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# Crop Diversification, Dietary Diversity and Nutrition: Evidence from Rural Bangladesh

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Using two rounds of nationally representative Bangladesh Integrated Household Survey (BIHS 2011-12 and 2015) data and Fixed Effects model, this study explores the linkages among household crop diversification, household dietary diversity and per capita nutrients intake of households. This study finds that households with higher crop diversification are more likely to diversify their consumption. In addition, there is a significant association between dietary diversity and per capita intake of calorie, protein, iron, zinc and vitamin A among farm households. Therefore, increasing crop diversification helps increase dietary diversity and dietary diversity, in turn, would decrease macro and micro nutrient deficiencies in Bangladesh.

**Keywords:** Agricultural Economics, Crop Diversification, Dietary Diversity, Nutrition
**JEL Classification:** Q10, Q12, Q18, D12

## I. INTRODUCTION

Bangladesh, as a least developed country, has made notable progress in providing food, health and nutrition for its large population. Despite such progress, the country is still facing high and persistent levels of undernourishment and malnourishment (Headey *et al.* 2015). 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) [BBS 2010]. As a result, research indicates that Bangladesh's food production is perhaps not diversified properly and this could be considered a major barrier in acquiring a standard nutritional status for such a growing population (Ahmed 2000). This lack of diversity might also be a cause of 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 prove to be the

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resilience of farming systems and environments. In Bangladesh, agriculture generally contributes to 19.4 per cent of the GDP. With nearly overall 41 per cent, and 52 per cent in rural, of the labour force engaged in agriculture (LFS 2016-17), approximately 76.5 per cent of the total population have their livelihoods either fully or partially dependent on agriculture (FAO, WHO 2014). Crop diversification could improve nutritional status in two ways: 1. by diversifying and potentially increasing the horizon of production and 2. by potentially increasing household income through the diversity in production. Sometimes, farmers diversify their production from staple to vegetables and high value crops which in turn increases the income of the households (Pellegrini and Tasciotti 2014). Due to an increase in crop diversification, farm households would get different types of crops, but this would not necessarily imply an increase in the quantity of food consumption, just perhaps an increase in the quality of food consumption through diversity in the intake of crops/food. Therefore, it can be asserted that the consumption of nutritious food would increase due to diversity in crop production. In turn, such an increase in the diversity of food intake would have a positive impact on nutrients intake. On the other hand, an increase in individual/family income could happen due to crop diversification and such an increase in 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 the improved nutritional status of a family/individual.

Several studies explore the relationships- in different contexts-among crop diversification, dietary diversity and nutrition intake. Some studies find a positive association between crop diversification and dietary diversity (Adjimoti and Kwadzo 2018, Chinnadurai *et al.* 2016, Deb and Bayes 2018, Pellegrini and Tasciotti 2014, Dillon 2014, Hirvonen *et al.* 2014, Kumar *et al.* 2015 Mulmi *et al.* 2017, Taruvinga *et al. 2*013, Mahabub *et al.* 2016, Andrew *et al.* 2014, Pandey *et al.* 2016, Arimond 2004, Steyn 2006, and Ruel 2001). On the other hand, some studies find no significant association between crop diversification and dietary diversity (Sibhatu *et al.* 2015, Srinivasulu *et al.* 2017), whereas some other studies find a positive association between crop diversification and nutrition (Pandey *et al.* 2016, Lovo and Veronesi 2015, Kennedy and Bouis 1993, Cohen *et al.* 1985, IFPRI, BIDS and INFS 1998, Mazunda *et al.* 2018).

Therefore, there is mixed evidence regarding the association among crop diversification, dietary diversity and nutrition. However, the magnitude and mechanisms-in the case of existing studies- are not fully understood and the datasets are not extensive either. Most of the studies use largely cross-sectional data with which it is difficult to capture farm level farmer's inherent capability. Moreover, most of the datasets are not nationally representative as well. In addition, most of the available studies are based on Sub-Saharan Africa (Jones 2017), where small farmers are mostly subsistent and where green revolution has not been successful (FAO 2014). Therefore, the magnitude of the association among crop diversification, dietary diversity and nutrition may be different in the context of South Asian countries like Bangladesh.

Hence, this study explores the following two research questions:

1. Does production diversity result in consumption diversity or dietary diversity?
2. Does dietary diversity result in better nutrients intake, particularly in micro nutrients?

We use two rounds of Bangladesh Integrated Household Survey (BIHS 2011-12 and 2015) data and a Fixed Effect Model and find that farm households with higher diversification in their production are more likely to diversify their dietary intake. Thus, a higher number of crop production by farmers helps their households consume more variety of food items through making more options available to them. The results indicate that a one-unit increase in crop diversification (Rice Share Index) leads to a 0.4-unit increase in Household Dietary Diversity Score (HDDS) and a 0.02-unit increase in Dietary Diversity Index (DDI).

We also find that dietary diversity, measured by the two methods of Households Dietary Diversity Score (HDDS) and Dietary Diversity Index (DDI), has a positive and significant association with the macro and micronutrient intake of households. So, farm households with higher dietary diversity in their food intake have higher probability of getting a higher amount of both macro and micro nutrients. Over the two periods of time and for a given household, a 0.1-unit increase in dietary diversity index (DDI) is 4 per cent positively associated with per capita calorie intake, 12 per cent positively associated with per capita protein intake, 17per cent positively associated with per capita iron intake, 13 per cent positively associated with per capita zinc intake, and 22 per cent positively associated with per capita vitamin-A intake.

The contributions of this paper are twofold. First, to the best of my knowledge, this is the first study in Bangladesh that uses nationally representative panel data to estimate both the association of crop diversification on dietary diversity and the association of dietary diversity on nutrition. Second, a new method of calculating dietary diversity is highlighted which may contribute to the existing literature. The existing method of dietary diversity (e.g., HDDS) can only capture whether a household consumes food or not but cannot capture the amount of food a household consumes. This limitation has been overcome by the new index of dietary diversity (details are in the next section).

In the following sections, we discuss our empirical approach to analysing the necessity of crop diversification for dietary diversity and nutrition. We then present the results of our descriptive and regression analyses and discuss the association among crop diversification, dietary diversity and nutrient intake. In the final conclusion section, we underline the policy implications of this study and underscore the contributions and future scope of research.

