Farm-level pathways to improved nutritional status: Introduction to the special issue

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ABSTRACT

Global, national and local policies and programs for agricultural development are recurrently justified based on their alleged role in improving food and nutrition security. However, strikingly little evidence is available to prove that a direct, household-level link between agricultural production and improved nutrition exists. The objective of this special issue is to systematically and empirically test, using data from Africa and South Asia, whether a relationship between household agricultural production and nutrition can be found. Overall, the studies in this special issue support the hypothesis that household agricultural production has direct and important linkages with dietary patterns and nutrition.

I. Introduction

To address concerns over food and nutrition insecurity, policy makers often promote investments aimed at increasing agricultural productivity and production, with the ultimate goal of ensuring that enough food can be produced to feed the growing and more urbanised population (Conway, 2012; FAO, 2013). This emphasis has been particularly common in recent years as a result of the volatile and rising global food prices, which have been associated with increased hunger among poor households that rely heavily on purchasing food to obtain calories and nutrients (Headey and Fan, 2010).

In response to concerns over food security in the continent, for example, the governments of the African Union resolved to allocate 10 percent of their budgetary resources to agricultural development in the Maputo declaration (African Union, 2003). Similarly, following the 2008 surge in world food prices, governments attending the June 2011 G20 Agricultural Ministers' Meeting committed to actions designed to boost agricultural productivity growth and increase food production while also paying special attention to smallholders (FAO, 2011).

This emphasis on agricultural policies to improve food and nutrition security is driven by the increased recognition of the importance of agriculture for food security, dietary quality and nutrition. By the same logic, agricultural support to smallholders should therefore have the potential to improve the nutrition of farming households. This farm-level link is, however, hard to document and identify in empirical work. Understanding the potential for promoting food production to improve nutritional welfare requires carefully considering the farm-level relationship between agriculture and nutrition.

Evidence of the impacts of agricultural programs focused on different agricultural commodities (including nutrient-rich fruits, vegetables, dairy, eggs, fish and other animal source foods) has been the subject of various reviews in the past decade. A recent systematic review of 36 articles evaluating 27 projects that focus on agricultural production as a means to

improve nutrition notes that: ‘Overall the evidence base for the potential of agricultural strategies to improve the nutrition and health of women and young children is largely grounded in a limited number of highly heterogeneous, quasi-experimental studies, most of which have significant methodological limitations. While household food production strategies hold promise for improving the nutrition of women and children, the evidence base would be strengthened by additional research that is methodologically robust and adequately powered for biological and dietary indicators of nutrition.’ (Girard, Self, McAuliffe and Oludea, 2012, page 205).

Similar conclusions came out of a major international conference on agriculture and nutrition held by the International Food Policy Research Institute (IFPRI, 2011), and an updated review of evidence (Ruel and Alderman, 2013), which found that global evidence of the impact of agriculture programs on child anthropometry or micronutrient status is inconclusive. This is in spite of the fact that many of the studies reviewed document positive impacts of agricultural programs on several intermediary outcomes along the impact pathway to nutritional status, including household production and consumption, dietary diversity and maternal and child intake of target foods and micronutrients (Leroy, Ruel, Verhofstadt and Olney, 2008; Olney, Aminuzzaman, Iannotti, Ruel and Quinn, 2009). The lack of evidence of impact on child nutritional status is interpreted as the result of weaknesses in program design and implementation (especially the nutrition behaviour change communication intervention), and even more importantly the lack of rigor in evaluations (Ruel and Alderman 2013).

The objective of this special issue is to systematically and empirically test the relationship between household agricultural production and nutrition in a variety of settings and types of data and fill an important gap in the literature—that is, generating evidence on the contribution of agricultural household production to improvements in nutrition. The eight studies included in the issue examine the relationship between agricultural production (crops

or livestock), household dietary diversity, and children's (and in some cases maternal) diet and anthropometric outcomes across countries in Sub-Saharan Africa and South Asia. The data used in these studies include nationally-representative data and detailed case studies across a range of countries. This allows for comparisons of results across countries in the two regions where undernutrition remains a major concern. The individual research papers analyse, both theoretically and empirically, the different conditions under which own production is likely to be closely linked to farm household food access, diet quality and nutrition outcomes.

