Impacts of Agriculture on Nutrition: Nature of the Evidence and Research Gaps

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Introduction

In the last few years, there has been a proliferation of interest in how to leverage agriculture to maximize its impacts on nutrition, particularly among mothers and children (USAID 2011; Herforth 2012). The belief that "agriculture contributes not just to food production, but also to human nutrition and health" (IFPRI 2012) is widely held, and it underpins ongoing efforts globally to "make agricultural policies and programs nutrition-sensitive."(BMGF 2012) However, the search for solid empirical findings of 'what works' in this arena has been stepped up as donors and national governments increasingly call for "evidence-informed policymaking" against a backdrop of demands for greater accountability, fiscal austerity and enhanced credibility (Mallet et al. 2012). This research brief synthesizes the results of a ten reviews conducted since 2000 to, a) highlight their major conclusions and b) reflect on the implications of those conclusions for planned and future research.

Evidence of Impacts

Nine of the ten reviews considered here set out to answer fundamental questions framed along the lines of 'do agricultural interventions improve nutrition?' The types of interventions considered vary considerably across the studies—some focusing on any form of agricultural investment that had an explicit nutrition impact as part of its design, versus others only including interventions that …. Other differences across the review papers include the units of observation used (households, mothers, all women, children under 5 years of age, children under 2, etc.), the metrics of impact (increased production of specific nutrient-dense foods, consumption diversity, anthropometry, clinical assessment of micronutrient deficiencies, etc.), and the threshold of evidence imposed on the studies that they examined (formal systematic reviews versus less rigorous reviews of case studies) (see Table 1). The tenth review (Hawkes et al. 2012) is not of findings, but of ongoing and planned research in this area.

Ruel (2001) reviewed interventions from the 1990s that promoted production of micronutrient-rich foods through home gardening, small animal husbandry, and aquaculture, as well as BCC (behavior change communication) efforts aimed at promoting changes in dietary patterns. Focused specifically on micronutrient outcomes, the author noted that only a few of the home garden and nutrition education studies actually measured the impact of their activities on intended outcomes, and of those that did, few could demonstrate any positive statistical significance. The conclusion was that "although the question of whether home gardens have a positive impact on vitamin A status has been examined in a number of reviews, including some recent studies, evidence is still scant. […] In the end, the same question posed in reviews published decades ago remains: what can food-based interventions to control vitamin A and iron deficiency really achieve?" (Ruel 2001)

Building on that work, Berti et al. (2004) broadened the scope of agricultural interventions considered in their systematic review that pushed back to the 1980s. They only included studies that did measure

Table 1: Characteristics of Recent Reviews

Review paper	Systematic review?	Number of studies screened	Studies retained for review	Period of studies retained	Agriculture activities included	Important conclusions
Ruel (2001)	N	Not specified	14	1995-1999	Home gardens, small animals, aquaculture, BCC*	➢ "information now available to judge the effectiveness of food-based strategies…is inadequate." ➢ "basic information on efficacy is needed."
Berti et al. (2004)	N	36	30	1985-2001	Home gardens, animal husbandry, irrigation, cash cropping, credit, land distribution	➢ "mixed results in terms of improving nutrition." ➢ "home gardening projects usually had a higher success rate than other types of intervention." ➢ "negative effects were not uncommon."
Leroy and Frongillo (2007)	Y	Not specified	14	1987-2003	Animal husbandry, aquaculture, poultry, credit, BCC	➢ measured of impact "on nutritional status are rare." ➢ "only 4 studies evaluated impact on nutritional status and found a positive effect." ➢ "integrated [activities] generally found positive results."
World Bank (2007)	N	Not specified	52	1985-2007	All forms of agriculture activity	➢ "agricultural interventions have not always been successful in improving nutritional outcomes."
Bhutta et al. (2008)	Y	Not specified	29	1985-2004	Home gardens, animal husbandry, small ruminants, BCC	➢ "dietary diversification strategies have not been proven to affect nutritional status or micronutrient indicators on a large scale."
Kawarazuka (2010)	Y	Not specified	23	2000-2009	Aquaculture	➢ "data on the linkage from improved dietary intake to nutritional status were scarce." ➢ "nutritional outcomes were not clearly demonstrated."
Masset et al. (2011)	Y	7,239	23	1990-2009	Biofortification, home gardens, aquaculture, poultry, husbandry, dairy development.	➢ "very little evidence was available on changes in the diet of the poor." ➢ "we found no evidence of impact on prevalence rates of stunting, wasting and underweight among children."
Arimond et al. (2011)	N	>2,000	39	1987-2003	All forms of agriculture activity	➢ "very few agricultural interventions with nutrition objectives have been successfully scaled up." ➢ "many of the studies…were weakly designed."
Girard et al. (2012)	Y	3,400	37	1990-	Home gardens, biofortification, BCC, husbandry, poultry, aquaculture	➢ "of the 37 studies reviewed here, only one was graded as high…when biases, weaknesses were considered. All remaining studies were graded low to very low." ➢ "estimates for effects on stunting…were not significant."