## II. DATA AND METHODS

### Methodology

This study aims to identify the associations, if any, among crop diversification, dietary diversity and nutrition in the case of farm households in Bangladesh. Two rounds of nationally representative (of rural Bangladesh) survey data were used to analyse the associations between the explanatory and dependent variables. Since the data at hand is panel data, this study uses a fixed effect model to control for the unobservable time invariant characteristics among households in rural Bangladesh and analyse how the variations of household crop diversification influence household dietary diversity and how the variations in dietary diversity influence nutrients intake. The Fixed Effects model removes the effect of time-invariant characteristics so that the net effect of the predictors on the outcome variable can be assessed. For example, an individual may have some inherent time invariant characteristics that lead them to choose their food for consumption. These types of characteristics cannot always be measured. Therefore, for controlling such factors, using the fixed effects model is appropriate. However, there is a limitation that we may have some time variant unobservable factors, such as market access and food availability in the market, that cannot be captured in this model. Nevertheless, the fixed effect model can capture variables like farmer's inherent capability/skills, distance to market, distance to main road, etc. These time invariant factors cannot be controlled in cross section or pooled data. So, despite this limitation, the fixed effect model can give more consistent and unbiased results compared to cross section or pooled regression. This method was also used by Mulmi *et al.* (2017) and Lovo and Veronesi (2015) in exploring relationships similar to the ones tested in this study.

The main regression measures the association of crop diversification with consumption diversification, and then tests the possible relationship between dietary diversity and macro/micronutrients intake of farm households.[1] In the case of the first estimated model, household dietary diversity is the dependent variable, while crop diversification and other household characteristics are the explanatory

[1] In terms of nutrition intake, log of per capita intake has been used.

variables. On the other hand, in the case of the second estimated model, household nutrition intake (in logarithmic form) is the dependent variable, while dietary diversity and other household characteristics are the explanatory variables.

*Model 1:*

$$Y_{it} = \beta_0 + \beta_1 * (SI\ or\ EI\ or\ RI)_{it} + \beta_2 * X_{it} + \alpha_i + u_{it}$$

Here, $Y_{it}$= Dietary Diversity Index (our dependent variable is measured by two methods: Household Dietary Diversity Score and Dietary Diversity Index) for household i at time t, $SI_{it}$= Simpson Index for household i at time t, $EI_{it}$= Entropy Index for household i at time t, $RI_{it}$= Rice Share Index for household i at time t, $\alpha_i$= household fixed effect, $\mu_{it}$ = error term of household i at time t, t= time variable, and $X_{it}$= vector of other characteristics of household i at time t.

*Model 2:*

$$Y_{it} = \beta_0 + \beta_1 * (DDI/HDDS\ )_{it} + \beta_2 * X_{it} + \alpha_i + u_{it}$$

Here, $Y_{it}$ = Log of nutrients intake such as per capita kcal/protein/iron/zinc/vitamin A of household i at time t, $DDI_{it}$= Dietary Diversity Index of household i at time t, $HDDS_{it}$= Household Diversity Score of household i at time t, $\alpha_i$= household fixed effect, $\mu_{it}$ = error term of household i at time t, t= time variable, $X_{it}$= vector of other characteristics of household i at time t.

Now, the $(X_{it})$[2] vector includes time variant explanatory variables such as: per capita income, ratio of agricultural income as compared to total income (ratio of agricultural income to total income indicates how much a household is dependent on agriculture for their livelihood), household size, years of education of household head, age of the head, type of farm in terms of landholding (small, medium and large), household's annual total crop production (in kg per capita), number of international migrants in household, number of domestic migrants in household, gender of household head, etc. Among these explanatory variables, gender of the household head has the potential to be time invariant. However, there is some variation as gender of head changed from 2011-12 to 2015 due to a four-year gap between the first round and the second round of the surveys. Thus, we have kept gender of head in our regression as a dummy variable.

*Main Explanatory Variables*

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

[2] $X_{it}$ only includes the time variant factors. Moreover, fixed effect automatically deletes the time invariant variables during regression

HDDS cannot differentiate among weights or the actual quantity of the consumption of different food groups.[3] Thus, along with HDDS a new index, similar to the Herhindahl Hirschman Index[4] (HHI) of crop diversification, has been used in this study. This new index is called Dietary Diversity Index (DDI). The Rice share index 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. However, the Rice share index does not necessarily measure the crop diversification rather than concentration on rice production. Less concentration on rice might lead to higher crop diversification sometimes. The mathematical expression of the Rice share index 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 = the amount of all crop production. The value of the rice share index lies between zero and one; where, rice share index tends to zero means more diversification and vice versa. There is a limitation of rice share index that smaller proportion of rice share does not always refer to increasing variety of crop production. This implies that lower rice production may or may not induce production towards higher variety. Despite this limitation, we have considered this as a distinct crop diversification index. One of the most widely used crop diversification indices is the Simpson Index (SI). It is the difference between the value one and the sum of squares of all the proportions of particular crops involved in a particular household. The index is represented as:

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

where,

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

Here, $a_i$ = the 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 (last one year as per BIHS surveys). Another method of

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[3] HDDS is widely used as an indicator of dietary diversity. But it cannot differentiate between the amount of food consumption from different food groups. For example, consuming 300 grams of rice, 200 grams of meat, 400 grams of vegetable is the same as 500 grams of rice, 300 grams of meat, 500 grams of vegetables for HDDS. But it is not the same for DDI.

[4]HHI is mostly used in industrial economics to measure few numbers of firms' concentration in an industry.

measuring crop diversification is the Entropy Index[5] which is an inverse measure of concentration and has been widely used to measure diversification (Shiyani and Pandya 1998). The formula for computing the Entropy index is:

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

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

*Dependent Variables*

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 (FAO 2011). In the case of calculating the HDDS, an additional $13^{th}$ food group is counted: leafy vegetable. The following food groups are used to calculate the HDDS. The value of HDDS varies from 0 to 13; 13 means maximum diversity and 0 means no diversity. These thirteen food groups include cereals, roots and tubers, vegetables, leafy vegetables, fruits, meat and poultry, eggs, fish and sea food, pulses and nuts, milk and milk products, oil/fats, sugar and honey, and miscellaneous. To overcome the limitations of HDDS, a new dietary diversity index[6] (DDI) has been used. DDI is the deviation of the sum of squares of the entire proportion of consumption items in a particular household from the value of one. The DDI is exactly similar to the HHI. The index is represented as

$$\mathrm{DDI} = 1 - \sum_{\mathrm{i}=1}^{\mathrm{n}} C_i^2 \quad \text{where,}$$

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

Here, $a_i$= amount of a particular food item consumed by a household in a given time period, A= total amount of food consumed by a household in a given time period.

[5] The value for EI is similar to SI, but it is always lower than that of SI.
[6] DDI is the method of dietary diversity which is similar to HHI, and it can overcome the limitations of the HDDS of measuring dietary diversity.