The remainder of this introduction is organised as follows. Section II lays out the conceptual link between agriculture and nutrition at the farm level and provides the foundation for the analysis presented in the special issue. Section III discusses the issues with empirically establishing a link between agriculture and nutrition at the farm level and highlights how these issues are addressed by the papers. A summary of results presented in the special issue are included in Section IV and Section V provides some general conclusions.

II. Farm-level pathways to improved nutritional status

The literature notes several pathways through which agriculture can influence nutrition (Pinstrup-Andersen, 2012). While authors may differ in the definition of specific pathways (see, for example, World Bank, 2007; Arimond et al., 2011; Hoddinott, 2012; Gillespie and Kadiyala, 2012; Ruel and Alderman, 2013), four key areas are recurrent in the literature and have been recently taken on by the Study Group in charge of the *Lancet* Series on Maternal Health and Nutrition (Ruel and Alderman, 2013). These four broad areas are: (i) food prices, (ii) income from agriculture, (iii) consumption of own production due primarily to market imperfections, and (iv) factors linked to gender. The latter include issues such as women's social status and empowerment in agriculture, women's time, and women's health and

nutritional status, all of which can be both influenced by their role in agriculture and affect their productivity in agriculture and ability to care for their family and especially their young children. Each of these is briefly discussed below, although it is the latter three links that form the foundation of the special issue.

In the short run the lowering of food prices broadly affects households, including poor households, by providing less expensive access to food and nutrition. Correspondingly, rising food prices can erode access to food and nutrition. This price effect is not dependent on whether households produce food and, in fact, farmers that are net buyers of food may benefit from lower prices. On the other hand, farmers who are net sellers and have access to the key resources needed to turn farming into a profitable activity may be hurt by the reduction of food prices if it lowers their income (Zezza et al., 2009). With respect to policy, food price effects are generally the result of broader agricultural policies that alter overall food supplies—that is, interventions that expand aggregate production and food availability. These effects are not directly linked to being an agricultural producer, and have been at the centre of a considerable amount of research and publications over the past few years (Headey and Fan 2008; Zezza et al., 2009; Aksoy and Hoekman, 2010). In the longer run these effects may be reversed as poor workers may benefit from higher wages, and poor farmers from higher agricultural profits as they increase their output in response to better terms of trade (Ivanic and Martin, 2014). This special issue does not focus on the potential price effects of agriculture policies on nutrition since our emphasis is on farm-level links.

The other three pathways by which agriculture can influence nutrition relate to links within agricultural households, which is the focus of this research. For an agricultural household, beyond the price effect, the main effects of expanded agricultural production depend on whether this primarily induces income gains or whether households modify their consumption patterns and increase their consumption of the agricultural goods they produce, or some

combination of both. The mechanisms by which these effects occur are mediated by gender relations within the household.

The expansion of any economic activity, including agriculture, can have an impact on nutrition as higher income can alter the amount, composition and quality of the food consumed as well as facilitate the purchase of health- and nutrition-related goods and services such as health care or specially formulated foods or supplements for young children. In fact, much of the early literature on agriculture-nutrition linkages hypothesised that poor nutrition was primarily a result of low income and that increasing income through agriculture would lead to significant nutritional gains. Evidence shows, however, that the commercialisation of agriculture and the resulting shift away from staples to cash crops did not result in improvements in children's nutritional status and in some cases may have negative nutritional consequences on the poor (see Von Braun and Kennedy, 1994). Lessons learned from this work—and consistent with more recent analyses (Ecker, Breisinger and Pauw, 2011)—suggest that agricultural income is important, but not sufficient to improve nutrition, especially among poor farming households who lack access to other essential inputs to improved nutrition such as access to preventive and curative health services and to adequate water, sanitation and hygiene services.

