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Agricultural interventions for improved nutrition: A review of livelihood and environmental dimensions



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ABSTRACT

A diverse group of agricultural interventions aim to improve the nutritional status of women and children. These interventions range from the cultivation of bio-fortified crop varieties to home gardening to livestock intensification. We systematically review 42 evaluations of agricultural interventions for improved maternal and child nutrition. Using these evaluations, we identify three intervention typologies – Enhancement, Diversification, and Substitution – that reflect the differential impact of interventions on household livelihoods and patterns of food consumption. Our typologies allow for a nuanced approach to categorize and generalize about pathways of impact for agricultural interventions. In applying our typologies to existing evaluations, we summarize the evidence base and emphasize areas for further inquiry, particularly in terms of understanding these interventions amid complex environmental, political and economic local contexts.

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1. Introduction

A substantial proportion of the world's 795 million people who are unable to meet daily food needs are food-producers, such as small-scale farmers and fishers (FAO, 2015). Policies and programs increasingly seek to address the co-occurrence of malnutrition and food insecurity in farming households by improving nutrition through agriculture. Interventions in this arena promote strategies ranging from home gardens to biofortified crops to fish farming. By improving the quality, quantity, and diversity of smallholder production, these efforts attempt to improve nutritional status of women and children in targeted households.

Many of the major gains in curbing malnutrition in the last half century have been made through nutrition-specific interventions, such as supplements (e.g. iron supplements or folic acid supplements for pregnant women), fortification (e.g. fortification of salt with iodine), and nutrition education (Bhutta et al., 2013; Bhutta et al., 2008; Smith and Haddad, 2015). Yet food-based solutions that expand agricultural production of nutritious foods have possible benefits that do not exist for specific supplementation and fortification efforts. For example, such solutions can support both

the livelihoods and nutritional status of smallholders, while having the potential to more sustainably address persistent rates of malnutrition (Pinstrup-Andersen, 2013). Food-based solutions have the potential to confront nutritional needs directly and within the contexts of the primary source of macro and micro-nutrients (Demment et al., 2003; Burchi et al., 2011). These approaches are oriented to improve food security and provide households with a variety of foods that can meet multiple dietary and micronutrient requirements (Blasbalg et al., 2011; Tontisirin et al., 2002). However, agricultural approaches to nutrition are often less targeted than specific supplementation and fortification efforts, both in terms of the specific micro/macro-nutrients provided, and in terms of the specific person in the family receiving the benefits.

The Sustainable Development Goals have prioritized a goal of simultaneously reducing hunger and promoting sustainable agriculture (United Nations, 2015). As the second SDG 2 unifies the aims of agricultural production and improved nutrition, improving the nutritional quality and diversity of crops produced is of paramount importance (Jones and Ejeta, 2016). Previous reviews of the effects of agricultural interventions on nutritional status have demonstrated methodological limitations in generalizing from the current body of evidence, while motivating further analysis (Webb-Girard et al., 2012; Masset et al., 2012). Our work builds on this evidence through a review of the literature on existing programs that aim to improve nutrition by altering household

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agricultural production, inclusive of fish farming and livestock. We create and apply a typology for understanding the livelihood implications of different agriculture-nutrition activities and goals, and their possible pathways to improved nutrition for women and children. We focus on the extent to which agricultural interventions shape, supplement, or replace livelihoods and analyze the context to assess the role of the external environmental and socio-economic factors in these interventions.

2. Background

Household, or farm-level, agricultural production has been linked with improved household dietary patterns and better nutrition of individual household members (Carletto et al., 2015). A growing body of literature evaluates these linkages and focuses on three of four key pathways linking food production and nutrition: income from agriculture, consumption of a household's own produce, and gender-related factors (Carletto et al., 2015). Work on agricultural and nutrition outcomes demonstrates a link between crop production diversity and dietary diversity (Dillon et al., 2015; Kumar et al., 2015; Malapit et al., 2015; Shively and Sununtnasuk, 2015; Jones, 2015; Sibhatu et al., 2015), and explores the particular role of women's empowerment (Malapit et al., 2015). Livestock ownership also emerges as a factor potentially beneficial for animal source food intake and growth (Azzarri et al., 2015; Hoddinott et al., 2015; Slavchevska, 2015; Rawlins et al., 2014), despite livestock presenting sanitation issues (Azzarri et al., 2015). Calls for a focus on diet quality (McDermott et al., 2015) and evidence that increasing the percentage of dietary energy from non-staples is most effective in improving stunting rates (Smith and Haddad, 2015) further reinforce the importance of dietary diversity in general and animal source foods in particular.