### Data

Data from two rounds of the Bangladesh Integrated Household Survey (BIHS) 2011-12 and 2015 have been used to conduct this study. This BIHS survey data is statistically representative of the following levels:

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

However, households that are not involved in the production system have been excluded in this study as crop diversification in the case of these households cannot be measured. On the other hand, households with production in both the survey rounds are included in the sample. Therefore, the sample size is smaller than the original BIHS data[7]: 1,780 (3,560 for 2 rounds) out of 4,423 and 4,619 nationally representative data respectively from 2011-12 and 2015. In terms of production data, this nationally representative survey captures the total production of households over the last year. The first round covers production from December 1, 2010 to November 30, 2011 and the second round covers production from December 1, 2013 to November 30, 2014. Therefore, it includes all three seasons of crop production- *Aus, Aman* and *Boro*.

## III. RESULTS AND DISCUSSION

### Descriptive Statistics

This study postulates that crop diversification may have a significant association with improving diversity in food intake or dietary diversity. Moreover, dietary diversity could also be considered an indicator of food quality in a household.

[7]The actual sample size of the BIHS is 6,500. From that entire sample, 4,423 and 4,619 households are nationally representative for 2011-12 and 2015 respectively.

Figure 1: **Household Dietary Diversity Score (HDDS) by Crop Diversification and Year**

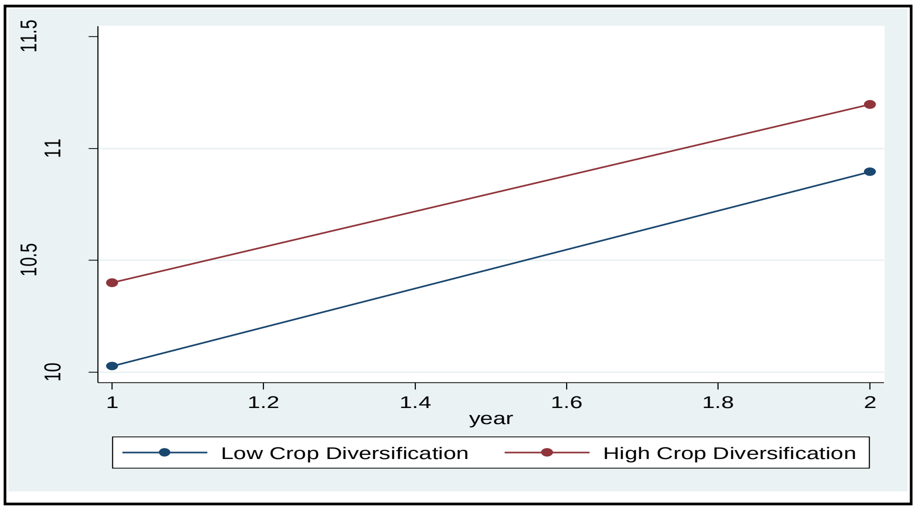
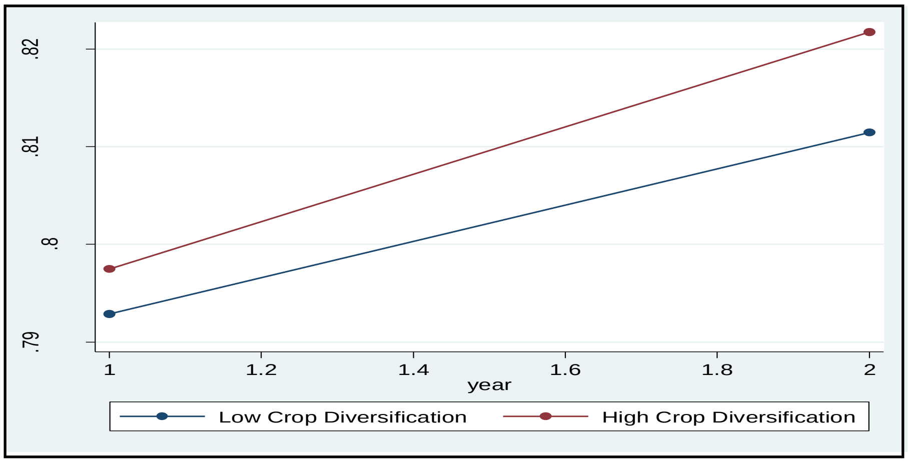



Figure 2: **Dietary Diversity Index (DDI) by Crop Diversification and Year**




Panel Figures 1 and 2 show the relationship between crop diversification and dietary diversity using HDDS and DDI respectively. Here, low crop diversification indicates the households which fall below the median crop diversification and high crop diversification refers to the households which fall above the median crop diversification. Both the indicators of dietary diversity show that mean dietary diversity is higher in the case of the households who are more diversified in crop production. However, the difference of mean dietary diversity between high and low crop diversified households decreases if HDDS is used and it increases if DDI is used instead of HDDS. Diversifying crop production among households has a positive relationship with diversifying their diets. There may be three reasons behind higher crop diversified households having higher dietary diversity. Firstly, when a farmer diversifies his/her production, he/she may prefer to eat from his/her production to test the taste. Secondly, subsistence farmers might produce the crops they need for their households' consumption. And finally, high crop diversified households earn more than the low diversified households which increases their ability to pay for high diversity food consumption (Pellegrini and Tasciotti 2014). Any of these reasons may lead high crop diversified farmers to diversify their food intake.

The classification of farmers based on the size of their land ownership may have some implications for both crop diversification and dietary diversity (Table I). The results indicate that the Simpson Index (SI) is highest in the case of large farmers and lowest in the case of small farmers. Accordingly, the DDI and HDDS are highest in the case of large farmers and lowest in the case of small farmers. So, there is a positive relationship between farmer's land ownership and diversity in dietary intake, and also between farmer's land ownership and crop diversification among the farm households. This implies that the smaller farmers are less diversified both in crop production and dietary intake compared to the larger farmers. Besides, over time, crop diversification has decreased and dietary diversity has increased among farm households.

TABLE I

**AVERAGE CROP DIVERSIFICATION AND DIETARY DIVERSITY INTAKE BY FARMER'S LAND HOLDING**

| Type of farmer | Simpson Index (SI) | | HDDS | | DDI | |
|---|---|---|---|---|---|---|
| | 2011-12 | 2015 | 2011-12 | 2015 | 2011-12 | 2015 |
| Small farmer | 0.62 | 0.63 | 10.03 | 10.93 | 0.79 | 0.81 |
| Medium farmer | 0.83 | 0.82 | 10.60 | 11.33 | 0.81 | 0.82 |
| Large farmer | 0.87 | 0.87 | 10.96 | 11.48 | 0.81 | 0.82 |
| All | 0.67 | 0.66 | 10.18 | 11.01 | 0.79 | 0.82 |

**Source:** BIHS 2011-12, 2015.

The relationship between dietary diversity and per capita income of households is shown in Figure A1 (in appendix). It is seen that, for both the survey years, higher income households have, on average, higher dietary diversity compared to lower income households. Therefore, along with crop diversification and farmers land ownership, income of the households is correlated with the dietary diversity of the households.