Similarly, the literature looking at the relationship between agricultural income and calorie consumption shows that the linkages are complex and the results inconsistent. Study results range from showing an absence of response in calorie consumption among the very poor to income gains to near one where almost all additional income goes toward expanded calorie consumption (Strauss and Thomas, 1995). There are a number of methodological issues that might explain some of these differences (Bouis and Haddad, 1992), but even factoring differences in approaches in establishing the income-calorie relationship, it appears that some of the differences might reflect complex and possibly nonlinear responses at the household

level. In particular, some evidence suggests that elasticities are high for very poor households but decline with income as household shift to emphasizing dietary diversity and quality (Subramanian and Deaton, 1996; Hoddinott and Wiesmann, 2010). In summarising this literature, Strauss and Thomas (1995) note that the evidence suggests that there is some scope for income-based policies to improve calorie consumption, but that this is insufficient since households care about dimensions of welfare other than calorie consumption.

More recent research looking specifically at child nutrition outcomes (for example, anthropometric measures) has mirrored this view. A study by Haddad, Alderman, Appleton, Song and Yohannes (2003) on child undernutrition finds that the Millennium Development Goal of halving the prevalence of underweight children is unlikely to be met through income growth alone. In examining when growth is "nutrition sensitive" using a cross-country dataset, Headey (2011) finds that growth is necessary for nutrition but not sufficient, noting that child undernutrition has not improved in a number of countries where significant economic growth has occurred. The findings also suggest that agricultural growth is more nutrition sensitive than nonagricultural growth, but that the role of agricultural growth depends on the size of the sector, the degree of food insecurity, and the extent to which agricultural growth delivers increased food availability. These results correspond to those by Christiaensen, Demery and Kuhl (2011) who find that agricultural growth is significantly more effective in reducing poverty among the poorest of the poor. The general consensus in the literature remains that growth is good but not good enough for improving child nutrition and reducing micronutrient malnutrition (Ecker et al., 2011). A recent multicountry analysis shows that a 10% increase in GDP is associated with a 6% decrease in child stunting (low height-for-age), but also with a 7% rise in the prevalence of being overweight or obese among women (Ruel and Alderman, 2013). Economic growth by itself can therefore lead to positive nutrition outcomes, but it can also have unintended negative consequences such as

aggravating the rapidly growing double burden of malnutrition problem (coexistence of stunted children and overweight/obese mothers), especially in middle income countries experiencing rapid economic and nutrition transitions (Doak, Adair, Monteiro, and Popkin, 2000; Monteiro, Conde and Popkin, 2004).

Given this evidence, there have been attempts to understand the ambiguity in the link between income and nutrition. One possible explanation is that people use mental accounting to decide on how to use funds—that is, people dedicate income from certain types of activities for specific types of expenditures. For example, evidence from Côte d'Ivoire suggests that increases in the output of the "appreciated" crop, yam, are associated—ceteris paribus—with shifts towards expenditures on education, staples, and overall food consumption and away from adult goods and "prestige" goods such as jewellery (Duflo and Udry, 2004). This suggests that producers tend to think of certain income sources as being dedicated to certain types of expenditures and, therefore, if these income sources decline or increase these specific types of expenditures change disproportionately (Villa, Barrett and Just, 2010). Promotion of agriculture, or even of a particular crop or livestock, may then alter the use of funds in specific ways that influence dietary intakes.

Gender-related factors are also likely to play a key role. The literature on intrahousehold dynamics shows that households respond differently to changes in income depending on who has control of the resources within a household (Quisumbing, 2003). If agricultural income accrues to household members more concerned with diet quality and nutrition, this may lead to more spending on goods and services linked to nutrition outcomes. Even beyond the individual accrual of income, the promotion of agriculture is likely to alter the allocation of resources within the household, particularly the time use of household members. For example, if the promotion of agricultural activities induces women to devote more time to agricultural activities, this can alter the balance between time generating income and time allocated to

household management and care giving. The resulting change in labour requirements can also affect the calorie requirements and nutritional status of women (Ruel and Alderman, 2013). This means that the nutritional impact of policies promoting agricultural production depends on who within a household benefits from these policies and how it alters household resource allocation as well as intrahousehold dynamics, particularly the relative bargaining power of men and women within the household.