* BCC = Behaviour change communication (nutrition/health education)

a range of nutritional outcomes, but this allowed for consideration of irrigation and cash cropping schemes, large ruminant husbandry, and mixed garden-small ruminant interventions. They applied formal search protocols and conducted quality (validity) control based on used of counterfactuals, sample sizes appropriate to measuring intended differences in outcomes, and appropriate choice of outcome variables. They found "mixed results in terms of improving nutritional status in participating households."(Berti et al. 2004) That is, some interventions reported significant improvements, while others found no impact or even negative impacts. A lack of disaggregation of data, lack of statistical power (small sample sizes), and lack of a clear understanding of confounders prevented any overall conclusion to be reported.

LeRoy and Frongillo (2007) took a different direction, choosing to narrow down the focus to the role of animal sourced protein in improving nutrition as generated by interventions promoting animal production. This systematic review generated 14 studies across a range of husbandry, small ruminant, aquaculture and/or BCC activities. Most of the studies reported positive impacts on production associated with an intervention, but only 4 evaluated nutrition outcomes directly. Those 4 reported improvements in various nutritional parameters (night blindness, serum retinol and ferritin levels, hemoglobin levels, and linear growth), but did not document statistical significance attributable to the intervention or in relation to counterfactuals. The authors concluded, as had Ruel (2001) and Berti et al. (2004), that studies available for review "suffered from important limitations in their design, evaluation and analysis." This meant that while there were indications that increased production and consumption of animal protein could be promoted through the kinds of interventions considered, conclusive evidence remained elusive.

The World Bank (2007) compilation of lessons learned was not systematized (search methods and results were no specified and conclusions drew heavily from the earlier reviews outlined above), but it included assessment of 52 studies that considered agricultural impacts on food expenditure, caloric intake and anthropometry. The over-riding conclusion was that interventions aimed at increasing production and productivity of staple foods showed impacts on child nutritional status that were "limited and mixed". Similarly, programmes focused on promoting animal source foods (many of which had been reviewed by LeRoy and Frongillo (2007) "showed mixed results", while home garden activities "failed to achieve significant impacts on nutritional outcomes".

The Lancet series on maternal and child nutrition of 2008 (Bhutta et al. 2008), also included a review of interventions designed to improve nutrition under the rubric of dietary diversification strategies. Although most of the 29 studies considered demonstrated various benefits to producer households in terms of increased food production and consumption, especially when combined with a nutrition education component, significant impacts on nutrition were weak (Haider and Bhutta 2008). As a result, the Lancet review concluded that "although some promising multidisciplinary nutrition interventions have been implemented, dietary diversification strategies have not been proven to affect nutritional status or micronutrient indicators on a large scale." (Bhutta et al. 2008) As a result, diet diversification strategies of the kinds considered were classified as an 'optional' intervention to be used in appropriate settings (when trying to improve nutrition), but without modeling the potential effects to be gained or specifying what settings are more 'appropriate' than others.

The review by Kawarazuka (2010) focused more narrowly on aquaculture (in part because such interventions had not featured prominently in earlier reviews). It considered 23 studies that sought to document the impact of fish consumption and aquaculture activities on dietary intake and the nutritional status of poor households in Africa, Asia and Oceania. He found that many different kinds off interventions increased fish (and other forms of aquatic protein) consumption as well as household income. However, few studies analyzed impact on nutritional status and the author had to conclude that "there is little evidence of the positive changes in nutritional status among households taking up aquaculture" and that the nutritional impacts associated with small-scale fisheries "were not clearly demonstrated". The author reiterated the *potential* for aquaculture to support enhanced nutrition and called for research-based evidence to convincingly demonstrate efficacy and effectiveness of such interventions.

