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Engagement in agriculture protects against food insecurity and malnutrition in peri-urban Nepal[1,2,3]

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Abstract

Background: Urbanization is occurring rapidly in many low- and middle-income countries, which may affect households' livelihoods, diet, and food security and nutritional outcomes. **Objective**: The main objective of our study was to explore whether agricultural activity amongst a peri-urban population in Nepal was associated with better or worse food household security, household and maternal dietary diversity, and nutritional outcomes for children and women. **Methods:** A cross-sectional survey administered to 344 mother-child pairs in Bhaktapur district, Nepal, including data on household agricultural practices, livestock ownership, food security, dietary diversity and expenditures, anthropometric measurements of children (aged 5-6 years old), maternal body mass index (BMI), and maternal anemia. Multivariable adjusted and unadjusted odds ratios (AOR and OR respectively) were calculated using logistic regression. **Results:** Our findings suggest that in this sample, cultivation of land was associated with a lower odds of child stunting (AOR 0.55, 95% CI 0.33,0.93) and household food insecurity (AOR 0.33, 95% CI 0.18, 0.63), but not low (or high) maternal BMI or anemia. Livestock ownership (mostly chickens) was associated with lower of food insecurity (AOR 0.34, 95% CI 0.16, 0.73) but not with nutrition outcomes. Women in farming households were significantly more likely to eat green leafy vegetables than women in non-farming households, and children living in households that grew vegetables had a lower odds of stunting than children in households that cultivated land but did not grow vegetables (AOR 0.49, 95% CI 0.25, 0.98). **Conclusions:** Our study suggests that households involved in cultivation of land in peri-urban Bhaktapur had lower odds of children's stunting and of food insecurity than non-cultivating households -- and that vegetable consumption is higher among those households. Given Nepal's rapid urbanization rate, more attention is needed to the potential role of peri-urban agriculture in shaping diets and nutrition.

Keywords: urban agriculture, nutrition, food security, dietary diversity, diet

1. Introduction

The world is increasingly urbanizing: just under half of the population in low- and middle-income countries now lives in urban areas and over a quarter of urban dwellers are involved in agri-food value chains (1, 2). Recent papers have highlighted the important role that agricultural

participation can play in shaping dietary patterns and nutritional outcomes (3-5). As the global community and national governments seek to end hunger and poverty under the Sustainable Development Goals agenda (6), it is important to gain an improved understanding of how agriculture in urban and peri-urban areas influences diet and nutritional outcomes. Several recent systematic reviews on urban agriculture and nutrition have noted the limited body of evidence on this topic and highlighted a need for more studies to understand the relationships between engagement in urban agriculture and children's nutritional status (7-9).

The Kathmandu Valley is one of the most rapidly growing urban areas in South Asia and is home to 17% of Nepal's population (10). Even in Nepal's urban and peri-urban areas, agriculture remains an important contributor to livelihoods and income. For example, the 2011-12 Living Standards Monitoring Survey (LSMS) in Nepal found that approximately 9% of all "agriculture households" were based in urban areas, with 72% of these working their own land (11). Based on our literature search, which included a number of recent reviews on the topic of urban food security and nutrition, we are not aware of any studies that have empirically explored links between agricultural practices and the food security situation, dietary quality, or nutritional status of peri-urban households in Nepal (9, 12).

This paper offers new insights into how participating in peri-urban agricultural activity contributes to women's and children's nutritional status, and their household food security, expenditures and diet diversity. Data for the study were collected in Bhaktapur Nepal, a municipality in the Kathmandu valley, approximately 15 kilometers from the capital. Over the last decade, Bhaktapur saw the largest annual population growth rate in the country (excluding the capital) and, as of the most recent report in 2011, was the most population-dense district outside of Kathmandu (13).

The two key research questions examined in this paper are: (1) whether households who engaged in agricultural activity had better or worse food household security, household or women's dietary diversity, or nutritional outcomes for children and women compared to those who did not; and (2) what were the associations between engagement in specific agricultural practices, including vegetable gardening, production of different types of crops or ownership of animals, and these same outcomes?

2. Methods

This analysis uses cross-sectional data collected from a survey conducted in Bhaktapur, Nepal. Details on the study design —including sampling frame, participant recruitment and data collection methods—have been described elsewhere (14). Briefly, 500 lactating women and their infants participated in a survey in 2008-09; four years later (August 2012 - February 2014) the study team located and re-contacted the same women for a follow-up survey; a total of 344 women were successfully resurveyed. During the follow-up survey, the only source of data for this analysis, women were asked questions about household characteristics, including agricultural engagement and a recall of expenditures; data were also collected from mothers and children on anthropometric measures, and blood samples were taken from mothers for the assessment of hemoglobin and anemia.