The literature on intrahousehold allocation and mental accounts suggest that the variation in the link between income and nutrition may be partially explained by the fact that the source and recipient of income can matter. For example, evidence from the US Food Stamp program shows that the marginal propensity to consume food out from food stamps is higher than for cash even for households that use both cash and food stamps on food. Breunig and Dasgupta (2005) find that this discrepancy is a result of intrahousehold bargaining and results from the fact different household members have control over different resources. Looking at child benefits in the Netherlands, Kooreman (2000) finds that parents who receive the benefit—whether single or two-parent households—have a higher marginal propensity to purchase children's clothing out of the benefit than they do for other forms of income implicitly tying the child benefit to purchases for their children. This suggests a mental link between the income source and expenditures. Considering these explanations, using data from East Africa Villa et al. (2010) find evidence of differential dietary diversity responses to various sources of income. While intrahousehold allocation issues appear to explain part of the reason for this link, they cannot rule out the possibility that mental accounting also plays a role.

The other hypothesised pathway linking agriculture and nutrition is the household's consumption of own production. This can be for the reasons noted above and related to who obtains income from certain commodities due to mental accounting and intrahousehold allocation, but it also may be related to market imperfections or failures (Villa et al., 2010). If

markets do not function, or transaction costs create a wedge between buying and selling prices, agricultural production by the household can have an influence on household consumption. At the extreme, if a household is autarkic in the production of a staple good, or even a set of goods, nutrition is likely to be influenced by the amount and composition of food produced by the household (Muller, 2009). But even if markets are imperfect in output, input, labour, credit or insurance markets, this can create a situation in which production and consumption decisions become linked, or nonseparable, within an agricultural household (Singh, Squire and Straus, 1986). A household decision on the amount and composition of food to produce depends partially on the consumption needs of the household, potentially creating a direct link between own agriculture production and the nutrition of household members.

For example, analysing autarkic farm households in Rwanda, Muller (2009) finds that production of several food commodities are found to have a positive influence on nutrition, whereas some, like the production of traditional beer, have a negative impact. Looking at urban agriculture, Zezza and Tasciotti (2010) find that the production of crop and livestock goods within cities and towns is positively associated with greater dietary diversity and calorie availability suggesting that what urban households produce has a direct effect on nutrition. Another important aspect affecting consumption of own production is seasonality of production which creates “hunger seasons”. Vaitla, Devereux and Swan (2009) documents that, as expected, undernutrition is most acute during the time of year when harvest stocks are depleted, food prices are high, and jobs tend to be scarce.

Other analyses have sought to establish if household production of certain types of foods, bred with particularly desirable nutritional traits, can be linked to nutrition outcomes. These programs are more amenable to the use of experimental and quasiexperimental methods, and are therefore different in approaches as well as in thematic coverage from much of what has

been reviewed thus far. For example, using a randomised controlled trial design, Hotz and colleagues assessed the impact of a program that promoted home production and consumption of β-Carotene-rich orange sweet potato (OSP) in Mozambique and Uganda, and documented positive impacts on maternal and child vitamin A intakes in both countries and on child vitamin A status in Uganda (Hotz et al., 2012a; Hotz et al., 2012b). It is important to note that, in addition to the agricultural component, these programs had a strong behaviour change communications intervention that promoted intake of OSP, especially among mothers and young children who are most at risk of vitamin A deficiency. The studies did not test whether agriculture alone—without the behaviour change component—would have achieved similarly positive impacts on vitamin A intakes and status.

If household-level effects of agriculture on nutrition exist, they are most likely the result of one or a combination of these factors—higher agricultural income, market imperfections (resulting in greater consumption of own consumption) and gender-related factors. Policies and programs that seek to use agriculture as a direct means to improve food security and nutrition of agricultural households implicitly assume these household-level effects exist and that their magnitude is economically meaningful. Correspondingly, policies that promote commercialisation of agriculture, or generally seek to expand the value of agricultural production, assume that enhanced income generation is sufficient to improve food security and nutrition and that composition of household production does not matter.

III. Empirical challenges in establishing the farm-level agricultural-nutrition link

The first challenge in empirically establishing a farm-level relationship between agriculture and nutrition is identifying the right set of variables to analyse. Of course, the concepts noted in the previous section should be the basis of such an analysis but, as seen in that section, much depends on the particular link that is expected between farm production and nutrition. If

a direct link between production and consumption is anticipated—that is, farm households are expected to consume their own production—then the production of certain products or even the diversity of production are hypothesised to influence nutrition outcomes. In that case, the production of particular products or sets of products, or a production diversity index might be appropriate agriculture measures. Alternatively, if the expectation is that higher income leads to improved nutrition, then measures such as the value of production or agricultural income might be the most relevant. However, even the use of an income measure is complicated by the possibility that the income source (mental accounting) and the recipient (intrahousehold allocation) may influence income use suggesting a need to carefully consider how agricultural income is disaggregated. As such, a range of agriculture measures might be used.