To link crop diversification with nutrients intake, we are also going to focus on the changes in the intake of particular macro and micronutrients among farm households in rural Bangladesh over a period of time and across the seven administrative divisions. It is anticipated that there might be changes in the number of households having the recommended level of nutrients in this particular time period. Accordingly, we would highlight the relationship between dietary diversity and nutrients intake. The recommended level of nutrients intake developed by the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) in 2004 has been used in the analysis.

TABLE II

**AVERAGE NUTRIENTS INTAKE OF THE HOUSEHOLDS ACCORDING TO THEIR DIETARY DIVERSITY**

| Dietary Diversity | Calorie (Kcal) | Protein (grams) | Iron (mg) | Zinc (mg) | Vitamin-A (rae[8]) |
|---|---|---|---|---|---|
| Lower | 2925.9 | 84.3 | 23.3 | 9.32 | 424.5 |
| Higher | 3071.7 | 107.8 | 30.9 | 12.9 | 525.4 |
| Difference | 145.8 | 23.5 | 7.6 | 2.69 | 100.9 |
| P-value | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

**Source:** BIHS 2011-12, 2015

Table II shows the average nutrients intake by the households with dietary diversity (DDI) values, either less than the median DDI or above the median DDI. The average nutrients (calories, protein, iron, zinc and vitamin A) intake by the households with above the median DDI are significantly higher than that of the households with the below median DDI. This implies that households with higher dietary diversity are more likely to have higher nutrition.

TABLE III

**PERCENTAGE OF THE HOUSEHOLDS CONSUMED REQUIRED LEVEL OF NUTRIENTS BY THEIR DIETARY DIVERSITY**

| Consuming required level of nutrition | Dietary Diversity | |
|---|---|---|
| | <=Median | >Median |
| Calories | 87% | 89% |
| Protein | 96% | 98% |
| Iron | 66% | 90% |
| Zinc | 82% | 93% |
| Vitamin A | 8.4% | 29% |

**Source:** BIHS 2011-12, 2015.

[8] Retinol activity equivalents.

Also, in high dietary diversified households, the proportion of consuming the required level of nutrition is always higher compared to low dietary diversified households (Table III). This implies that high dietary diversified households are more likely to have the required amount of nutrition compared to low dietary diversified households.

Table A1 (in appendix) shows that, besides households' dietary diversity, income also has significant implications for nutrition intake. As income increases, average per capita nutrition intake also increases. The relationship of income with dietary diversity is similar to that of income with nutrition intake. This suggests that households with higher income have a higher probability of having higher nutrition compared to households with lower income. The reason behind this is that higher income households may have better opportunity to choose among the food groups and nutrition values.

**Regression Analysis**

So far, using descriptive statistics, the linkage among crop diversification, dietary diversity and nutrition has been discussed. In this section, we are going to see the correlates of dietary diversity and nutrition intake among the farm households. Panel data models have been used to analyse the association among crop diversification, dietary diversity and nutrition intake. More specifically, the association of crop diversification with dietary diversity and the association of dietary diversity with nutrition intake of households have been estimated. The Rice Share Index (RI), Simpson Index (SI) and Entropy Index (EI) are each used to measure crop diversification. On the other hand, the Household Dietary Diversity Score (HDDS) and Dietary Diversity Index (DDI) are each used to measure the dietary diversity of the households. Since we would like to control for households' time invariant characteristics, Fixed Effects (FE) model has been used.

TABLE IV

**CORRELATES OF THE HOUSEHOLD DIETARY DIVERSITY**

| VARIABLES | HDDS | | | DDI | | |
|---|---|---|---|---|---|---|
| RI | -0.400** | | | -0.017* | | |
| | (0.172) | | | (0.009) | | |
| SI | | -0.182 | | | 0.0003 | |
| | | (0.207) | | | (0.0107) | |
| EI | | | -0.0837 | | | 0.003 |
| | | | (0.0855) | | | (0.00441) |
| Age of the head | -0.010 | -0.011 | -0.011 | 0.0003 | 0.0003 | 0.0003 |
| | (0.007) | (0.007) | (0.007) | (0.0004) | (0.0004) | (0.0004) |
| Gender of the head (female=1) | -0.178 | -0.151 | -0.158 | 0.0033 | 0.0007 | 0.0012 |
| | (0.220) | (0.220) | (0.220) | (0.0114) | (0.0113) | (0.0114) |

*(contd. Table IV)*

| VARIABLES | HDDS | | | DDI | | |
|---|---|---|---|---|---|---|
| Years of education of the head | 0.0117 | 0.0104 | 0.0104 | 0.0017 | 0.0017 | 0.0017 |
| | (0.0266) | (0.0266) | (0.0266) | (0.00137) | (0.00137) | (0.00137) |
| Income per capita (log) | 7.99e-05*** | 8.00e-05*** | 8.02e-05*** | 3.78e-06*** | 3.87e-06*** | 3.88e-06*** |
| | (1.59e-05) | (1.58e-05) | (1.58e-05) | (8.20e-07) | (8.13e-07) | (8.13e-07) |
| Ratio of agricultural income | -0.390 | -0.445* | -0.430* | -0.0211 | -0.0188 | -0.0198 |
| | (0.261) | (0.258) | (0.259) | (0.0135) | (0.0133) | (0.0134) |
| Household size | 0.117** | 0.119** | 0.119** | -0.00162 | -0.00157 | -0.00162 |
| | (0.0543) | (0.0543) | (0.0543) | (0.00281) | (0.00280) | (0.00280) |
| No. of children (below 5) | -0.0342 | -0.0443 | -0.0457 | -0.00161 | -0.00171 | -0.00154 |
| | (0.0779) | (0.0776) | (0.0777) | (0.00403) | (0.00400) | (0.00401) |
| Asset per capita (log) | 0.106*** | 0.101*** | 0.101*** | 0.00466*** | 0.00448*** | 0.00448*** |
| | (0.0087) | (0.0085) | (0.0085) | (0.00045) | (0.00044) | (0.00044) |
| Production per capita (log) | 0.0073 | 0.093** | 0.096** | 0.0029 | 0.0017 | 0.0011 |
| | (0.0552) | (0.0469) | (0.0473) | (0.00285) | (0.00242) | (0.00244) |
| International migrants dummy | 0.115 | 0.133 | 0.133 | 0.00337 | 0.00468 | 0.00458 |
| | (0.142) | (0.142) | (0.142) | (0.00734) | (0.00732) | (0.00732) |
| Domestic migrants dummy | 0.0907 | 0.106 | 0.105 | 0.0131*** | 0.0131*** | 0.0131*** |
| | (0.0792) | (0.0788) | (0.0787) | (0.00409) | (0.00406) | (0.00406) |
| Medium farmer (base: small farmer) | -0.0197 | -0.0297 | -0.00872 | -0.000892 | -0.000871 | -0.00209 |
| | (0.128) | (0.128) | (0.132) | (0.00662) | (0.00661) | (0.00681) |
| Large farmer (base: small farmer) | 0.146 | 0.123 | 0.161 | -0.00306 | -0.00181 | -0.00367 |
| | (0.240) | (0.240) | (0.245) | (0.0124) | (0.0124) | (0.0126) |
| Constant | 8.954*** | 8.278*** | 8.257*** | 0.699*** | 0.700*** | 0.701*** |
| | (0.595) | (0.526) | (0.527) | (0.0307) | (0.0271) | (0.0272) |
| Observations | 3,463 | 3,475 | 3,475 | 3,463 | 3,475 | 3,475 |
| R-squared | 0.190 | 0.188 | 0.188 | 0.137 | 0.136 | 0.136 |
| Number of households | 1,779 | 1,779 | 1,779 | 1,779 | 1,779 | 1,779 |