Women reported on land ownership (owning versus renting), and crops grown. For each crop, they were asked how much was produced in the past year and whether any was sold. For rice, women reported the number of months for which the rice produced was sufficient for household consumption. All units of measure for land size and agricultural output were converted to standard international metric system units (i.e., *ana* to hectares, *muri* to kilograms). We defined "cultivating households" or "farming households" in this paper as those who reported cultivating any land, irrespective of the source of that land. "Livestock owning households" reported ownership of at least one chicken, goat, pig, cow or buffalo.

Household expenditures were estimated using a 13-item tool with a monthly recall period for different categories of food, electricity and fuel. Reported expenditures were translated to per capita values, based on the reported number of household members. Staple food expenditure was defined as money spent on rice, wheat or corn. Local currency (Nepal rupees) was converted to US dollars, using the average exchange rate from 2012-2013, and then to current US dollars using inflation rates (15).

Household wealth was calculated using inverse probability weighting (16) based on the WAMI (Water and sanitation, Assets, Maternal education, and Income) index (17) and using the following dichotomous variables: household had a separate kitchen room, household owned a refrigerator, household owned a television, household owned a motorcycle/motorbike, household owned a bicycle, household had piped water, household had an improved floor, and used electricity or

propane for cooking (the latter two were based on DHS wealth index guidelines (18)). The availability of each of these characteristics at the household level was calculated (all binary variables) and was divided by the proportion of the sample with a "yes" for each. These per-item values were then summed together into a total score, and households were classified into quartiles according to these summed scores. .

The Household Food Insecurity Access Scale (HFIAS) (19) was used to assess household food security. Additionally, 24-hour recall data collected at two points in time from children's mothers was recoded into dichotomous yes/no consumption variables according to the 10 food groups used to compile the Minimum Dietary Diversity for Women (MDDW) score (20), with score summed for each day and averaged across the two points in time. Anthropometric measures were taken from the children who had participated in the original study, by trained enumerators using standardized equipment: at the time of the survey, these children were aged 5-6 years (mean 5.1 years). The WHO Child Growth Reference for school-aged children was used to calculate z-scores (21). Women's body mass index was calculated using their measured height (in meters) and weight (in kilograms) using the formula $[weight/(height^2)]$. Women's hemoglobin concentration was assessed using a sample drawn from a fingerstick and analyzed using Hemocue® 201+ (Agelholm, Sweden). Anemia was defined by hemoglobin < 12.3 g/dL, reflecting an upwards adjustment of 0.3 g/dL for altitude. Women's anthropometric measures, both anemia and body mass index, were calculated only for non-pregnant women.

Data were analyzed using Stata version 14. Differences between groups were analyzed using t-tests for continuous variables (except for tests of differences between monthly expenditures: since these were not normally distributed, Wilxocon rank-sum tests were used), and odds ratios were used to express the results of logistical regression analyses. We used a theory-driven approach to guide our analysis and covariate selection, drawing on the framework presented in **Figure 1**, with models including measures of socio-economic status (maternal and paternal education, maternal and paternal employment status, household wealth score), demographic factors (maternal age, child birth order, child sex), and other factors (months of exclusive breastfeeding, birth at a health facility).

Ethical clearance was given by the Institute of Medicine at Tribhuvan University in Nepal, by the Norwegian Regional Committee for Medical and Health Research Ethics (REK VEST), and by the IRB at the Harvard T.H. Chan School of Public Health.

3. Results

The study population for this analysis included 344 women and their children; characteristics of these households are shown in **Table 1**. The average household included 5.5 people. Just under one-third of households reported owning livestock (30.5%). All livestock owning households owned chickens (median of 2 chickens owned) and very few (2.9%) sold the chickens or their eggs. Nearly two-thirds (61.9%) of the households in this sample cultivated some agricultural land. The average plot of agricultural land was approximately 0.10 hectares (reported size ranged from 0.003 hectares to 0.71 hectares). Rice and vegetables were the most common crops grown, followed by wheat and maize. Among vegetable growers, households cultivated an average (and median) of 5 different varieties over the past year. Agriculture was reportedly the main occupation of only 10% of males from farming households and 2.3% of non-farming households. Among non-farming households, 57.3% of males relied on daily wage work as a main occupation and 20.6% were self-employed, compared with farming households in which 40.9% were daily wage earners and 31.5% were relied on self-employment as the main source of income. Among all households, nearly two-thirds of women were reportedly not working (n=216, 64.5%) and 14.0% (n=47) were daily wage earners. In the full sample, 9.6% (n=32) of women were reportedly employed in agriculture; nearly all of these women (n=27) resided in households that reported participating in agriculture.

Less than one-quarter of households growing any crop reported selling it. Three-quarters of the households grew rice (72.8%), and on average, this rice was reportedly sufficient for these households' consumption for 7.4 months of the year. Most commonly, households grew several crops, usually at least one staple food plus vegetables (82 households reported growing two or three staple crops plus vegetables) over the previous year.

