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Agricultural Diversity and Child Nutrition in Nepal

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Introduction

Nepal has experienced economic growth and a general decline in poverty rates over the past decade but continues to lag behind many of its peers in reducing child malnutrition and mortality. The 2010/2011 Nepal Living Standards Survey (NLSS) shows that 42 per cent of children are stunted, 14 per cent are wasted and 31 per cent are underweight. The extent of malnutrition has important implications for the future development of the country because adequate levels of child nutrition are essential to enhancing human capital and supporting economic activity. Many factors contribute to nutritional outcomes, among them agricultural performance. In a recent review, Haddad (2013) highlights several key pathways that link improvements in agriculture to improvements in nutrition. These include higher incomes, lower food prices, more nutritious on-farm production and consumption, and synergies between agriculture and nutrition arising from women's empowerment. Although there is a clear positive correlation between income and child growth across all ecological zones in Nepal, this correlation is relatively modest in magnitude, as illustrated by Figure 1.

In many areas of Nepal food intake is closely tied to on-farm agricultural production. While the country was considered food sufficient until 1980, population growth has surpassed agricultural production since then and Nepal currently faces a food deficit (NPC 2010). Children and women are among the most severely affected. Agriculture remains the primary source of income, food and employment for the majority of the rural population and particularly among households in lower income groups. Reliance on rainfall, underutilization of fertilizer, degradation of land and poor seed quality all exacerbate Nepal's poor agricultural performance and contribute to high levels of food insecurity (Shively, Gars and Sununtnasuk 2011). Furthermore, the country's landscape creates isolation. Harsh terrain, high transportation costs and poor infrastructure create challenges to moving food from food-surplus to food-deficit areas, whether through markets or government intervention. Given the close association of on-farm agricultural production and food access, nutrition risks are often highly localized.

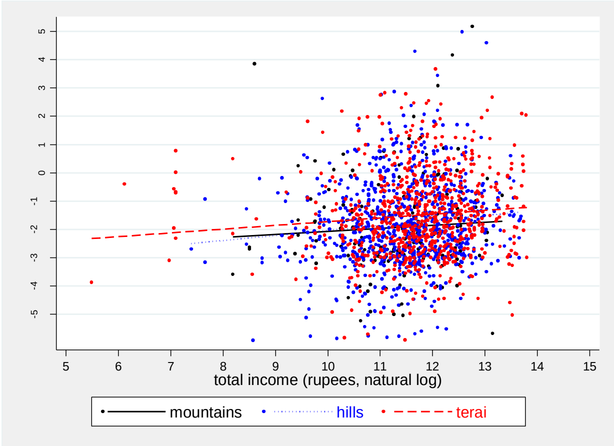

Figure 1: Income and height-for-age among agricultural households in Nepal, 2011

A fairly standard empirical approach to explaining observed variations in child nutrition outcomes is to use multiple regression analysis to measure correlations between anthropometric indicators and underlying household, child and maternal characteristics. For example, Tiwari, et al. (2014) use data from the 2011 Nepal Demographic and Health Survey to isolate a number of factors correlated with stunting in Nepal. Our research expands this type of analysis by incorporating information on agricultural production. We use the 2010/2011 Nepal Living Standards Survey (NLSS) to study 1,769 children residing in 1,289 farm households. The 2010/2011 Nepal Living Standards Survey (NLSS) is a nationally representative household survey conducted by Nepal's Central Bureau of Statistics. The household questionnaire addresses multiple topics following the methodology of the World Bank's Living Standard Measurement Survey. Anthropometric measurements were collected as a part of the NLSS.

One might reasonably expect indicators of overall agricultural production for Nepalese farm households to have a positive correlation with access to food and child nutrition. We ask more specifically whether observed indicators of crop composition and diversity are correlated with long-term nutrition outcomes. This provides observational insights into one of the most direct pathways between agriculture and nutrition where households produce predominantly for consumption. A second question considered is whether market participation is correlated with nutrition outcomes. As agricultural households become more market oriented, income generated from sales may provide access to both more food and more diverse diets than production for own consumption.

Methods

To relate agricultural production characteristics to child growth outcomes, we focus on height-for-age Z-scores, a standard measure of long-term nutrition outcomes. We include as explanatory and control variables a set of geographic indicators, characteristics of the child, mother and father, and various household characteristics. To examine links between agriculture and child growth, we also include variables representing characteristics of agricultural production. Because districts differ in terms of poverty levels, average land holdings, major crops grown and physical environment, we cannot assume that the errors in the regressions are independent and identically distributed. To relax this assumption, we cluster errors by district. This ensures that results are robust with respect to district-group correlation.