Masset et al. (2011) took on arguably the largest undertaking of this kind to date. The authors excluded studies that did not use control groups, but did cast a wide net in the search for studies meeting appropriate study design criteria. Indeed, over 7,000 studies were identified through specified inclusion criteria. But only 23 of those were retained for full analysis is when exclusion criteria were applied. Overall, the review found "no evidence of impact" on child nutrition as evinced by statistically significant improvements in anthropometry. A positive impact on vitamin A intake was noted for just 4 studies of home gardening activities. An additional 5 studies considered impacts on iron intake, but only 1 of those showed a positive impact at the 5 percent significance level.

The authors appropriately went out of their way to state that "the absence of reported statistically significant impact of agricultural interventions on children' nutritional status…should not be attributed to the inefficacy of these interventions. Rather, it is the lack of power of the studies reviewed." Indeed, the authors' critique of standards of research on these topics is scathing. They note that not one study reported participation rates or the degree to which a programme fully reached its target population (coverage). There was no disaggregation of effects by sub-populations to determine if the most vulnerable to nutritional deficiencies had been included. Anthropometric data were collected in only 13 of the 23 studies retained for analysis, and only 8 of those reported prevalence rates of child stunting or wasting. The overall conclusion of this review was simply that given the current state of evidence, it remains impossible to answer how effective agricultural interventions are in improving child nutrition.

The review by Arimond et al. (2011) summarized and integrated lessons learned both from preview literature reviews (4 of the co-authors of this assessment were authors in their own right of several of the reviews noted above), and operational insights gained from more recent interventions. The authors describe a set of interventions from around the world that do show increased production of targeted (nutrient rich) commodities, enhanced consumption of target foods, and some positive effects on nutrition outcomes for women and children. But they also caution that "impacts on diets, nutrient intakes and nutritional status…showed mixed results" and that "the evidence base is still limited." Once again, weak study designs limited the strength of findings, thus preventing unqualified conclusions about impact. There is suggestive evidence of the potential for well-designed interventions that promote consumption of nutrient-rich foods, animal source protein, and agriculture-

derived income controlled by women to help improve nutrition, but that potential has yet to be convincingly documented.

Finally, Girard et al. (2012) sought to assess maternal, neonatal and child health outcomes of interventions "aimed at increasing the quantity and/or quality of household food production." Four of the studies offered sufficient data to conduct meta-analyses on child growth outcomes (anthropometry). The finding was that "agricultural strategies were not significantly associated with stunting, underweight or wasting." Many studies suggested improved production and consumption of target foods, but concrete evidence of nutrition impact "is largely grounded in a limited number of highly heterogeneous…studies, most of which have significant methodological limitations.

In sum, these nine reviews of the past decade come to similar conclusions. Regardless of approach used, criteria applied to the selection of evidence, and analytical techniques adopted for meta-analyses, the interpretation of findings across all reviews is consistent:

1. The current state of empirical evidence for impacts on nutrition ascribed to defined agricultural interventions is weak and mixed at best.
2. Statistically significant impacts have been documented in a few cases, mainly in terms of micronutrient status (usually Vitamin A), but even in such instances net effects across all nutrients have not been documented.
3. Where impacts on child growth lean towards the positive, it appears that key factors may involve: i) integration of BCC activities with whatever agricultural intervention is promoted; ii) actions that increase income, overall dietary quality (and quantity), *as well as* consumption of the one target nutrient-rich food—not just one or the other; iii) women's empowerment through decisions on resource use in agriculture, control over derived income, and knowledge on best uses of such income and home-produced foods to support desired nutrition outcomes in children; and iv) attention to net effects of interventions, such that gains in one area (such as increased animal husbandry) are not off-set by increased zoonotic diseases that result in lost nutrients through, say, diarrhea.
4. The lack of sound, empirical evidence on efficacy, effectiveness at scale, and cost-effectiveness of all kinds of agricultural intervention on nutrition remains a significant hurdle to policy advocacy and investment. The sooner methodologically rigorous studies can produce findings that offer guidance on how best to leverage agriculture's potential for nutrition the better.