Table 2 presents anthropometric measurements of women and children. Over one-third of children (39.2%) were classified as stunted (<-2 height-for-age Z-score) and 18.2% of the children were underweight (<-2 weight-for-age Z-score). Approximately 40% of mothers (among women not

currently pregnant) were classified as overweight or obese (BMI>25 kg/m^2), and very few (2.2%) had a BMI below 18.5 kg/m^2. About one-third of women (32.9%) had mild or moderate anemia (Hb<123 g/L).

Characteristics of children and households are also disaggregated by farming status and livestock ownership in Table 2. Farming households had a lower prevalence of child stunting and underweight, and of maternal underweight, overweight and anemia compared with non-farming households. Households without livestock appeared to have slightly higher rates of maternal overweight and lower rates of child underweight.

The relationships between agricultural participation and child nutritional outcomes were explored through logistic regression models (**Table 3**). The odds of stunting among children from farming households was approximately half that among children from non-farming households in multivariable adjusted regression models (AOR 0.55 [95% CI 0.33, 0.93]), and a similar but non-significant trend emerged for underweight [AOR 0.65 [95% CI 0.34, 1.27]). Livestock ownership was not significantly associated with odds of stunting or underweight. While no statistically significant associations were observed between stunting or underweight and cultivation of staple crops, cultivation of at least 1 type of vegetable was associated with significantly lower odds of stunting (AOR 0.49 [95% CI 0.25, 0.98]). Households that grew wheat (AOR 0.45 [95% CI 0.23, 0.86]) or maize (AOR 0.39 [95% CI 0.18, 0.85]) were significantly less likely to have a mother who was overweight or obese; beyond these relationships, no significant associations between agricultural practices and maternal nutritional outcomes were observed (Supplemental Table 1).

Overall, the dietary diversity scores of women (MDDW) in farming/non-farming households and livestock/non-livestock-owning households were similar (p-values of 0.5 and 0.8, respectively, for t-tests of difference in mean dietary diversity scores) but differed in the specific types of food consumed. In both unadjusted and adjusted models, women in farming households were significantly more likely to have consumed dark green leafy vegetables than women in non-farming households; while in unadjusted models only, women in households with livestock were significantly more likely to have consumed dairy and eggs compared to women in households without livestock (these relationships were not robust to the inclusion of covariates) (Supplemental Table 2). The only

significant predictor of dark green leafy vegetable consumption, after adjusting for important covariates about household sociodemographic characteristics, was cultivation of rice (AOR 2.23, 95% C.I. [1.14, 4.37]).

Farming households had significantly lower monthly per capita expenditures on all staple foods, vegetables, and other food (**Figure 2**). Summing across these three subcategories, total monthly per capita spending on food among agricultural households was US$ 7.75 [range US$ 0-33.14] while among non-agricultural households it was US$ 13.66 [range US$ 0-50.41]. Farming households were much more likely to report zero spending within each subcategory during the preceding month than non-farming households (Supplemental Table 3).

Roughly 20% of households were classified as moderately or severely food insecure using the Household Food Insecurity Access Scale measure (Table 2; **Figure 3**). Farming households had a significantly reduced odds of moderate or severe food insecurity (AOR 0.33, [95% CI 0.18, 0.63]), as did households with livestock ownership (AOR 0.34, [95% CI 0.16, 0.73] (**Table 4**). Farming and livestock owning households were much less likely to express concern about household food insecurity domains related to food anxiety and intake. Among farming households, those that cultivated above-median size plots of land were significantly less likely to be classified as food insecure. Households growing rice and maize were also significantly less likely to be food insecure, but no relationship was found with wheat or vegetables.

4. Discussion

To our knowledge, this is only the second paper from South Asia, and the first from Nepal, to explore the links between agriculture participation and nutrition outcomes in a peri-urban setting (12). Our findings indicate that farming households in Bhaktapur, a peri-urban area in the Kathmandu Valley of Nepal, had lower odds of both child stunting and food insecurity compared with non-farming households. Further investigation of agricultural practices revealed that land cultivation, but not livestock ownership, was associated with lesser stunting after adjusting for other indicators including socioeconomic status. We also found indication that participation in agriculture was associated with greater consumption of green leafy vegetables, but that overall dietary diversity was similar for

women in agricultural and non-agricultural households. We did not find a significant association between household farming and adult women's nutritional outcomes.

A number of recent review papers have outlined the complex web of pathways linking participation in agriculture to the nutritional status of women and children (4, 5, 22-25). A common theme in these reviews is the lack of empirical data to ground the understanding of which pathways matter most and under which contexts. Reviews of the contribution of urban agriculture to nutrition and food security come to a similar conclusion: while there are largely anecdotal reasons to think that agriculture *could* improve nutrition -- through income-related effects, increasing dietary diversity through greater access to fresh foods, buffering food shortage during seasonal food insecurity or times of stress, or increasing women's time with children -- few studies have been able to empirically explore any of these pathways (9, 26). Indeed, a recent review identified only 12 studies in urban areas, four from Asia and eight from East Africa, examining food security (n=9), dietary diversity (n=3), nutritional status (n=4), motivation for engagement in agriculture (n=7), and barriers to urban agriculture (n=5) (9).