Policy makers with an interest in malnutrition may be more motivated by statistics indicating the overall prevalence of malnutrition than in Z-scores per se. Therefore we also discuss results from binary logistic regressions that are used to estimate the probability that a child is stunted. While the linear regression models for Z-scores explain linear changes in outcome due to unit changes in explanatory variables, these logistic regressions indicate which variables are most highly correlated with the probability of stunting.

To further examine the implications of crop diversity, we use the share of each food group within total diversity. The share is calculated as the number of crops within the specific group divided by the total number of crops. These "group ratios" are calculated for cereals, roots, pulses, fruits and vegetables. As an example, if a household produced ten distinct crops, including 2 cereal varieties and 3 vegetable varieties, then it would be assigned values of 0.20 for the cereal group ratio and 0.30 for the vegetable group, indicating relatively more diversity in the vegetable group than in the cereal group. The production of eggs, milk, and meat is indicated by a single binary variable which takes a value of one if any of the three animal products is produced on the farm. Two agricultural production variables characterize the ratio of own-consumption to total food consumption and the ratio of crops sold to total crops harvested. Both are measured in terms of annual value. The ratio of crops sold to crops harvested indicates the household's degree of commercialization.

Table 1 reports the main variables used in the analysis. Farm size includes owned and rented land. Annual yield (kg/ha) provides an indicator of agricultural productivity. A simple count of the number of crops cultivated by the household is used to measure crop diversity.

Table 1: Description of variables used in the analysis

Variable	Description	Mean	Min	Max
Dependent Variables				
HAZ	Height-for-age Z-score	-1.67	-5.92	5.17
Stunted	Height-for-age Z-score < -2.0	0.45	0	1
Geographic				
Rural	Rural area	0.90	0	1
Urban	Urban area	0.10	0	1
Mountain	Mountain zone (omitted)	0.10	0	1
Hill	Hill zone	0.48	0	1
Terai	Terai zone	0.42	0	1
Child				
Age	Age in months	30.3	0	59
Male	Child is a male (omitted)	0.51	0	1
Female	Child is a female	0.49	0	1
Vaccines	Number of vaccines received	6.2	0	38
Education				
Mother	Mother has primary or secondary education	0.46	0	1
Father	Father has primary or secondary education	0.78	0	1
Household				
Lowest	Lowest income quintile (0 – 50,873 NPRs)	0.20	0	1
Second	Second income quintile (51,000 – 93,159 NPRs)	0.20	0	1
Middle	Middle income quintile (93,339 - 141,920 NPRs)	0.20	0	1
Fourth	Fourth income quintile (141,981 - 240,662 NPRs)	0.20	0	1
Highest	Highest income quintile (240,831 – 3,067,685 NPRs)	0.20	0	1
Age of head	Age of the head of household	45.4	18	89
Female head	Head of household is a female	0.22	0	1
Uncovered water	Drinking water is obtained from an uncovered source	0.15	0	1
Piped water	Household has access to piped water	0.40	0	1
No toilet	Household has no access to a toilet	0.58	0	1
Flush toilet	Household has access to a flush toilet	0.21	0	1
Agriculture				
Land	Agricultural land owned and/or rented (ha)	0.74	0.003	10.67
Yield	Annual yield (kg/ha)	3205	1	9844
Own-Consumption	Ratio of produced to total food consumption (NPRs)	0.47	0	0.94
Sold Ratio	Ratio of sold to harvest crops (NPRs)	0.10	0	1
Crop Diversity	Number of crops	10.2	1	26
Cereals	Share of cereals in crop diversity	0.28	0	1
Roots	Share of roots in crop diversity	0.08	0	1
Pulses	Share of pulses in crop diversity	0.16	0	0.67
Fruit	Share of fruit in crop diversity	0.08	0	0.67
Vegetables	Share of vegetables in crop diversity	0.34	0	1
Proteins	Household produces eggs, milk, or meat	0.79	0	1

Findings

The characteristics of children in the sample are reported in Table 2. To examine how closely agricultural patterns correspond to income, we calculated a variety of agricultural input and output indicators by income quintile.