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

The model in Table IV is a panel fixed effects model, where the Household Dietary Diversity Score has been used as the dependent variable in columns 1, 2 and 3. Three different crop diversification indices have been used (Rice share index, Simpson index and Entropy index in respectively columns 1, 2, and 3) as the main explanatory variable, along with other controlling variables. A different dietary diversity measure–Dietary Diversity Index (DDI)–has been used as the dependent variable in columns 4, 5 and 6; while the explanatory variables remain the same as in the other columns.

The association of crop diversification with dietary diversity is only significant when the Rice Share Index (RI) has been used as the crop diversification index and other crop diversification indices show no significant association. The coefficient of RI is negative, which means that a higher concentration on rice or lower crop diversification tends to lower dietary diversity. Other things remaining constant and for a given household, as rice concentration (RI) increases across time by one unit, dietary diversity (HDDS) decreases by 0.40 unit. In other words, decreasing the proportion of rice production significantly increases the diversity in dietary intake. Thus, households with a lower concentration of rice production tend to consume more food groups. Accordingly, using the Dietary Diversity Index (DDI) as the indicator of dietary diversity instead of only the Household Dietary Diversity Score (HDDS) shows similar results in the case of the Rice Share Index (RI)- lower RI (higher crop diversification) tends to higher DDI (higher crop diversification) and vice versa. However, other crop diversification indices such as SI and EI do not show any significant association with HDDS or DDI (dietary diversity indices). Interestingly, the value of the coefficient of crop diversification (RI) drops significantly when we use Dietary Diversity Index instead of Household Dietary Diversity Score. This may be the result of differences in the ways we measure these two indices and differences in the values they take. The Household Dietary Diversity Score only takes integer values between zero and thirteen, which means that it has a very small range of only fourteen distinct values; whereas the Dietary Diversity Index takes hundreds of fractional values that range between zero and one.

Among the other explanatory variables, two of the most important economic indicators (income and asset) show a strong positive association with dietary diversity of the households. In addition, households with at least one domestic migrant have more dietary diversity than the households which do not have any internationally migrant member. The other remaining variables, such as the gender of the household head, the age of the household head, international migration dummy and type of farmer are not significant.

To sum up from Table IV, crop diversification has a positive and significant association with dietary diversity. However, this association is method sensitive– only RI has shown significant association with both HDDS and DDI. Additionally, economic indicators (income and asset) have shown a strong association with dietary diversity and the coefficients are also higher/stronger than in the case of crop diversification. This implies that income or asset has more association with diet diversity than crop diversification. It could sometimes be misleading if we think that crop diversification does not necessarily increase diversity in dietary intake. It does increase dietary diversity but the results indicate that income or asset increases dietary diversity in more magnitude compared to crop diversification. This may happen when more farmers are market oriented. It implies that farmers produce a variety of crops mostly for selling to markets to raise their income so that they can meet their demands.

Descriptive statistics regarding the determinants of nutrition intake has been discussed earlier in this section. Now, we are going to discuss inferential statistics. The following inferential analysis estimates the association between household dietary diversity and nutrients intake among households. In order to control for time invariant unobservable characteristics among households, panel fixed effects (FE) model has also been used here.

TABLE V

**CORRELATES OF THE PER CAPITA NUTRIENTS INTAKE**

| VARIABLES | Calorie (Kcal) | Protein (grams) | Iron (mg) | Zinc (mg) | Vitamin A (rae) |
|---|---|---|---|---|---|
| Dietary Diversity Index (DDI) | 0.399*** | 1.166*** | 1.664*** | 1.259*** | 2.229*** |
| | (0.0945) | (0.113) | (0.117) | (0.102) | (0.213) |
| Age of the head | -0.000976 | -0.00188 | -0.00172 | -0.00205 | -0.00317 |
| | (0.00139) | (0.00167) | (0.00172) | (0.00150) | (0.00314) |
| Gender of the head (female=1) | -0.0942** | -0.135** | -0.0959* | -0.123*** | -0.130 |
| | (0.0440) | (0.0526) | (0.0543) | (0.0473) | (0.0989) |
| Years of education of the head | -0.00492 | -0.00369 | -0.0103 | -0.00899 | -0.0202* |
| | (0.00533) | (0.00638) | (0.00659) | (0.00573) | (0.0120) |
| Income per capita (log) | 2.01e-05*** | 2.25e-05*** | 2.51e-05*** | 2.03e-05*** | 2.31e-05*** |
| | (3.17e-06) | (3.80e-06) | (3.92e-06) | (3.41e-06) | (7.14e-06) |
| Ratio of agricultural income | -0.0214 | -0.00497 | -0.00892 | 0.0170 | -0.0218 |
| | (0.0516) | (0.0617) | (0.0638) | (0.0555) | (0.116) |
| Household size | -0.108*** | -0.106*** | -0.105*** | -0.0968*** | -0.0957*** |
| | (0.0109) | (0.0130) | (0.0134) | (0.0117) | (0.0244) |
| No. of children (below 5) | -0.0417*** | -0.0428** | -0.0360* | -0.0492*** | -0.0639* |
| | (0.0155) | (0.0186) | (0.0192) | (0.0167) | (0.0349) |
| Production per capita (log) | 0.0347*** | 0.0259** | 0.0270** | 0.0236** | 0.0270 |
| | (0.00872) | (0.0104) | (0.0108) | (0.00937) | (0.0196) |
| International migrants dummy | 0.0490* | 0.0495 | -0.00331 | 0.0370 | 0.0774 |
| | (0.0284) | (0.0340) | (0.0351) | (0.0305) | (0.0639) |
| Domestic migrants dummy | 0.00515 | -0.0278 | 0.0247 | -0.00456 | 0.00776 |
| | (0.0158) | (0.0189) | (0.0195) | (0.0170) | (0.0356) |
| Medium farmer (base: small farmer) | -0.0228 | -0.0440 | -0.0509 | -0.0424 | 0.0215 |
| | (0.0255) | (0.0304) | (0.0315) | (0.0274) | (0.0573) |
| Large farmer (base: small farmer) | -0.0104 | -0.0100 | 0.0448 | 0.00683 | 0.0693 |
| | (0.0478) | (0.0572) | (0.0591) | (0.0514) | (0.108) |
| Constant | 8.116*** | 3.991*** | 2.468*** | 1.843*** | 5.090*** |
| | (0.124) | (0.149) | (0.154) | (0.134) | (0.279) |
| Observations | 3,475 | 3,475 | 3,475 | 3,475 | 3,475 |
| R-squared | 0.208 | 0.170 | 0.237 | 0.196 | 0.115 |
| Number of households | 1,779 | 1,779 | 1,779 | 1,779 | 1,779 |