Despite the different geographical context of our study, and the limitations identified in many of those studies, some of our findings are consistent with the existing literature. We observed strong protective associations between participation in agriculture and child stunting, findings that are concordant with studies from Uganda (27, 28) but not with other cross sectional studies from Uganda or Malawi (29, 30) We did not observe any associations of this exposure and other indicators of maternal or child nutrition including anemia, an outcome that to our knowledge has not been explored previously in urban or peri-urban studies although it has been investigated in rural contexts (e.g., (31)).

Livestock ownership, which in this setting consists primarily of poultry, was not associated with child stunting or underweight. This may be because the number of chickens owned by each household was quite low (median of 2 chickens per household), which may not provide a steady source of eggs/meat or income sufficient to affect nutritional status. The literature on this topic is nuanced and few studies have examined the entire pathway from livestock ownership and storage to meat/egg/milk consumption, and on to child nutritional status (25). Some observational studies have

found positive association between consumption of animal source foods or purchase of animal source foods and child growth or lower stunting risk (32-37). A randomized study in rural Nepal evaluated the effects of a community development and livestock promotion program, and found a significant impact on child weight and height, potentially mediated through greater livestock ownership, income, and better sanitation practices (38). Moreover, a recent observational study from Ethiopia found that ownership of poultry was positively associated with child mean height-for-age z scores, but that confinement of poultry within the house had negative association with child growth at 2 years, suggesting that effect might be mediated through exposure to pathogens from the animals or feces (36). In these different studies, livestock ownership appears to be a potential source of key nutrients needed for child growth, a potential risk factor for growth-inhibiting pathogens, and an important marker of greater socioeconomic status (and therefore subject to confounding). More studies are needed to tease out these relationships, particularly with randomized designs that will allow for causal inference.

Our findings suggest that there are meaningful associations between participation in agriculture, women's dietary diversity (which may also reflect dietary diversity of other household members), and child stunting in this peri-urban setting. Of particular note were findings linking household production of vegetables and greater consumption of vegetables, and greater consumption of vegetables with lower odds of child stunting. These findings are consistent with observational findings from Indonesia and Nepal suggesting greater height and less stunting among children with more vegetable consumption and share of vegetables respectively (39, 40). Other studies have also suggested links between homestead gardening and lower risk of stunting (41). While much of the literature on home gardening assumes the primacy of the pathway from greater income to lower malnutrition, our findings raise the possibility of a direct link from consumption to lowered stunting risk. This requires more investigation as the underlying mechanisms through which vegetable consumption could influence child growth area unclear and it is not possible to rule out the possibility of unmeasured confounding given the observational and cross-sectional nature of the design.

Overall, stunting was present in 33% of these children (aged between 44 and 79 months, with a mean and median of 61 months). While it is difficult to find comparable data on children of this age

group, our finding is similar to the observed stunting prevalence among children aged 48-59 months from the urban sample of 2011 Nepal Demographic and Health Survey (DHS) (26%) (42). Other recent DHS analyses in southern Asia have found prevalence rates of stunting among children in this age group of 42% (Bangladesh, 2011) and 46% (Pakistan, 2012) (43).

Our finding of a high rate of maternal overweight among the mothers of children adds to the evidence that urban parts of Nepal are experiencing the double burden of malnutrition. Interestingly we also observed that women living in households who grew maize or wheat were less likely to be overweight or obese. These crops are known to be more labor intensive, and it may be possible women living in households cultivating them may have higher energy expenditure as a result of greater involvement in agriculture.

One novel feature of our study was the breadth of information collected and the ability to examine the pathway from agricultural engagement through to nutritional outcomes. We were also able to adjust for many potential confounders, a limitation of many prior studies. The main focus of our data collection was on outcome measures, which included both intermediate outcomes (dietary diversity, food security, expenditures) and nutritional status (child and maternal anthropometry and maternal anemia). As such, time limitations constrained our ability to collect detailed information on exposure variables. Our study used relatively coarse measures of agricultural participation, and we were not able to examine in detail issues such as productivity, land use, agricultural inputs, the extent to which foods produced through agriculture were consumed versus sold, income from non-agricultural sources, women's participation in agriculture and time use, and how households used the money derived from agriculture. That said, we were still able to investigate and capture numerous relationships in line with our main research questions of interest.

Some findings should be interpreted with care. First, the cross-sectional and observational nature of our findings limits our ability to draw causal inference. It is important to recognize that the peak period of growth velocity of children occurs during fetal development and early childhood. For children in our study, this time period was five to seven years prior to the measurements presented here. Based on our knowledge of the local context, we do feel that it is likely that households currently practicing agriculture were also doing so in the past, though the collection of prospective

information on agriculture-related exposures would have enabled stronger confidence that findings related to stunting risk were not due to confounding. Additionally, given the relatively crude nature of the women's dietary diversity score it is also possible that this measure is not sensitive to true differences in dietary quality or reflective of the consumption of other household members.