Table 2: Characteristics of children in the sample

	Height-for-age		
Characteristic	Mean Z-score	% below -2.0	% below -3.0
All children	-1.67	44.5	15.4
Age in months			
<6	0.21	6.5	2.2
6-8	-0.64	13.1	3.6
9-11	-1.11	28.3	5.4
12-17	-1.41	33.3	10.9
18-23	-1.99	53.3	17.2
24-35	-1.96	52.0	17.0
36-47	-1.98	54.2	18.7
48-59	-2.11	53.5	22.0
Sex			
Male	-1.67	43.1	15.3
Female	-1.67	46.0	15.5
Residence			
Rural	-1.71	45.5	16.2
Urban	-1.26	34.7	7.6
Ecological zone			
Mountain	-1.92	55.7	19.5
Hill	-1.77	46.8	16.6
Terai	-1.50	39.3	13.0
Region			
Eastern	-1.57	44.3	10.6
Central	-1.63	41.0	15.7
Western	-1.66	42.2	15.0
Mid-Western	-1.80	51.6	19.0
Far-Western	-1.70	42.9	16.6
Income quintile			
Lowest	-1.99	51.4	21.8
Second	-1.75	46.0	16.7
Middle	-1.67	47.5	17.8
Fourth	-1.51	40.4	11.6
Highest	-1.43	37.4	9.1

We find that the utilization rates and quantities of nearly all agricultural inputs increase as one moves up the income distribution. Farm size more than doubles between the lowest and highest income quintiles; and purchased fertilizer use increases nearly four-fold. With respect to agricultural output, yield, own consumption, the sales ratio, crop diversity and weighted crop diversity, all increase across income quintiles. It is worth noting that own-consumption of production increases slightly with income. This may be due to the lower yields produced by poorer households and/or the composition of what they produce. Differences in the composition of output across the income gradient are less distinct. Shares of cereals decline, but shares of roots, pulses and vegetables remain roughly constant. The share of fruit in total diversity shows the strongest relationship with income. The production of proteins shows only a slight increase between the poorest and richest households. In part this reflects the way we have constructed this variable, since a household which produces only eggs is assigned the same value as a household which produces eggs, milk and meat. Generally speaking, the synergistic relationship between income and agricultural output makes it difficult to identify the direction of influence and impact. With prices given, and holding other things constant, higher yields increase household income by definition. But a higher income also facilitates purchases of inputs that boost yields. Through simple observation alone, it is not possible to identify the causal mechanisms that link income and yields.

Figure 2 plots HAZ against yield for separate sub-samples of male- and female-headed households. We observe a positive relationship between yield and HAZ that roughly parallels the relationship between income and HAZ displayed in Figure 1, which reflects the widespread importance of agriculture to income in Nepal. Relationships for male- and female-headed households are almost exactly the same, although at the higher end of the income distribution our confidence surrounding these predictions becomes lower, due to the relative scarcity of observations that occur at these higher levels.

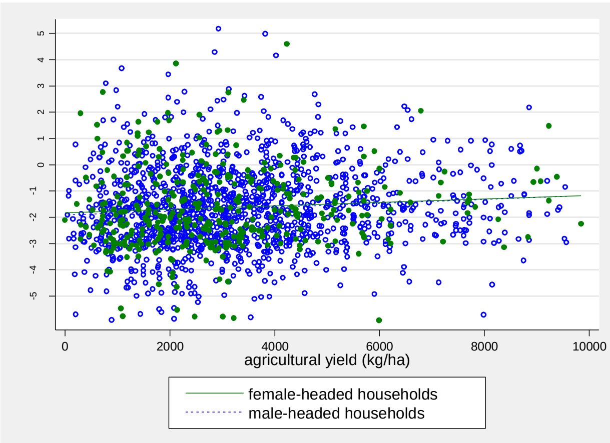

Figure 2: Agricultural yields and height-for-age in Nepal, 2011

Figure 3 plots agricultural diversity against total income. The graph illustrates a fairly robust pattern in the data in which crop diversification rises with income. Male-headed households are slightly more diversified than female-headed households (10.2 crops, on average vs. 9.8, p=0.08). Diversification also increases with income at a slightly more rapid rate among male-headed households, perhaps reflecting better access to inputs and marketing among men.

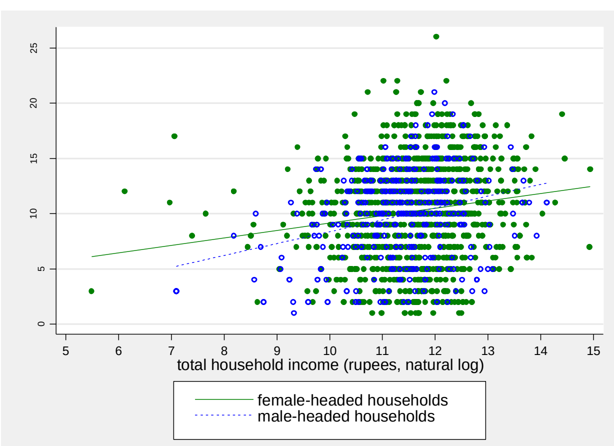

Figure 3: Crop diversification and total household income in Nepal, 2011

Subsistence-oriented households tend to produce a slightly more diverse portfolio of crops than those that are sales-oriented. Unlike male-headed households, female-headed households tend to specialize as they commercialize (Fig. 4).