Intervention context, including the impact across global, regional, and local scales of government policies and programs, market dynamics, environmental conditions as well as the immediate factors such as program participation further shape the magnitude of nutritional impacts. For example, market access can influence a household's decision about which crops or livestock to produce (Dillon et al., 2015) or the magnitude of nutritional effects of livestock ownership (Hoddinott et al., 2015). Similarly, climate variability may impact crop diversity and agricultural revenue (Dillon et al., 2015). The gender of intervention participants (Malapit et al., 2015) and the intensity of their engagement (de Brauw et al., 2015) may also influence outcomes.

While a more robust body of evidence now examines correlations between agricultural production and household nutrition (Carletto et al., 2015), evaluations of *interventions* to improve household food production have not yet demonstrated significant impacts on individual's nutritional status (Webb-Girard et al., 2012; Masset et al., 2012; Ruel et al., 2013). There is a great theoretical appeal of food-based programs and their potential for improving nutrition, and there is a strong suggestion that food-based programs could plausibly have effects on nutritional outcomes due to their impacts on intermediate factors associated with nutrition outcomes (e.g. dietary diversity). In spite of these attributes, methodological limitations have largely limited our understanding of the effects of evaluations of household food production interventions to date (Webb-Girard et al., 2012; Masset et al., 2012; Berti et al., 2004; Randolph et al., 2007; Leroy and Frongillo, 2007).

Assessing the consequences of interventions that alter the production patterns and time use of subsistence producers requires appreciating complexities across scales. First, the complexity of the interacting social, ecological, and economic factors shapes the context in which these interventions operate. Second, a

diversity of household livelihood strategies position agricultural activities as one piece of a households' complex portfolio. Finally, individuals within the same household may experience sharply different livelihood opportunities and access to food.

To understand the pathways from food production to nutrition we must unpack the domains of "agriculture" and "nutritional status" and the context in which they are embedded (Webb and Kennedy, 2014). Many contextual factors, ranging from political economy to gender to the natural environment, are important determinants of poor child nutrition (Stewart et al. 2013; Smith and Haddad 2015). Closer study of how these factors shape consumption and dietary quality can better illuminate these influences (McDermott et al., 2015). The context in which agricultural-nutrition interventions operate is characterized by the political, social, ecological, and economic conditions that often shape production and consumption, as well as how interventions shift these patterns within livelihoods and households.

A livelihood is similarly complex, and includes people, their capabilities, and the means by which they live, including food, income, and assets (Chambers and Conway, 1991). Five types of capital – physical, financial, social, human, and natural – comprise the 'Sustainable Livelihoods Framework,' which conceptualizes the categories in which livelihoods operate and has a goal of widespread opportunities (Chambers and Conway, 1991; Scoones, 1998). Livelihood strategies may focus on particular types of capital, diversification, or intensification (Scoones, 1998). Integrating the diverse aspects of livelihoods within contextual complexities is particularly valuable in understanding vulnerability, resilience, and coping mechanisms in periods of shocks and stress (Chambers and Conway, 1991). Previous examinations of agricultural interventions in the context of this framework evinced the importance of interventions investing in different types of capital (Berti et al., 2004) and recognizing the diversity of livelihood strategies (Allison and Ellis, 2001).

Households are neither static nor fully cooperative units (Guyer and Peters 1987). Instead, the household is the site of dynamic relations between strategies and resources, and households face changing circumstances in which they make a living (Berry 1984). Household assets may also be shared unequally, with particular constraints on women's access to land, credit, production inputs, technology, and markets (Agarwal 2012). Household food access may not represent individual access; individuals may go hungry in households that are food secure or be well nourished in households that are food insecure (Messer 1997). There may also be gender-biased intra-family food distribution and feeding practices, which would be suggested by higher female than male mortality beginning in childhood (Chen et al. 1981).