Secondly, although the original baseline sample was designed to statistically represent households with young children in Bhaktapur, loss to follow-up over the five years between the baseline survey and the and follow-up survey through which data for this paper was collected, limits our ability to claim that these findings represent the district. Most likely, the participants who were available for the follow-up survey were in more stable households, and therefore more likely to be economically better-off than those who moved away. The follow-up survey also did not include people who moved into the study area during the intervening period, and since Bhaktapur has seen fast population growth in recent years, this also may limit the generalizability of these results. Furthermore, there is the potential for reporting or recall bias. For example, many questions—most significantly, about food insecurity, recall of agricultural production and expenditures—included long periods (six months in the case of food security and a full year for agricultural production). Although many tools use similar recall periods, the validity of such tools to capture seasonal patterns has not been well explored. We would speculate for agricultural production that a longer recall period would lead to an underestimation of production, leading to an attenuation of estimates of the relationship with other outcomes, but cannot test this hypothesis in the present dataset. As data collection spanned 11 months, we feel that it is unlikely that the dataset would have systematic bias due to seasonality; each household only contributed data at one time point, but any such bias should not be present in the aggregate dataset.

Many urban areas in Asia and Africa are experiencing rapid population growth, and one of the great challenges associated with urbanization is how to ensure a diverse and nutritious food supply. While our findings suggest that farming and livestock ownership in peri-urban areas has benefits for farming households, important questions persist about the scale to which these benefits apply in other urban parts of Nepal or elsewhere. An analysis of multiple household income and expenditure surveys including a 2003 Nepal survey concluded that "it is hard to see urban agriculture

playing a substantial role in poverty alleviation outside of Africa" based on the small amount of income shares derived from agricultural activities in Asian countries (26). The same study found that on average only about 11% of household income in urban areas of Nepal came from agriculture but that 52% of households participated in crop activities and 36% in livestock activities, and that poorer households were more likely to engage in agriculture. The relevance of those numbers to the present situation in Nepal should be taken with caution given rapid population growth and change during the 13 years since the 2003 survey.

Our findings do suggest that agricultural participation in Bhaktapur may have benefits that extend beyond just income-related effects, and suggests that greater exploration of the potential benefits of policies that support agricultural participation in urban parts of the Kathmandu valley may be useful. It is also important to note that Kathmandu valley, in which Bhaktapur district is located, houses a finite amount of cropland, much which is being rapidly turned into housing. This trend follows global patterns in Asia and Africa, and it has been noted that croplands near urban areas tends to be much more productive than other land (44). Given that agricultural production appears to have an important role in shaping the food security, dietary diversity and nutritional status of households, it is unclear how the continued reduction of urban and peri-urban agricultural land will affect the food security and nutrition of farming households, or of non-agricultural households potentially via decreased availability of high-quality perishable goods for purchase. Further work is needed to develop strategies to mediate potential adverse effects of reduced access to land for agriculture close to urban areas.

In conclusion, the findings from this survey conducted in peri-urban Nepal, suggest that agricultural participation, and specifically land cultivation and vegetable production, but not livestock ownership, is associated with lower odds of stunting, but few significant relationships with maternal nutritional status. We also found evidence that land cultivation and livestock ownership were associated with less household food insecurity. Our findings provide some of the first quantitative evidence that agriculture in peri-urban areas appears to have benefits that extend to nutritional status. This has implications for the design of national-level multisectoral nutrition policies in Nepal,

including the role of agriculture. The potential for supporting urban nutrition through tailored agricultural investments within urban and peri-urban settings needs more attention in such a policy context.

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RKC, SH, TAS, MU, WWF, LML, PSS, PW and ATL designed and conducted the underlying research study; CM and ATL designed this analysis and analyzed data; CM and ATL wrote paper and had primary responsibility for final content. All authors have read and approved the final manuscript.