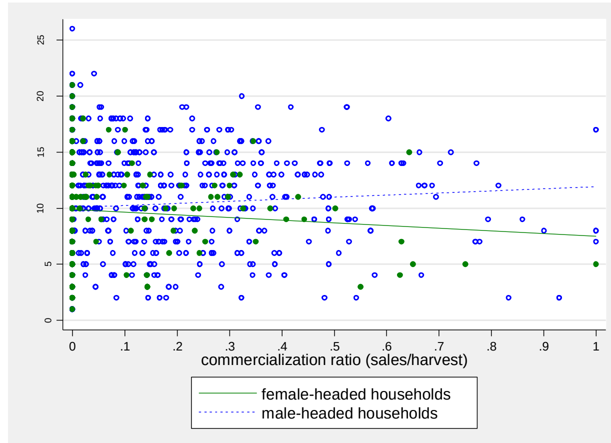

Figure 4: Commercialization and crop diversity in Nepal, 2011

Regression results are reported in detail in our research paper. Here we review those results. Observed patterns of results are similar in the HAZ and the stunting regressions. We discuss them together, highlighting important differences where they appear. We note that geographic indicators in the multiple regressions do not always reflect the unconditional, bivariate patterns observed in the descriptive statistics. Z-scores among urban children below the age of 24 months are not significantly higher than among their rural cohorts and do not have a significantly lower probability of being stunted. This also holds for children above two years of age. On average, compared with children residing in the mountains, children under five and those residing in the Terai are significantly less likely to be stunted, but only children above 24 months of age have a HAZ that is significantly higher (0.55 standard deviations).

We find that HAZ decreases and the probability of stunting increases as children get older, but at a decreasing rate. This coincides with what is observed when stunting rates are disaggregated by age (as in Table 2). The pattern is robust across model specifications. We find no statistically significant difference in outcomes between sexes.

The number of vaccines the child has received has a significant and positive correlation with HAZ and a negative and significant correlation with the probability of stunting across both age groups, with the exception of reducing stunting in children under two. Each additional vaccine is correlated with a 0.02 and 0.03 standard deviation increase in HAZ for the older and younger age groups, respectively. We note, however, that vaccines, *per se*, may not be the causal mechanism at play: the number of vaccines received may be a proxy for a number of unobserved factors, including the intensity or quality of health services and interventions in the child's location, or general levels of parental care.

With respect to the education of the mother and father, we find maternal education to be a strong and robust predictor of HAZ and stunting in both sub-samples. While the coefficient on father's education is also positive, it is not significantly different from zero in most regressions. Among household indicators, income is strongly correlated with increases in HAZ and, to a lesser extent, reductions in the probability of stunting, but this pattern holds only for the sample of children under two years of age. Relative to households in the lowest income quintile, children in the younger age group and in all higher income quintiles have higher HAZ. The incremental change is largest when moving from the lowest income quintile into the second income quintile. Whether a household has a flush toilet is an indicator of adequate sanitation, but may also be regarded as a socioeconomic indicator. Relative to children from homes which have no toilet, access to a flush toilet is significantly correlated with higher HAZ across age groups, but only when agricultural characteristics remain unaccounted for. In general, results suggest that access to safe water and proper sanitation facilities have an important role to play in ensuring a child's long term health.

Turning to the key variables of interest, those measuring agricultural production, we note that farm size, which is widely regarded as an indicator of well-being and agricultural capacity has no significant correlation with average growth outcomes. The amount of land used for agriculture, though eventually a binding constraint for total output, says little about the intensity of land use. Instead, we find that overall agricultural yields (output per hectare) provide a better measure of resource intensity and efficiency of production. The household's annual agricultural yield has a positive and significant correlation with HAZ and a negative and significant correlation with the probability of stunting. However, the magnitude of the association is relatively small. A one ton/ha increase in yield is associated with a 0.07 standard deviation increase in HAZ and a reduction in the probability of stunting of roughly 2 percentage points.