On the nutrition side, much depends on whether measures focus on inputs, such as food, caloric or micronutrient intake, or dietary diversity indicators (designed to be used as a proxy for diet quality—see Arimand et al., 2010) or outcomes, which are generally measured by anthropometric indicators, such as height-for-age, weight-for-age, weight-for-height or body mass index (BMI), or biomarkers to measure micronutrient status. The selection of indicator is complicated by the unit of analysis, household or individual, and the population of interest within the household (age category). Certainly, these measures are not mutually exclusive and a combination of measures linked to anticipated effects based on the causal chain identified in a conceptual model can be used.

When using data not collected specifically for the purpose of analysing the agricultural-nutrition link, the farm-level analysis may be limited by data availability both on agriculture and nutrition outcomes. The conceptual framework and the available data then determines what types of relationships can be explored. Table 1 provides an overview of the agriculture and nutrition variables used in the papers included in the special issue.

[TABLE 1 ABOUT HERE]

With respect to agriculture, a number of the papers use some form of production diversity measure (Nigeria, Zambia, Nepal 1 and Nepal 2) with the idea that greater diversity in production has an impact on nutrition through consumption. Some papers focus on particular types of products. The Ethiopia paper focuses on dairy cows and products while Uganda looks more broadly at animal products and Tanzania examines general livestock production. The Mozambique paper looks specifically at consumption of Vitamin A fortified sweet potato. A number of papers also examine overall value of crop production as well as agricultural income.

To measure nutrition, six of the papers incorporate a form of nutritional input (Ethiopia, Mozambique, Nigeria, Uganda, Zambia and Nepal 2) and six also use anthropometric measures (Ethiopia, Tanzania, Uganda, Zambia, Nepal 1 and Nepal 2). In three of the studies, the nutritional input indicator used is household dietary diversity, while in two of the studies, the focus is on children's intake — of dairy products in Ethiopia and of Vitamin A and dietary diversity—and one case (Nepal 2) on the dietary diversity of mothers. The studies that use anthropometric measures nearly all focus on children under five years of age, with analyses breaking down the sample into smaller age groups to look at potential age differences in nutrition impacts. Two of the studies have anthropometric data on other age groups: Tanzania has anthropometric data on all individuals in the household, which allows the authors to explore the linkages between agriculture and nutritional status for a range of household members, while Nepal 2 uses maternal body mass index (BMI).

Given appropriate variables, the second challenge in assessing farm-nutrition linkages relates to the use of appropriate data and methods to establish a relationship between agriculture and nutrition. There are two issues to consider: the geographic coverage and resolution of the data and the type of data.

Data is either representative at the nationally level or comes from a case study conducted in a particular region or to evaluate a specific intervention. National data sets provide broader validity to establishing relationships and identify contexts in which nutrition outcomes are closely linked to farm household production, but they tend to allow less detailed examination of local issues. Case study data sets, on the other hand, have the advantage of exploring in more detail a specific context or a certain intervention.

As seen in Table 1, the papers for the special issue capitalise on these two types of data. The papers analysing national-level data sets (Nigeria, Tanzania, Uganda and Nepal 1) are generated in collaboration with the World Bank's Living Standards Measurement Study survey program and feature extensive modules on agriculture and in most cases anthropometric measures. The case studies include detailed agriculture and nutrition information and are generated for evaluations of particular interventions, although in Ethiopia, Zambia and Nepal 2 the data used are from the baseline survey conducted before the intervention of interest was rolled out.