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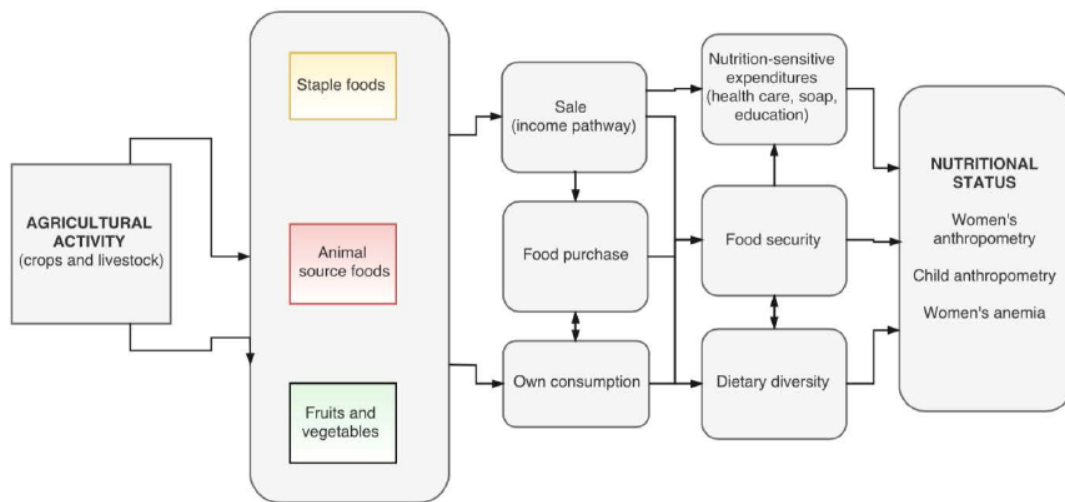
Figure 1: Conceptual framework for the analysis
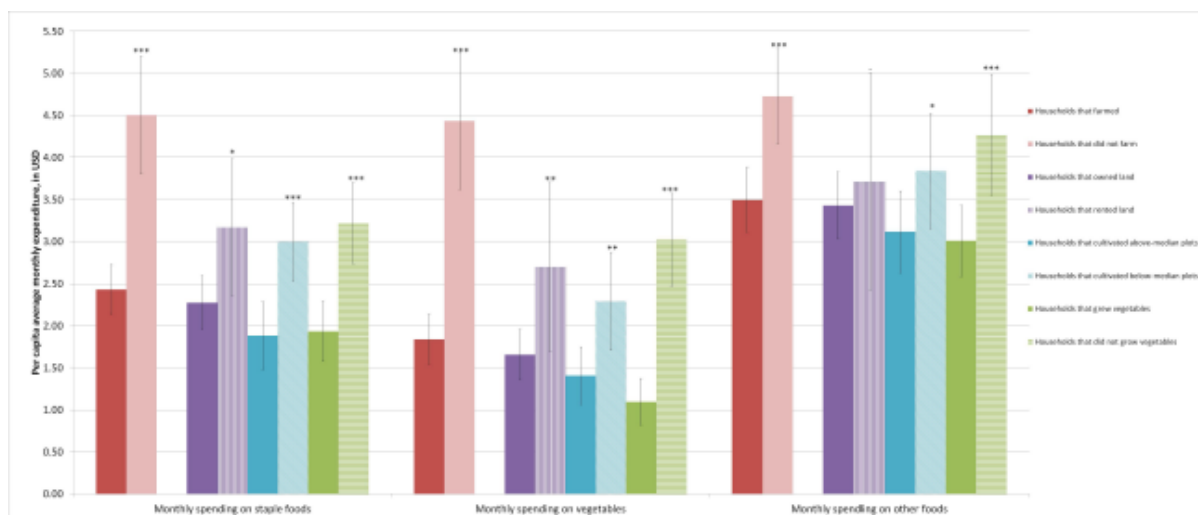
Figure 2: Association between households' reported agricultural activity, and monthly per capita food expenditures (in current USD) (n=353 households)

Red (leftmost per expenditure category) histogram bars report on all households; remaining histogram bars are only among the subset of households that reportedly cultivated any land. Vertical error lines represent 95% confidence intervals. Asterisks represent levels of significance for Wilcoxon rank-sum tests of difference between groups: * p < 0.1, ** p < 0.05, *** p < 0.01.
†Median = 0.1 hectares

Figure 3: Monthly reporting of food insecurity, among farming versus non-farming households (n=340 households)

Vertical error lines represent 95% confidence intervals.