In this review, we engage the context in which food production interventions shift patterns of livelihoods and consumption. We summarize the consideration of external factors (e.g. environment, market access) and intervention features (e.g. gender sensitivity, time burden, nutrition counseling) in intervention evaluations. We also develop typologies that elucidate different pathways of impact, nutrition outcomes, and displacement effects and apply them to the interventions reviewed.

3. Methods

To assess agricultural interventions that aim to improve maternal and child nutrition and health, we re-reviewed studies examined in two recent reviews: Masset et al. (2012) and Webb-Girard et al. (2012) and included in our review all articles reviewed that focused on an intervention (n=38 total articles). To capture work published after these reviews, we forward searched all articles citing these and using their search terms, yielding an

additional 60 articles published between January 2012 and August 2015. Two independent reviewers (KJF and RLC) reviewed titles and abstracts of articles retrieved by forward searches. The full texts of potentially appropriate articles were retained for full review for compliance with either study's review criterion. [Masset et al. \(2012\)](#) included only studies that assessed effects of agricultural interventions aiming to affect child nutritional status (measuring anthropometric and intermediary intake measures) and had a valid counterfactual analysis (e.g. control group available). [Webb-Girard et al. \(2012\)](#) included only studies of interventions that aimed to increase food quality or quantity, were conducted in low and middle income countries ([World Bank 2015](#)), and reported health or nutrition outcomes for children 0-59 months (e.g. WHZ, vitamin A intake, morbidity) or women of reproductive age (e.g. BMI, vitamin A status). Based on these combined criteria, we rejected 56 articles and retained 4 articles from forward searches. In total, we include 42 articles representing 36 unique projects evaluating effects of agricultural interventions on maternal and child nutrition ([Fig. 1](#)). As we include articles identified by previous reviews in addition to current articles identified, our review thus includes articles from 1995 to 2015 that evaluate the nutritional impact of an agricultural intervention on children's food quantity or quality of intake and anthropometric indicators, and women's food quantity or quality of intake.

Data from studies identified were abstracted into a standardized form. We examined the intervention type and coded the agricultural strategy used and produced foods of interest, contextual factors (any mention of environmental factors, including weather conditions or abnormalities, soil quality, land availability, or market context, including prices, policies, physical access), livelihood impact (gender considerations, time burden, displacement of previous activities, degree of change from previous household activities), food consumption impact (degree of change from previous household food consumption patterns) and nutritional outcome measure (e.g. dietary diversity, stunting).

We used our review of the types of interventions to qualitatively identify key differences in the ways diverse strategies aim to shift livelihoods and consumption patterns. From this analysis of emergent patterns, we built typologies of agricultural interventions that aim to improve nutrition outcomes. Our typologies reflect, in particular, the degree of impact on livelihoods and consumption patterns.

We next applied these typologies to the reviewed evaluations of nutritional impacts of agricultural interventions. Three reviewers (KJF, RLC, EMM) independently coded our application of typologies to reviewed articles. Differences in typology coding were resolved through discussion and, in some cases, the recognition of interventions as fitting multiple intervention typologies. We use this categorization to summarize the types of interventions that currently comprise each intervention and their areas of emphasis with regard to external and enabling factors that

affect impact. Due to the limited number of interventions, the creation of typologies and their application to evaluations of agricultural interventions is not independent.

4. Results

Three typologies for the livelihood dimensions of agricultural interventions that aim to impact nutrition emerged: Enhancement, Diversification, and Substitution. Below, we discuss these typologies and apply them to the 42 evaluations of agricultural interventions reviewed.

4.1. Intervention Typologies

Our typologies – Enhancement, Diversification, and Substitution – reflect both the way agricultural interventions fit into the lives of participant families and their potential pathways to improved nutrition ([Table 1](#)). Differences among the typologies are largely characterized by the extent to which they aim to alter current livelihoods, introduce new activities, and shift food consumption patterns. A single intervention, however, may reflect multiple typologies.

Enhancement adjusts an aspect of a household's current production strategy to provide improved yield or more nutritious crops. *Diversification* refers to agricultural interventions that introduce a new food production method, activity, or strategy to complement a household's on-going livelihood activities. *Substitution* reflects the introduction of a new and substantially changed food production strategy or alternative livelihood.

4.2. Enhancement

Enhancement interventions aim to make relatively minor adjustments to on-going household food production strategies and consumption patterns through adjustments to food and nutrient availability. These interventions are typified by biofortification of crops already produced by households (e.g. orange-fleshed sweet potato). The provision of agricultural training, extension services, or inputs, such as improved seeds or fertilizers, may also be an Enhancement intervention when targeted households are already engaged in the supported agricultural activities.