Results for our measure of own consumption, i.e. the proportion of food consumed that is produced by the household itself, are mixed. The correlation is not significant for HAZ or stunting for children under two. However, it is significantly different from zero in both cases for older children. An increase in this ratio is associated with a nineteen percentage point increase in the probability of stunting and reduction in HAZ of more than half a standard deviation. This reflects a pattern in which a high degree of subsistence orientation puts children at a nutritional disadvantage. Alternatively, it may signal that access to and reliance on markets improves long-run household food security. We included the ratio of the value of crops sold to crops harvested in an attempt to provide an indicator of the degree of agricultural commercialization in a household. The regressions reveal a positive and significant association between this ratio and HAZ for children below two. No significant relationship is seen between the ratio and the probability of stunting. The low sample average of the ratio of crops sold to harvested, 10 per cent, may reflect sales of low-value crops such as cereals rather than higher-value crops. Within sample, the result could also indicate that nonagricultural income or income from non-crop agricultural production (for example, sales of livestock) may be more closely linked to nutrition. It may further reflect the fact that, at the national level, rates of commercialization remain low. Small percentages of aggregate output are actually traded in most markets, and a large majority of farmers in Nepal remain subsistence-oriented.

The composition of agricultural production can directly influence the availability and quality of food in the household. We find no significant relationship between a household's total agricultural diversity and either HAZ or stunting. Although a close examination of the composition of diversity should help shed light on the specific crops which have the most potential for reducing stunting outcomes, we find significant negative correlations with stunting only for the share of vegetables (among children younger than 24 months) and roots (among children older than 24 months). It is important to underscore the differences in shares of vegetables in crop diversity among subgroups of the sample. We find that shares of vegetables remain relatively constant across income quintiles at roughly 30 per cent of total crop diversity. When comparing households participating in the market to those not participating, however, the only crop group in which the mean share in total crop diversity is not statistically different across groups is vegetables. This highlights the potential benefits across all income quintiles of increases in on-farm production of vegetables, regardless of the degree of market participation. Our indicator for production of animal proteins is positively correlated with HAZ patterns in the older age group. In households that produce meat, milk or eggs, HAZ is approximately ¼ standard deviation higher, on average.

To measure whether the relationship between crop diversity and a child's long term nutrition is different for children of mothers with primary or secondary education and those with mothers who have no education, we include an interaction term between these two variables. Mother's education is positively correlated with nutritional status even when controlling for a household's crop diversity. The positive coefficients on both crop diversity and education of the mother relay that both factors contribute to increases in HAZ. When the variables are combined, the interaction term is significant and the sign is negative. This suggests some degree of substitution between a mother's education and the household's crop diversity, at least in statistical terms. One possible explanation is that educated mothers are more aware of the nutritional requirements of their children and supplement poor diversity of agricultural production with more diversified food purchases from local markets, a possibility that warrants further study.

Conclusions

This study contributes to our understanding of the observed correlations between measures of agriculture and human nutrition. Regression results based on 2010/2011 data from 1,769 children under age five highlight the role of household agricultural production characteristics, and their varied importance depending on the age of the child, in increasing HAZ and reducing the probability of stunting. Specifically, in children above the age of 24 months, increases in overall crop yields are associated with improvements in HAZ and decreased probabilities of stunting. On the other hand, higher ratios of own-consumption are associated with lower HAZ and increased probabilities of stunting. With respect to specific crop groups, higher shares of roots are correlated with reductions in the probability of stunting while the production of animal products improves HAZ by nearly a quarter of a standard deviation. For children under two, the link between agriculture and nutrition is less strong, but increases in vegetable production are associated with decreases in the probability of stunting in all children. We find a small positive association between the degree of commercial market-orientation of households and child HAZ, but only among children below 24 months of age.

From a policy perspective, our findings suggest the following:

• Diversifying agriculture and improving overall agricultural performance will be beneficial to children;

• The production of animal products is associated with improvements in HAZ of nearly a quarter of a standard deviation;

• The link between agriculture and nutrition is stronger for children over two years of age than for those under two;

• Promoting agricultural commercialization, at least to the limited extent observed in this sample, is not likely to have large impacts, positive or negative, on nutritional outcomes.

While specific characteristics of agricultural production have been found to have positive associations with long term nutrition outcomes, more research is needed to identify the precise nutritional benefits of household crop composition. This could be done, for example, by assessing the nutritional value of harvests in terms of calories or specific micronutrients, rather than the weight or share of crops in total agricultural diversity. Moreover, our analysis suggests a number of positive associations between the agricultural characteristics of households and child growth, but does not identify the causal pathways that might connect agricultural opportunities, choices and constraints to specific nutritional outcomes. Of course such causal pathways will be of utmost interest to policy makers, who must weigh efforts to promote specific crops, encourage market participation, and/or foster higher rates of agricultural commercialization and market access.

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