Table 1: Sample characteristics (n=344)
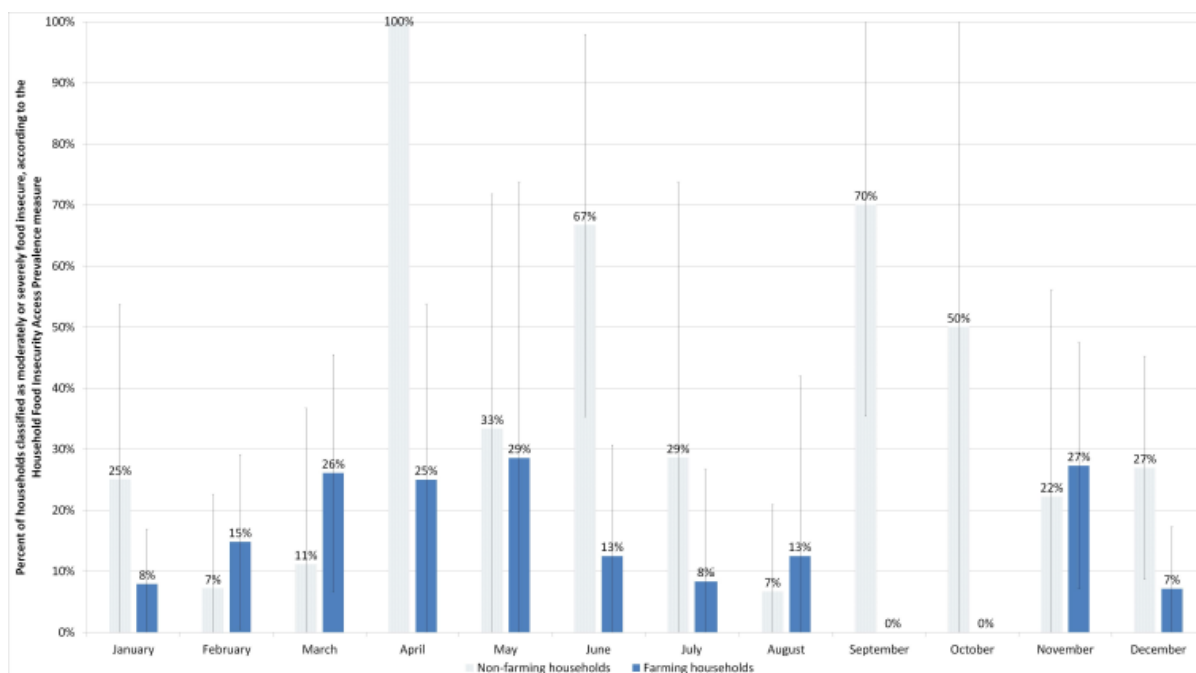
Average household size (SD)	5.5 people (2.5)
Livestock ownership, %	30.5%
Among households that owned livestock (n=107):	
Owned chickens, %	100%
Owned ducks, %	6.7%
Owned buffalo, %	1.0%
Owned pigs, %	1.0%
Household farmed, %	61.9%
Among farming households (n=213):	
Owned land, %	83.3%
Plot size, median in hectares (minimum, maximum)	0.10 (0.003, 0.71)
Last year, grew:	
Rice, %	72.8%
Sold any of the rice?, %	7.9%
Reported mean number of months of rice sufficiency	7.4 months
Wheat, %	40.9%
Sold any of the wheat?, %	16.5%
Maize, %	27.7%
Sold any of the maize?, %	17.2%
Vegetable(s) , %	62.4%
Sold any of the vegetables?, %	24.8%
Among households that grew vegetables (n=133):	
Grew potatoes, %	54.6%
Grew green leafy vegetables, %	97.0%
Grew eggplant, %	25.0%
Grew tomatoes, %	13.6%
Grew cabbage, %	32.6%
Grew cauliflower, %	39.4%
Grew onion, %	31.8%
Grew pumpkin, %	27.3%
Grew yams, %	40.9%
Grew garlic, %	91.7%
Grew green beans, %	45.9%
Number of different vegetables grown, mean (SD)	5 (2.7)

Table 2: Agricultural activity, maternal and child nutritional status, and household dietary diversity

	Full sample (n=329)	By household farming activity:		By household livestock ownership:	
		Farming households (n=203)	Non-farming households (n=126)	Livestock owners (n=99)	Non-livestock owners (n=230)
Nutrition and growth outcomes, % per outcome					
Children: Stunting (HAZ<-2z scores)	39.2%	35.5%	45.2%	38.4%	39.6%
Children: Underweight (WAZ<-2z scores)	18.2%	16.8%	20.6%	21.2%	17.0%
Women: Underweight* (BMI<18.5)	2.2%	1.5%	3.2%	2.1%	2.2%
Women: Overweight or obese* (BMI>25)	40.6%	39.7%	42.1%	34.0%	43.4%
Women: Mild or moderate anemia* (Hb<12.3 g/dL)	32.9%	32.0%	34.7%	36.2%	31.5%
Dietary diversity: women's consumption of individual food items (any consumption over 2-day recall period)					
Grains, white roots and tubers, and plantains	100%	100%	100%	100%	100%
Pulses (beans, peas and lentils)	32.8%	29.66%	38.2%	25.7%	36.0%
Nuts and seeds	0.6%	0%	1.5%	0%	0.8%
Dairy	27.9%	26.3%	30.5%	33.3%	25.5%
Meat, poultry and fish	9.6%	8.9%	10.7%	8.6%	10.0%
Eggs	2.3%	2.3%	2.3%	3.8%	1.7%
Dark green leafy vegetables	39.5%	46.0%	29.0%	41.9%	38.5%
Other vitamin A-rich fruits and vegetables	17.2%	13.6%	22.9%	11.4%	19.7%
Other vegetables	43.6%	41.8%	46.6%	37.1%	46.4%
Other fruits	2.0%	1.9%	2.3%	1.9%	2.1%
Woman's average dietary diversity score	4.06	4.02	4.11	4.08	4.05