With the exception of Mozambique, all of the data used in the special issue is observational. The Mozambique experiment allows the authors to establish whether the promotion of a Vitamin A biofortified sweet potato, and the intensity of that promotion, achieves its desired outcome of improving nutrition. The benefit of this type of experimental data is that it is easier to establish a causal relationship between agriculture and nutrition, particularly when addressing a specific issue as in this particular case. Of course, experiments have well-known limitations that have been noted in the literature (see, for example, Deaton (2010) and Barrett and Carter (2010)) and observational data plays an important role in trying to understand the farm-nutrition relationship.

The challenge in observational data is identifying a causal impact between agriculture and nutrition outcomes. Of particular concern is that any estimate of impact will be biased since

the relationship will capture the characteristics of the type of farmer rather than the type of production. Of course, there are approaches to establishing an unbiased and causal relationship including the use of panel data, instrumental variables and robustness checks. Even with the potential issues with observational data, this does not mean that such studies do not provide important insights into the farm-nutrition link, particularly given the advantage they offer in the scale and types of relationships that can be studied. The last two columns of Table 1 shows the type of data and methods used in each of the studies included in this special issue.

IV. Synthesis of results

Notwithstanding the substantial variation in measures, methods and approaches, the papers in the special issue all trace some association between agricultural production and diets or nutrition outcomes, though in some cases causality is difficult to establish given the empirical issues discussed in the previous section.

The paper by de Brauw, Eozenou and Moursi measures the impact of the participation, and the intensity of participation, in a biofortification (B-carotene-rich orange sweet potato) program on the Vitamin A density, micronutrient density adequacy and the diversity of children's diet in Mozambique. Exploiting the randomised trial nature of their data, the authors are able to trace positive impacts of program participation on all outcomes, and particularly on Vitamin A density. The intensity of participation and the delivery mode of the program are also shown to be important for the magnitude of the observed impacts, a finding that has important implications for program design. The results confirm that biofortification can play an important role in improving children's diets, but that mechanisms should be put in place to promote high participation in the program's agriculture and nutrition interventions in order to maximise their nutritional impact.

The papers by Dillon, McGee and Oseni, and by Kumar, Haris and Rawat both focus on the relationship between engagement in agriculture and crop production diversity on dietary diversity (both papers), anthropometric outcomes (Kumar et al. only), and consumption of specific food groups (Dillon et al. only) in Nigeria and Zambia, respectively. Both studies find positive associations between crop and diet diversity, and the Zambia study also shows a positive association between crop diversity and height-for-age z-scores in children 24 months and older. The Nigeria study also documents an impact (albeit small in magnitude) of agricultural revenues on dietary diversity.

Three of the studies in the special issue (Slavcheska; Hoddinott, Headey and Dereje; Azzarri, Cross, Haile and Zezza) look specifically at the role of livestock ownership in improving diets by way of an increased consumption of animal source foods. These are of particular nutritional interest given their high density in protein and key micronutrients (for example, iron, zinc calcium, B12). As in the Nigeria paper, Slavcheska also examines the relationship between the value of crop production and nutrition outcomes. Using nationally representative and panel data which allows for controlling for unobserved heterogeneity, Slavcheska finds small but significant effects of crop value on anthropometric outcomes of preschoolers and children 5 to 9 years old. In female headed households, higher crop value is also linked to better linear growth for children less than 24 months old. There is also limited evidence that greater value of crop production increases BMI among adolescents (ages 10 to 19). Slavcheska also finds that ownership of large livestock holdings is associated with lower odds of stunting among preschoolers and that children ages 5 to 9 from pastoralist households are better nourished. A lack of livestock ownership is also associated with low BMI of adolescents. No effects of crop production or livestock ownership are found for adults.

In their analysis of data from 93 *woredas* in Ethiopia, Hoddinott et al. show that household cow ownership is strongly associated with an increased frequency of milk and dairy

consumption among young children. The effects are large: between 16 and 29 percent depending on the dairy product considered (23 percent for milk). They can also trace a corresponding reduced probability of stunting (by a considerable 5.5. percentage points) for children under 2 in households owning cattle. By splitting the sample based on market access, the analysis makes a compelling case for market imperfections being the driver of the linkages between milk and dairy production and child nutritional status: the magnitudes of the point estimates are 2 to 3 times higher in non-market villages, and the effects are in fact not statistically significant in market villages.