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

Table V shows the regression results from fixed effects model where five variables of nutrients have been used as dependent variables and dietary diversity index as dietary diversity measurement has been considered the main explanatory variable. Both macro and micro nutrients (calorie, protein, iron, zinc and vitamin A) in per capita term have been considered as the dependent variables. Also, all nutrients intake variables are shown in logarithmic forms.

Increasing dietary diversity has positive and significant association with all five macro and micronutrients in our models. However, this association of dietary diversity with micronutrients is higher than that with macronutrients. Other things remaining constant and for a given household, as dietary diversity (DDI) increases across time by 0.1unit, calorie (kcal) per capita increases by 4 per cent, protein (gm) per capita increases by 12 per cent, iron (mg) per capita increases by 17per cent, zinc (mg) per capita increases by 13 per cent, and vitamin-A (rae) per capita increases by 22 per cent. So, irrespective of macro and micronutrients, households with higher dietary diversity can achieve higher per capita nutrients intake. However, this positive association of dietary diversity with nutrition is more likely for micronutrients than macronutrients. In other words, increasing dietary diversity in a household increases nutrients intake, but micronutrients intake increases more than macronutrients due to the same amount of increase in dietary diversity.

Among the other explanatory variables, income has shown a strong and positive association with nutrients intake of the households. In contrast, female household head, higher household size and number of children below five have each shown a negative association with nutrients intake. The coefficients of the other remaining variables such as age of the household head, international migration dummy, domestic migration dummy and type of farmer do not show any significant association with nutrients intake.

To sum up from Table V, dietary diversity has a positive and significant association with per capita calorie, protein, iron, zinc and vitamin-A intake of the households. However, this association is much higher for micronutrients than macronutrients. It implies that diversity in diet plays a greater role to increase dietary intake of micronutrients which in turn might decrease micronutrient deficiencies. These results are based on considering the DDI as an indicator of dietary diversity. The same associations have been tested using the HDDS and the indicator of dietary diversity (Table A2 in appendix) and the results show a similar association between dietary diversity and nutrient intake.

In essence, both the descriptive statistics and regression analysis have delineated that crop diversification has a positive and significant association with dietary diversity. This implies that when a farm household produces a greater number of crops or has a lower concentration of particular crops, this leads the household to consume more variety of foods. It could be a usual scenario that during the harvesting of a crop, farmers may want to test the taste of their production, even if their sole target of production is selling to the market. Interestingly, income plays a very important role in increasing dietary diversity among the farm households. The reason behind this may be that income facilitates farmers to have greater food variety through greater market access. Therefore, both higher variety in crop production and higher income are important in accessing a higher variety of food consumption across households.

Additionally, dietary diversity has a positive and significant association with both macro and micronutrients intake–calorie, protein, iron, zinc and vitamin A. However, this association of dietary diversity with micronutrients is higher than that of the macronutrients. This implies that increasing diversity in dietary intake leads to consuming more micronutrients. Along with dietary diversity, income of the households plays a very important role in increasing both dietary diversity and nutrients intake. Therefore, there may be some implications of income on dietary diversity and nutrients intake. For example, increasing income could greatly help households to increase diversity in their dietary intake and also to consume more nutrients.

## IV. CONCLUSION AND POLICY IMPLICATIONS

The main aim of this paper was to explore the linkages, if any, among household crop diversification, household dietary diversity and per capita nutrients intake of the household. Using two rounds of nationally representative BIHS survey of 2011-12 and 2015, this study finds that there is a positive association between crop diversification and dietary diversity among the farm households. In addition, over a period of four years, both in terms of micro and macronutrients intake, the percentage of households having the required amount of nutrients has decreased except in the case of vitamin A intake. The percentage of households having the required per capita intake of calorie, protein, iron and zinc has decreased from 2011-12 to 2015. However, the percentage of households consuming the required level of vitamin A intake has increased over the period of four years. Importantly, for all the micro and macronutrients–calorie, protein, iron, zinc and vitamin A, higher dietary diversified households are more likely to consume per capita required nutrients compared to low dietary diversified households. Therefore, crop diversification- through increasing dietary diversity- has a positive association with per capita calorie, protein, iron, zinc, and vitamin A intake. So, diversity in dietary intake is not only good for micronutrients intake but also for macronutrients intake. Besides, we find that if income increases in households, the households are more likely to have increased dietary diversity and are more likely to attain better per capita micronutrients intake. So, increasing income is definitely a good tool to raise diversity in food intake and to improve the nutrition of households.

Therefore, the analyses in this study lead to the conclusion that there is a weak positive relationship between crop diversification and dietary diversity, and a strong positive relationship between dietary diversity and nutrients intake, especially micronutrients. Thus, if Bangladesh wants to increase nutrients intake and reduce micro nutrients deficiencies among the population, more focus should be given to raising crop diversification, dietary diversity and household income; and more incentives should be given for homestead gardening as a tool of crop diversification. Future research might be to investigate the association between crop diversification and dietary diversity in terms of nutritional outcomes such as stunting, wasting and underweight of children. This would help examine whether diversity in crop production and dietary intake have implications for nutritional outcome.

## REFERENCES

Adjimoti, G. O., and G. T. Kwadzo. 2018. Crop Diversification and Household Food Security Status: Evidence from Rural Benin. *Agric & Food Secur* 7, 82. https://doi.org/10.1186/s40066-018-0233-x

Ahmed, A. 2000. "Trends in Consumption, Nutrition, and Poverty." Chapter 5. In: Raisuddin Ahmed, Steven Haggblade, and Tawfiq-e-Elahi Chowdhury (eds.) *Out of the Shadow of Famine: Evolving Food Markets and Food Policy in Bangladesh*, Pp. 101-120. Baltimore, MD: Published for the International Food Policy Research Institute (IFPRI) by Johns Hopkins University Press.