Among women who were not reportedly currently pregnant

Table 3: Relationship between agricultural activity and children's nutritional outcomes

	Children: Stunting (HAZ<-2z scores)		Children: Underweight (WAZ<-2z scores)	
	Odds ratio [95% CI], unadjusted model	Odds ratio [95% CI], adjusted model	Odds ratio [95% CI], unadjusted model	Odds ratio [95% CI], adjusted model
Farming households (ref: non-farming households)	0.67 [0.42, 1.05]	0.55* [0.33, 0.94]	0.77 [0.44, 1.36]	0.65 [0.34, 1.27]
Households that owned livestock (ref: did not own livestock)	0.95 [0.59, 1.54]	0.88 [0.51, 1.50]	1.32 [0.73, 2.38]	1.26 [0.64, 2.49]
Among farming households:				
Households that owned land (ref: rented land)	1.89 [0.80, 4.45]	1.78 [0.67, 4.72]	1.59 [0.52, 4.86]	1.51 [0.37, 6.18]
Households with more land (>0.1 hectares) (ref: below-median land size)	1.38 [0.74, 2.58]	1.36 [0.64, 2.88]	2.16 [0.94, 4.95]	1.83 [0.66, 5.05]
Households that, in the last year, grew: (ref: did not grow each crop)				
- Rice	0.83 [0.44, 1.56]	0.67 [0.32, 1.39]	0.92 [0.41, 2.08]	0.98 [0.36, 2.65]
- Wheat	0.94 [0.52, 1.69]	0.82 [0.41, 1.64]	0.92 [0.43, 1.96]	0.98 [0.39, 2.49]
- Maize	1.61 [0.86, 3.04]	1.39 [0.65, 2.99]	1.60 [0.73, 3.50]	1.82 [0.65, 5.14]
- Vegetable(s)	0.57 [0.31, 1.02]	0.50 * [0.25, 0.99]	0.65 [0.31, 1.37]	0.45 [0.17, 1.17]

Adjusted models include: mother's and father's educational attainment (none, primary, lower secondary, higher secondary, college, beyond), mother's and father's employment status (yes/no for formal employment, informal employment, or self-employment), mother's current age, child birth order, months of exclusive breastfeeding, whether the birth was at a health facility (yes/no), child sex, household wealth (quartile group), average MDDW score

*Asterisks indicate level of significance for the odds ratios: * p < 0.05, ** p < 0.01, *** p < 0.001*

Table 4: Association between households' reported agricultural activity, and food security

	Household Food Insecurity Access Scale domains Odds ratio [95% CI], unadjusted estimates			Classified moderately or severely food insecure Odds ratio [95% CI]	
	Anxiety domain	Quality domain	Intake domain	Unadjusted model	Adjusted model
Farming households (ref: non-farming households)	0.41*** [0.26, 0.65]	0.49* [0.31, 0.78]	0.39** [0.22, 0.67]	0.38*** [0.22, 0.64]	0.32** [0.17, 0.62]
Livestock owning households (ref: non-livestock owning households)	0.54** [0.32, 0.91]	0.70 [0.32, 1.16]	0.53* [0.28, 1.03]	0.46* [0.24, 0.88]	0.29** [0.13, 0.66]
Among farming households:					
Households that owned land (ref: rented land)	0.95 [0.41, 2.18]	1.29 [0.55, 3.03]	0.41 [0.17, 1.04]	0.59 [0.23, 1.51]	0.50 [0.16, 1.61]
Households with more land (>0.1 hectares) (ref: below-median land size)	0.31** [0.16, 0.62]	0.52* [0.27, 1.00]	0.40* [0.17, 0.99]	0.41* [0.18, 0.98]	0.29* [0.09, 0.88]
Households that, in the last year, grew:					
- Rice	0.26*** [0.14, 0.51]	0.54 [0.28, 1.03]	0.50 [0.22, 1.14]	0.42* [0.19, 0.94]	0.36* [0.13, 0.95]
- Wheat	0.67 [0.35, 1.28]	1.17 [0.63, 2.17]	0.83 [0.36, 1.90]	0.79 [0.36, 1.76]	0.61 [0.22, 1.68]
- Maize	0.61 [0.29, 1.28]	0.80 [0.40, 1.60]	0.18* [0.04, 0.78]	0.15* [0.04, 0.67]	0.13* [0.02, 0.72]
- Vegetable(s)	0.53 [0.28, 1.00]	0.78 [0.42, 1.45]	0.61 [0.27, 1.38]	0.65 [0.30, 1.41]	0.54 [0.21, 1.44]

Adjusted models include: mother's and father's educational attainment (none, primary, lower secondary, higher secondary, college, beyond), mother's and father's employment status (yes/no), household wealth (quartile group), average MDDW score

*Asterisks indicate level of significance for the odds ratios: * p < 0.05, ** p < 0.01, *** p < 0.001*