Azzarri et al. complement that perspective by looking at the whole range of animal source foods. Using panel data from Uganda, they trace a positive association between livestock ownership and the consumption of a range of animal source foods. They can only rely on cross-sectional data for the analysis of child nutrition outcomes, and report an impact of small ruminant ownership reducing the probability of wasting and underweight for children of age 3 to 5 years. Conversely, they find that large ruminant ownership increases the probability of underweight in the same age group, which they speculate could be linked to issues related to hygiene and livestock-borne diseases, or competition between humans and livestock for foodstuff consumption leading to a perverse effect of livestock ownership on nutrition outcomes.

The two Asia-focused papers use data from Nepal, one from a nationally-representative survey (Shively and Sununtnasuk) and the other from the baseline survey for an impact evaluation of a multisectoral nutrition program (Malapit, Kadiyala, Quisumbing, Cunningham and Tyagi). Both find associations between production diversity and dietary diversity or nutrition outcomes, including for maternal nutrition in the paper by Malapit et al. While identification issues prevent these two studies from making casual claims, they offer an interesting perspective in that they go beyond a general link between agriculture and nutrition

broadly to look more specifically into agricultural commercialisation (Shively and Sununtnasuk) and the mediating role of women's empowerment (Malapit et al.).

While the concern is sometimes expressed that agricultural commercialisation may be detrimental for child nutrition (Von Braun and Kennedy, 1994) the data for Nepalese agricultural households used by Shively and Sununtnasuk do not lend support for that hypothesis, and actually detect a positive, if small, association between market orientation and height-for-age z-scores for children under two years of age. In this case, it seems, the increased income generated by agricultural sales more than offsets possible adverse impacts associated with less food being available for own consumption.

The other Nepal study (Malapit et al.) uses a recently developed indicator of women's empowerment to investigate whether women's empowerment interacts with agriculture outcomes in influencing maternal and child nutrition. They find that women's engagement in the community, control over income, reduced workload, and the overall empowerment score are positively associated with better maternal nutrition. Control over income is associated with better child height-for-age z-scores [HAZ], and a lower gender parity gap improves children's diets and HAZ. Women's empowerment also mitigates the negative effects of low production diversity on maternal and child dietary diversity and HAZ, indicating that women's empowerment has greater potential to improve nutrition outcomes in households with less diverse production.

Table 2 summarises the main findings of the eight papers. However, much of the interest of the collection of studies is in the nuances and differences they present in terms of definitions of 'agriculture', food products considered, differential impacts by age groups and location, and the mediating effects of women's empowerment. To better appreciate the richness of this collection of studies, the reader is strongly encouraged to refer to the details provided in the individual studies.

[TABLE 2 ABOUT HERE]

V. Conclusions

Taken together, the studies support the hypothesis that household agricultural production has direct and important linkages with household dietary patterns and the nutrition of individual members. The magnitude of the impacts varies, probably as a result of differences between the studies in several key factors, such as commodities, contexts and location (for example, dairy in isolated Ethiopian villages) or the intensity of program participation (biofortification in Mozambique). While links to crop production and diversity of production are found to matter in certain contexts, livestock seems to emerge as particularly important and positively linked to nutrition. The results suggest that support to agriculture can play a direct role in promoting nutrition, but that the effects might not be as dramatic as anticipated and depend on local conditions.

The papers also highlight the limits of available data in precisely measuring farm-level causal relationships between agricultural production and nutrition. At the national level, panel data with details on agricultural production and appropriate nutrition measures (as used in Tanzania and Uganda) will help to improve observational studies. This type of data is becoming more available through the LSMS studies. At the case study level, more experiments involving interventions, similar to Mozambique, would help to establish causality of effects and better understand the specific nature of the linkages between agriculture and nutrition outcomes. Such studies are on-going, including in a few of the studies presented here, but more can be done. One clear policy conclusion then is the need to devote more efforts to filling the data gaps that make such analyses so difficult in the developing world.