Ahmed, Akhter, 2013. *Bangladesh Integrated Household Survey (BIHS) 2011-2012*. https://doi.org/10.7910/DVN/OR6MHT, Harvard Dataverse, V5, UNF:6:1PRGAwCia+Ux/u99jpHzkg== [fileUNF]

Andrew Dillon, Kevin McGee, and Gbemisola Oseni. 2014. "Agricultural Production, Dietary Diversity, and Climate Variability." *Policy Research Working Paper*, 7022, Development Research Group Poverty and Inequality Team, World Bank Group.

Arimond M., and M. T. Ruel. 2004. "Dietary diversity is associated with Child Nutritional Status: Evidence from 11 Demographic and Health Surveys." *Journal of Nutrition* ,134 (10):2579-2585.

Bangladesh Bureau of Statistics (BBS). 2010. *Household Income and Expenditure Survey 2010*. Dhaka: BBS.

Bangladesh Bureau of Statistics (BBS). 2018. *Labour Force Survey 2016-17.* Dhaka: BBS.

Chinnadurai, M., K. R. Karunakaran, M. Chandrasekaran, R. Balasubramanian, and M. Umanath. 2016. *"Examining Linkage between Dietary Pattern and Crop Diversification: An Evidence from Tamil Nadu."* Agricultural Economics Research Review, Agricultural Economics Research Association (India), vol. 29 (Conferenc).

Cohen N, H. Rahman, J. Sprague, M. A. Jalil, E. Leemhuis de Regt, and M. Mitra. 1985. "Prevalence and Determinants of Nutritional Blindness in Bangladeshi Children." *World Health Stat Q.,* 38(3):317-30.

Deb, U. K. and A. Bayes. 2018. "Crop Diversity, Dietary Diversity and Nutritional Outcome in Rural Bangladesh: Evidences from VDSA Panel Household Surveys."

Dillon, A., K. McGee, and G. Oseni. 2015. "Agricultural Production, Dietary Diversity, and Climate Variability." Policy Research working paper no. WPS 7022. Washington, DC: World Bank Group.

FAO (Food and Agriculture Organization). 2014. *The State of Food and Agriculture: Innovation in Family Farming*. Rome: Food and Agriculture Organization of the United Nations.

______2011. *Guidelines for Measuring Household and Individual Dietary Diversity.* Rome: Food and Agriculture Organization. Available at http://www.fao.org/docrep/014/i1983e/i1983e00.htm (accessed on September 28, 2015).

FAO and WHO. 2014. "*Country Nutrition Paper- Bangladesh."* 19-21 NOVEMBER, Rome, Italy

Headey, D., J. Hoddinott, D. Ali, R. Tesfaye, and M. Dereje. 2015. "The Other Asian Enigma: Explaining the Rapid Reduction of Undernutrition in Bangladesh." *World Development*, 66:749–61.

Hirvonen, K., and J. Hoddinott. 2014. "Agricultural Production and Children's Diets: Evidence from Rural Ethiopia." International Food Policy Research Institute (IFPRI) No. 69.

Hossain, Mahabub, Nusrat Abedin Jimi and Md. Aminul Islam. 2016. "Does Agriculture Promote Diet Diversity: A Bangladesh Study." *LANSA Working Paper Series*, No. 11.

IFPRI-BIDS-INFS. 1998. *Commercial Vegetables and Polyculture Fish Production in Bangladesh: Their Impacts on Income, Household Resource Allocation and Nutrition.* Donor Report, Washington, DC, IFPRI.

International Food Policy Research Institute (IFPRI). 2016. *Bangladesh Integrated Household Survey (BIHS) 2015*. https://doi.org/10.7910/DVN/BXSYEL, Harvard Dataverse, V4, UNF: 6: K4Bn/u8+Ja93lQy8F5d/fQ== [fileUNF]

Jones, A. D. 2017. "Critical Review of the Emerging Research Evidence on Agricultural Biodiversity, Diet Diversity, and Nutritional Status in Low and Middle-Income Countries." *Nutrition Reviews*, 75(10): 769–782.

Kennedy, E., and H. E. Bouis. 1993. "Linkages between Agriculture and Nutrition: Implications for Policy and Research." *International Food Policy Research Institute Occasional Paper*, 1993.

Kumar, Neha, Jody Harris, and Rahul Rawat. 2015. "If They Grow It, Will They Eat and Grow? Evidence from Zambia on Agricultural Diversity and Child Undernutrition." *The Journal of Development Studies*, 51(8): 1060-1077, DOI: 10.1080/00220388.2015.1018901.

Lovo, Stefania, and Marcella Veronesi. 2015. "Crop Diversification and Child Health: Empirical Evidence from Tanzania." *GRI Working Papers* 211, Grantham Research Institute on Climate Change and the Environment.

Marsh, R. 1998. "Building on Traditional Gardening to Improve Household Food Security." *Food, Nutrition and Agriculture*. 22. 4-14.

Mazunda, John, Henry Kankwamba, and Karl Pauw. 2018. "Food and Nutrition Security Implications of Crop Diversification in Malawi's Farm Households." *In Agriculture, Food Security, and Nutrition in Malawi: Leveraging the Links*, eds. Noora-Lisa Aberman, Janice.

Mulmi, P, W. A. Masters, S. Ghosh, G. Namirembe, R. Rajbhandary, S. Manohar et al. 2017. "Household Food Production is Positively associated with Dietary Diversity and Intake of Nutrient-dense Foods for Older Preschool Children in Poorer Families: Results from a Nationally-representative Survey in Nepal." *PLoS ONE* 12(11): e0186765. https://doi.org/10.1371/journal.pone.0186765

Pandey, Vijay Laxmi, Mahendra Dev S. and Usha Jayachandran. 2016. "Impact of Agricultural Interventions on the Nutritional Status in South Asia: A Review." *Food Policy*, 62: 28–40. doi: 10.1016/j.foodpol.2016.05.002.

Pellegrini, L. and L. Tasciotti. 2014. "Crop Diversification, Dietary Diversity and Agricultural Income: Empirical Evidence from Eight Developing Countries." *Canadian Journal of Development Studies*, 35(2):211–27.

Rajendran, Srinivasulu et al. (2017) "Does Crop Diversity Contribute to Dietary Diversity? Evidence from Integration of Vegetables into Mmaize-based Farming Systems." *Agriculture & Food Security*, 6(1). doi: 10.1186/s40066-017-0127-3.

Ruel, Marie T. 2001. "Can Food-Based Strategies Help Reduce Vitamin A and Iron Deficiencies?" No. 5, Food Policy Review 2001, International Food Policy Research Institute (IFPRI).

Shiyani, R. L. and H. R. Pandya. 1998. “Diversification of Agriculture in Gujarat: A Spatio-temporal Analysis.” *Indian Journal of Agricultural Economics*, 53 (4): 627-639.