Ongoing and Planned Research on Agriculture to Nutrition Linkages

In an attempt to define the priority holes in research coverage and map out current activities aimed at generating policy-relevant evidence, Hawkes et al. (2012) conducted a gap analysis. Starting from the position that "little strong evidence of impact" exists, and that there is a need "for more and better designed research", they identified 151 research activities (ongoing or planned) focused on agriculture-nutrition linkages for women and children, mostly centered on Africa and Asia. Almost 50 separate organizations are involved in these undertakings, funded mainly from 5 main donor sources; namely, the Bill and Melinda Gates Foundation, the United States Agency for International Development (USAID), the Canadian International Development Agency (CIDA), the International Development

Research Centre in Canada (IDRC), and the Department for International Development of the UK (DFID).

Most of this research is focused on specific agricultural interventions directed at improving the output of nutrient-rich foods, be it through biofortification, productivity enhancements, or promotion of indigenous/traditional foods. A second set of research projects focuses on value-chain promotion for nutrition. Roughly 46 of the 151 studies have a specific focus on children (18 on children under 2 years of age), and those same 46 typically also have some concern for women in general (10 on pregnant or lactating mothers, 12 on women of reproductive age).

The timeframes for the identified research activities range from just a year to many years (from 2012), meaning that new evidence will be materializing on an ongoing basis for some time to come. That said, the analysis identified some important "poorly researched areas" (indeed, research designs often still leave much to be desired), including 8 specific gaps:

i) Many research projects do not consider the pathways from changes in agriculture inputs or activities through value chains, through uses of commodities and income, to consumption and nutrition outcomes.
ii) The indirect effects on nutrition of changes in income derived from enhanced agriculture.
iii) The effects of policies on nutrition, mediated through relative prices and value chain effects.
iv) Governance and the policy process relating to the integration of agriculture, nutrition and other sectors of the economy.
v) Attention to appropriate metrics and relevant methodologies for demonstrating links between agriculture and nutrition.
vi) Consumers separate from producers, including non-agricultural rural consumers, the urban poor, etc.
vii) Nutritional risks beyond undernutrition (such a non-communicable diseases)
viii) Cost-effectiveness of alternative gains in nutrition (versus agriculture) or among potential alternatives in agriculture.

Thus, while the field of research on leveraging agriculture for nutrition will continue to grow in coming years, it will be increasingly important to ensure that the opportunities are not lost to generate the best possible quality of evidence to support decision makers making difficult choices.

Implications for Future Research

As it currently exists, the empirical knowledge base on agriculture's impacts on nutrition can be summarized in the words of Hawkes et al. (2012): "Despite the clear potential for agricultural change to improve nutrition in low and middle income countries, the evidence base for this relationship is poor. Recent systematic reviews of studies which have evaluated agricultural interventions for improving nutrition reveal little strong evidence of impact, and a need for more and better designed research." It is important to underline that this does not mean that the potential does not exist, or that positive impacts are not being achieved today; rather that, a) too few interventions have invested in

appropriately measuring their impact or cost-effectiveness, and b) researchers continue to pay too little attention to study design and methodological rigor.

This suggests that more coordinated efforts are needed to reach consensus on strategic priorities among the information gaps and to define how best (and who best) to fill those gaps. Many partners have to be involved across many disciplines and sectors to support both awareness and evidence-informed actions. In terms of research, there is an urgent need for agreed thresholds of necessary evidence (prototypes of research designs and standardized metrics) that are appropriate for enhanced monitoring and evaluation of nutrition-specific (direct) and nutrition-sensitive (indirect) policies and programmes. Such agreement on common frameworks and methods goes beyond agriculture-nutrition linkages. While the rationale for a multi-sectoral approach has been clearly articulated, there is clearly limited evidence on the policies and programme alternatives that can be considered when seeking significant effects on nutrition. As more countries adopt multi-sector plans, there is a need for guidelines on research design and metrics relevant to these kinds of complex interventions.

The Nutrition CRSP will seek to contribute to both of these goals: facilitating dialogue and engagement across stakeholders on priority needs, offering relevant empirical findings from field and process research (particularly relating to the research gaps numbered iv) through viii) identified by Hawkes et al. 2012), while also supporting institutional and individual capacity building for developing countries to conduct their own policy-relevant research. The NCRSP will work with its government, academic and civil society partners to provide platforms for creating awareness about "what works" for policy officials and implementers at all levels. The goal has to be to ensure that the next time a global systematic review of agriculture-nutrition-health linkages is conducted, that the conclusion is not 'evidence is lacking', but presents concrete conclusions based on rigorously designed studies.

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