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Table 1: Emprical approaches to establishing the farm-nutrition link

	Data			*Methods*		
	Agricultural measures	**Nutritional outcomes**	**Unit(s) of analysis**	**Scale**	**Data type**	**Estimation**
Ethiopia *(Hoddinott et al)*	Dairy cow ownership	HAZ; stunting, Intake of dairy products	Children 0-60 months with focus on 6-24 months	83 woredas with AGP with particpants and non-participants	Observational	OLS with robustness tests (placebo)
Nigeria *(Dillon et al)*	Agricultural revenues Crop diversity	Dietary diveristy Consumption of individual food groups	Household	Nationally representative Rural agricultural households	Observational	OLS Instrumental variables
Mozambique *(de Brauw et al)*	Intensity of participation in biofortificatyion program	Vitamin A density Micronutirend Adequacy Dietary diversity	Children 6-35 months	36 village oragnizations in 4 districts (Mozambique)	Randomized control trial Dose response	OLS (ANCOVA) Instrumental variables
Tanzania *(Slavchevska)*	Harvest value/production Large livestock ownership	HAZ, Stunting WAZ, WHZ BMI, underweight	Children 0-60 months Children 5-9 and 10-19 Adults 20-55	Nationally representative Farm households	Observational, panel	Fixed effects
Uganda *(Azzarri et al)*	Livestock by type	Meat/dairy expenditures Stunting, underweight, wasting	Household Children 6-59 months	Nationally representative Rural households	Observational, panel	Random effects Instrumental variable
Zambia *(Kumar et al)*	Production diversity Agricultural production and income	Dietary diversity HAZ and stunting WHZ and wasting	Household Children 6-59 months	1 district	Observational	OLS
Nepal 1 *(Shively et al)*	Crop diversity, yields, own consumption and crop shares, sold ratio	HAZ, Stunting	Children 0-60 months	Nationally representative Farm households	Observational	OLS and logit
Nepal 2 *(Malapit et al)*	Production diversity Women's Empowerment in Agirculture Index	Dietary diversity BMI, HAZ, WHZ	Mothers Children 0-60 months	Three agroecological zones	Observational	OLS

Table 2: Summary of results

	Association/Impact between agricultural and nutritonal outcomes
Ethiopia *(Hoddinott et al)*	Positive, quite large effects of cow ownership on child intake and nutrition for children 6-24 months: 16 to 29 percent higher probability of consuming dairy (depending on product), increase in height-for-age z-scores by 0.2 standard deviations, reduction in probability of stunting by 5.5% (up to 13% in some age brackets).
Nigeria *(Dillon et al)*	Positive for agricultural revenues (10% increase leading to 1.8% more dietary diversity). Positive but biased (no valid instruments) for crop diversity (10% increase leading to 2.4% increase in dietary diversity)
Mozambique *(de Brauw et al)*	Positive; stronger on Vitamin A density, weaker on others, but higher with participation intensity. Different by program components (vines+extension; promoter vs meeting only)
Tanzania *(Slavchevska)*	Positive; small effects of crop value on anthropometric outcomes of preschoolers and children 5 to 9 years old. Particular effects for children less than 2-3 in female headed households. Iincreased BMI from crop production among adolescents (ages 10 to 19). Ownership of large livestock holdings associated with lower odds of stunting among preschoolers. Children ages 5 to 9 from pastoralist households are better nourished and a lack of livestock ownership limits BMI of adolescents.
Uganda *(Azzarri et al)*	Positive impact of livestock ownership on consumption for different animal source foods (varies by type), except for the cattle-beef nexus (no impact). Small ruminant ownership decreases wasting and underweight among 24-59 months old. Large ruminant ownership increases the probability of underweight for children 24-59 months old.
Zambia *(Kumar et al)*	Positive on dietary diversity for households and children age 6-23 months; stunting down for children 24-59 months. Impact reduced when controls for preventive health care are included
Nepal *(Shively et al)*	Positive association between agriculture and nutrition for all children. Small, positive association for commercialization, only for younger children
Nepal *(Malapit et al)*	Production diversity at household level strongly associated with mothers' and children's dietary diversity and children's weight-for-height z-scores. Engagement in the community, control over income, reduced workload, and the overall empowerment score are positively associated with better maternal nutrition. Control over income is associated with better height-for-age z-scores, and a lower gender parity gap improves children's diets and long-term nutritional status. Women's empowerment also mitigates the negative effect of low production diversity on maternal and child dietary diversity and height-for-age z-scores.