	12.9925		
Garlic	22.218	Water melon	56.008		
Turmeric	11.9485	Bangi/Phuti/	0.112		
Ginger	0.0255	Litchis	5.48375		
Dhania/coriander	2.818	Guava	25.4775		
Other spices	76	Ata fol	0.825		
Pumpkin	12.814	Orange	0.0762		
Bringal (egg pla	97.7875	Lemon	1.785		
Patal	4.235	Shaddock (pomelo	7.521		
Okra	21.748	Black berry	4.5135		
Ridge gourd	2.422	Other fruits	0.444		

Table 4.1 B: Quantity of Crop Production, 2015

Crop	Quantity (MT)	Crop	Quantity (MT)
B Aus (local)	9.29	Arum	11.475
TAus (local)	5.947	Ash gourd	11.536
TAus (HYV)	146.382	Cucumber	33.358
T Aus (hybrid)	4.707	Carrot	3.68
BAman (local)	39.517	Cow pea	7.412
T Aman(local)	53.309	Snake gourd	18.399
T.Aman (HYV)	1640.458	Danta	0.225
T.Aman (hybrid)	58.107	Cauliflower	32.27
Boro (HYV)	2732.957	Water gourd	28.607
Boro (hybrid)	585.87	Sweet gourd	35.319
Wheat (local)	22.704	Tomato	28.069
Wheat (HYV)	51.859	Raddish	31.897
Maize	176.577	Kakrol	10.39
Job	0.035	Yam Stem	0.24
Cheena	0.2	Other green Vegetables	4.231
Kaun(Italian millet)	0.44	Bean	87.324
Others	4.036	Coriander leaf	2.11
Dhonche	8.575	BT Brinjal 2	2
Jute	60.526	Pui Shak	4.588
Other Fibre	5.43	Palang Shak (Spinach)	0.42
Lentil(Moshur)	9.982	Lal Shak	7.355
Mung	5.525	Kalmi Shak	0.03
Black gram (Mash)	4.735	Danta Shak	1.685
Chickling Vetch (Khesari)	10.964	Lau Shak	0.2
Chick pea (Chhsola)	0.34	Mula Shak	0.62
Field pea (Motor)	0.432	Other green leaf	1.66
Soybean	1.04	Cabbage	16.21
Other Pulses	0.37	Banana	110.192
Sesame	5.52	Mango	23.542
Linseed(tishi)	0.015	Pineapple	4.6
Mustard	38.723	Jack fruit	1
Ground nut/peanu	20.07	Papaya	2.03

Crop	Quantity (MT)	Crop	Quantity (MT)
Soybean	8.391	Water melon	0.67
Others Oilseeds	0.456	Litchis	0.06
Chili	41.897	Shaddock (pomelo	0.03
Onion	83.602	Potato	628.131
Garlic	28.201	Sweet potato	32.055
Turmeric	3.279	Sugurcane	317.63
Ginger	0.463	Tobacco	14.898
Dhania/Coriander	1.6205	Betelnut	1.8
without cultivat	0	Betel leaf	36.389
Pumpkin	2.56	Other Tobacco li	0.084
Bringal (egg pla	70.755	Cut flower (comm	9
Patal	14.073	Jutestick	83.15
Okra	33.117	Straw	2480.985
Ridge gourd	2.358	Other byproducts	89.69
Bitter gourd	18.9		
	Total Production		10231.5605

Table 4.3C: Average Crop Diversification and Dietary Diversity according to Literacy

Literacy		SI	HDDS	DDI
Household head	Cannot read or write	0.19	10.18	0.78
	Can sign only	0.20	10.39	0.79
	Can read only	0.28	11.67	0.84
	Both read and write	0.18	10.92	0.81
Household head	Cannot read or write	0.19	10.26	0.78
	Can sign only	0.21	10.33	0.78
	Can read only	0.29	8.00	0.64
	Both read and write	0.18	10.94	0.81

Source: BIHS 2011-12, 2015.

Table 5.1 A: Average Crop Diversification and Dietary Diversity according to Educational Literacy

Literacy	Average nutrients intake				
Household head:	Calorie	Protein	Iron	Zinc	Vitamin A
Cannot read or write	3445.59	89.25	15.69	10.61	422.73
Can sign only	3359.14	87.47	15.33	10.44	385.83
Can read only	3117.86	83.06	15.54	10.00	193.10
Both read and write	3421.86	90.93	16.01	10.86	398.27
All	3406.09	89.41	15.71	10.66	399.40
Household head's spouse:	3476.99	90.15	15.74	10.75	422.91
Cannot read or write	3380.81	87.24	15.29	10.8	385.11
Can sign only	3089.85	74.23	11.48	8.62	96.31
Can read only	3359.80	89.31	15.71	10.69	386.06
Both read and write	3388.11	88.73	15.57	10.59	392.21

Source: BIHS 2011-12, 2015.