The pathways of nutritional impact for these interventions are relatively focused. Strategies focused on the enhancement of a particular dietary nutrient provide for a directed pathway to improved micronutrient status via crop production, consumption, and nutrient absorption. When a targeting production more broadly, an enhancement of yields is anticipated to lead to improved nutrition via income, home consumption, or both pathways. Given the focus of this strategy on improvements to existing livelihood strategies, opportunities for women's empowerment and control of income are limited. However, the more minor adjustments to current livelihoods means that displacement of other activities and changes in time burden are of limited concern.

Enhancement interventions' adjustments to livelihood and consumption patterns may couple with other intervention strategies. For example, the introduction of orange-fleshed sweet potatoes into home gardens for households that have not previously produced sweet potatoes or had a garden constitutes both Enhancement and Diversification. The extent to which these interventions affect improved nutrition is based on the acceptability of these adjustments to production and consumption activities. Further, their uptake within agricultural policy and value chains (e.g. extension agent promotion, seed and storage access) is critical for their sustainability.

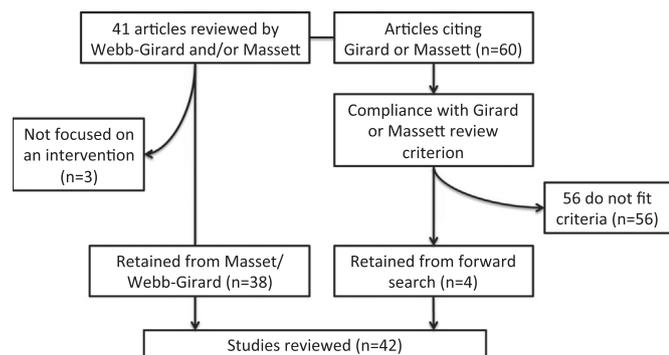


Fig. 1. Diagram of study inclusion pathways.

Table 1
Intervention typologies: Enhancement, Diversification, and Substitution.

	Description	Livelihood effect	Nutritional pathway	Sample nutritional outcome aims (for women and/or children)	Examples
Enhancement	Adjust an element of a household's current food production strategy to provide for nutrient-focused dietary improvements	Relatively minor adjustment	Food type or nutrient availability Increased consumption of foods produced	Micronutrient status Intake of vitamin A rich foods	Biofortification of cultivated crops; Vitamin A rich food production; Agricultural training, inputs, or irrigation to existing farms
Diversification	Introduce a new food production method or strategy to complement household's on-going activities	Additional activity, part of a suite of activities	Access to nutritious foods Diversification of self consumed foods Women's empowerment (often) Supplementary income (possibly)	Animal source food intake Dietary diversity Utilization of nutritious foods	Home gardens; Dairy goats; Poultry production
Substitution	Introduce a new food production strategy that provides for a substantial change in household activities	Substantial activity change or adjustment to livelihood activities	Increased income Increased consumption of foods produced (possibly)	Energy intake, high-quality food intake	Intensive livestock or fish production; Cash crop production; Irrigation expansion

4.3. Diversification

Diversification interventions aim to provide households with a new food production strategy that will complement on-going household livelihood activities and diversify food sources and consumption. Altering the livelihood profile of a household represents a partial shift in household activities that is coupled with a partial shift in consumption patterns. Interventions of this type typically include home gardening initiatives, dairy goat production, poultry keeping, or a combination of these. These strategies aim to address access to nutritious foods with high micronutrient content.

Diversification interventions improve nutritional status by supporting consumption of diverse diets and especially nutritious foods, which are often animal source foods, vitamin A rich foods, and/or dark green leafy vegetables. Typically these interventions include food production training and inputs to drive agricultural goals as well as nutrition counseling. These interventions often target women to increase their access to nutritious foods and control of their production, providing for further nutritional benefits through pathways from women's empowerment to improved nutrition outcomes for women, infants, and young children. Diversification interventions engage multiple and often diverse pathways and often rely on home consumption of the foods produced to alter nutritional status.