Sibhatu, K. T., V. V. Krishna, and M. Qaim. 2015. “Production Diversity and Dietary Diversity in Smallholder Farm Households.” *Proceedings of the National Academy of Sciences*, 112(34), 10657-10662.

Taruvinga, A., V. Muchenje, and A. Mushunje. 2013. “Determinants of Rural Household Dietary Diversity: The Case of Amatole and Nyandeni Districts, South Africa.” *International Journal of Development and Sustainability*, 2(4):2233-2247.

## ***Appendix***

Figure A1: **Household Dietary Diversity by Income Quintiles and Year**

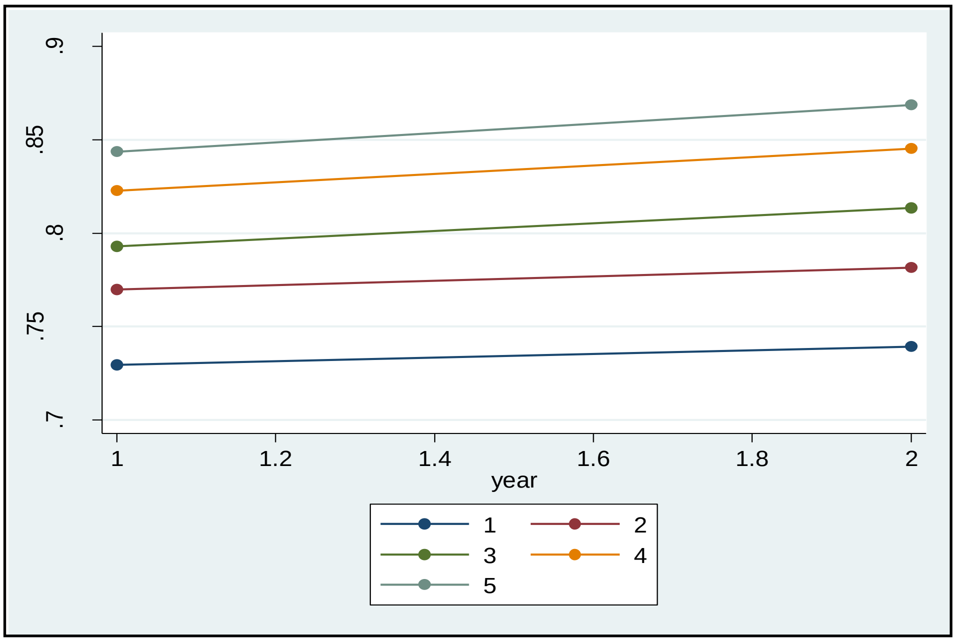



Table A1: **Average Nutrients Intake of the Households according to their Dietary Diversity**

| Income Quintile | Calorie (Kcal) | Protein (grams) | Iron (mg) | Zinc (mg) | Vitamin A (rae) |
|---|---|---|---|---|---|
| 1 | 2506.80 | 66.46 | 18.76 | 7.90 | 423.25 |
| 2 | 2895.01 | 82.61 | 23.05 | 9.69 | 509.86 |
| 3 | 3159.79 | 95.34 | 26.52 | 11.34 | 621.56 |
| 4 | 3152.02 | 106.31 | 30.19 | 12.61 | 673.50 |
| 5 | 3185.94 | 132.92 | 38.47 | 15.89 | 874.12 |

**Source:** BIHS 2011-12, 2015.

Table A2: **Regression Results of Nutrients Intake and HDDS**

| Variables | Calorie (Kcal) | Protein (grams) | Iron (mg) | Zinc (mg) | Vitamin A (rae) |
|---|---|---|---|---|---|
| Dietary Diversity (HDDS) | 0.0626*** | 0.103*** | 0.0997*** | 0.100*** | 0.153*** |
| | (0.00466) | (0.00547) | (0.00590) | (0.00490) | (0.0107) |
| Age of the head | -0.000195 | -0.000450 | -0.000180 | -0.000625 | -0.000903 |
| | (0.00133) | (0.00156) | (0.00169) | (0.00140) | (0.00306) |
| Gender of the head (female=1 | -0.0850** | -0.119** | -0.0804 | -0.107** | -0.106 |
| | (0.0420) | (0.0493) | (0.0532) | (0.0442) | (0.0964) |
| Years of education of the head | -0.00490 | -0.00278 | -0.00847 | -0.00789 | -0.0180 |
| | (0.00509) | (0.00598) | (0.00645) | (0.00536) | (0.0117) |
| Income per capita (log) | 1.66e-05*** | 1.87e-05*** | 2.36e-05*** | 1.71e-05*** | 1.94e-05*** |
| | (3.03e-06) | (3.56e-06) | (3.84e-06) | (3.19e-06) | (6.97e-06) |
| Ratio of agricultural income | -0.000273 | 0.0202 | 0.00540 | 0.0392 | 0.00610 |
| | (0.0493) | (0.0579) | (0.0624) | (0.0519) | (0.113) |
| Household size | -0.116*** | -0.120*** | -0.119*** | -0.111*** | -0.117*** |
| | (0.0104) | (0.0122) | (0.0131) | (0.0109) | (0.0238) |
| No. of children (below 5) | -0.0399*** | -0.0406** | -0.0348* | -0.0473*** | -0.0615* |
| | (0.0148) | (0.0174) | (0.0188) | (0.0156) | (0.0340) |
| Production per capita (log) | 0.0306*** | 0.0200** | 0.0223** | 0.0181** | 0.0191 |
| | (0.00833) | (0.00978) | (0.0106) | (0.00877) | (0.0191) |
| International migrants dummy | 0.0428 | 0.0416 | -0.00842 | 0.0299 | 0.0681 |
| | (0.0271) | (0.0318) | (0.0343) | (0.0285) | (0.0623) |
| Domestic migrants dummy | 0.00387 | -0.0232 | 0.0362* | 0.00153 | 0.0211 |
| | (0.0151) | (0.0177) | (0.0191) | (0.0158) | (0.0346) |
| Medium farmer (base: small farmer) | -0.0204 | -0.0406 | -0.0480 | -0.0391 | 0.0262 |
| | (0.0243) | (0.0285) | (0.0308) | (0.0256) | (0.0558) |
| Large farmer (base: small farmer) | -0.0179 | -0.0233 | 0.0311 | -0.00628 | 0.0488 |
| | (0.0457) | (0.0536) | (0.0579) | (0.0481) | (0.105) |
| Constant | 7.877*** | 3.954*** | 2.806*** | 1.894*** | 5.384*** |
| | (0.108) | (0.126) | (0.136) | (0.113) | (0.247) |
| Observations | 3,475 | 3,475 | 3,475 | 3,475 | 3,475 |
| R-squared | 0.277 | 0.271 | 0.269 | 0.297 | 0.159 |
| Number of households | 1,779 | 1,779 | 1,779 | 1,779 | 1,779 |