The impact of Diversification interventions on livelihoods is relatively variable. These interventions typically aim to supplement a household's current strategies with part-time activities. Yet the lines between kitchen gardening and farming or chicken rearing and a poultry operation may be hard to distinguish. The time necessary to undertake a new activity, for women especially, may result in some degree of displaced activities. Where care for children or other food production strategies may shift, these dynamics could counter nutritional benefits.

The extent to which Diversification activities shift the context of food production and consumption presents a substantial opportunity to change diets and nutrition. These interventions, which are often multi-pronged in their approach, engage a range of livelihood and household factors. At the same time, the broader context in which these interventions operate may substantially shape their impact as they are influenced by factors ranging from the food prices that drive sale or consumption of food products to the rainfall levels that affect the work required to irrigate a garden.

4.4. Substitution

Substitution interventions provide for a substantive change in household activities, creating a new or alternative livelihood that aims to produce more food and, especially, income. These interventions often focus on cash crop production with nutrition benefits derived via improved incomes. These interventions may also foster livelihood shifts in response to changing natural resources that hamper production, such as declines in soil quality, fish stocks, or forest access. Oftentimes livelihood support engages both household production and infrastructure or market development, such as dairy or poultry production and distribution support.

Although agricultural in nature, Substitution interventions often focus on sale of agricultural products rather than home consumption. Increasing the availability of micronutrient-rich and animal source foods in a country or region may serve nutrition goals if households are able to access these products. Further, the cash that households derive from more productive livelihoods may allow for the purchase of improved diets. Whether households eat or sell the crops that they produce and the effect on their nutrition is often dictated by market access. Market access includes issues

such as the policies and programs that shape agricultural markets, access to land and inputs, and food prices, all of which affect farmers' sale of what they produce and the availability of nutritious foods for purchase. While many livelihood interventions of the Substitution type are not necessarily nutrition-sensitive, more closely tying these agricultural interventions to household nutrition is a key area of interest. In particular, irrigation and cash crop programs rarely aim to improve nutrition, but offer a valuable pathway that merits further study.

Substitution interventions may result in substantial shifts in household activities. The risk and potential reward of these interventions is the degree of the change. The hope of more substantial livelihood shifts is that new production strategies will usher in substantially improved incomes providing for long-term shifts in dietary intake and improved nutrition. However, the specialization that these strategies require can sometimes push households into more limited livelihood strategies and dependence on particular markets or natural resources. The displacement of other strategies and activities can thus alter patterns of food consumption, time use, and care for women and children.

The specialization these interventions means farmers' outcomes are broadly influenced by the political and economic context that provide for access to land, capital, and markets. As farmers focus their livelihood activities, factors ranging from the building of a new road to international export market prices may substantially shape outcomes for income and nutrition.

5. Typologies applied to evaluation of agricultural interventions on nutrition

We applied our typologies to agricultural interventions in the reviewed studies to understand the extent to which evaluations have focused on each typology. Table 2 tabulates the inclusion of common factors that nutrition-sensitive agricultural evaluations emphasize, including women's access to foods produced and income generated, nutrition counseling, and the environmental and

market context of interventions. Despite their importance in understanding the political economic contexts in which interventions take place and key opportunities and challenges in their effectiveness, our review here is constrained by the limited extent to which environmental, market, and livelihood factors are discussed in these evaluations. In particular, discussion of time burden and the degree to which interventions alter patterns of livelihood activities and food consumption behaviors were somewhat limited. Furthermore, descriptions of environmental or market conditions, when they occur at all, are brief.

In our review, Diversification and Substitution interventions most often focused on women, with Enhancement and Diversification interventions providing the greatest degree of nutrition counseling and, often, nutrition sensitivity. Interventions considered a range of environmental factors, though typically in relatively cursory ways. Finally, physical market access for sale of agricultural products and input procurement was more often an explicit consideration of Substitution and Diversification interventions but discussion of broader political and economic factors influencing market contexts were virtually absent.

In an extension of this analysis, we outlined the typology of different interventions (Table 3). We observed that Enhancement intervention evaluations have primarily focused on orange-fleshed sweet potato. Two thirds of Diversification interventions emphasized home gardening with or without a focus on vitamin A rich crops and small animal production. In considering gaps in the evidence base, we also noted that far fewer and more varied Substitution interventions have been evaluated for their nutrition outcomes. Further, few interventions emphasized specific nutrients other than vitamin A.

The typologies are also characterized by similar outcome measures. Enhancement interventions primarily focused on improved consumption, with an emphasis on vitamin A rich foods. Diversification interventions have more diverse outcome measures as studies assessed different impacts including production, consumption, and income. Increased income was a main outcome measure for the Substitution interventions and was often coupled

Table 2

Common factors considered by nutrition-sensitive agricultural interventions. By typology, we provide the number and percentage of studies that consider gender and include nutrition counseling. We also outline the exogenous environmental and market variables these studies noted. A single study may include more than one of these factors, and few of these were included in quantitative data analysis.

	Women's role considered, % (n)	Nutrition counseling component, % (n)	Environmental description	Market description
Enhancement (8)	37.5% (3)	75% (6)	2 seasonality 2 pests 3 water	2 sale of agricultural products mentioned 1 sale of agricultural products & income changes measured 1 input purchase
Diversification/Enhancement (6)	17% (1)	100% (6)	1 seasonality 2 pest 2 water	1 sale of agricultural products mentioned 2 sale of agricultural products & income changes measured 1 input purchase
Diversification (17)	65% (11)	76% (13)	2 soil 3 seasonality 2 water 1 weather (storm)	1 sale of agricultural products mentioned 8 sale of agricultural products & income changes measured 3 input purchase 1 transportation issues 1 market popularity of agricultural products
Diversification/Substitution (3)	0% (0)	33% (1)		2 sale of agricultural products & income changes measured 1 input purchase
Substitution (8)	86% (6)	25% (2)	3 soil 3 seasonality 1 pest 2 water 1 overfishing	7 sale of agricultural products & income changes measured 1 input purchase

Table 3
Types of interventions within each typology.

	Types	References
Enhancement (8)	Orange fleshed sweet potato (5)	de Brauw et al. (2015); Hagenimana et al. (1999, 2001); Jones and de Brauw (2015); Low et al. (2007)
	Ivy Gourd [Vit A rich] (1)	Attig et al. (1993)
	Papaya and guava (1)	Kidala et al. (2000)
	Protein biofortified maize (1)	Gunaratna et al. (2010)
Diversification/Enhancement (6)	Home gardens: Focus on vitamin A rich crops (6)	Balcha (2001); Faber et al. (2002b)/Faber et al. (2002a); Laurie and Faber (2008); Smitasiri et al. (1999); Vijayaraghavan et al. (1997)
	Home production: diversified (11)	Bezner Kerr et al. (2011); Bushamuka et al. (2005); English et al. (1997)/English and Badcock (1998); Greiner and Mitra (1995); Kaufer et al. (2010); Langworthy and Caldwell (2009); Schmidt and Vorster (1995); Marsh (1997)/Talukder et al. (2000); Taher et al. (2002)
Diversification (17)	Home garden+small animal production (5)	HKI Nepal (2004); HKI Cambodia (2004)/Olney et al. (2009); Olney et al. (2015); Talukder et al. (2010)
	Fish farming+homestead small animal production (1)	Schipani et al. (2002)
	Fish farming or home gardens (1)	Kumar and Quisumbing (2010)
	Fish farming (1)	Roos et al. (2003)
Diversification/Substitution (3)	High value crop production (1)	Jones et al. (2005)
	Dairy livestock/large animal production (6)	Ayalew et al. (1999)/Kassa et al. (2003); Hoorweg et al. (2000); Miller et al. (2014); Rawlins et al. (2014); Walingo (2009)
	Fish farming (1)	Murshed-e-Jahan et al. (2010)
Substitution (8)	Poultry production (1)	Nielsen et al. (2003)

with child nutrition indicators. An effective Substitution intervention is outlined in [Box 1](#).

6. Discussion

In this paper, we developed three typologies, Enhancement, Diversification, and Substitution, which allow us to categorize existing interventions and how they alter household livelihoods and food consumption behaviors. The typology classifications suggest the extent to which agricultural interventions may displace other activities, alter or add to food production activities, necessitate shifting or new food consumption behaviors, and fit into a complex political, economic, and environmental context. As we develop and strengthen agricultural interventions that improve nutrition, our typologies provide a tool to differentiate among this set of interventions.

Enhancement interventions provide for a relatively limited, though potentially meaningful, shift in household production and consumption. Typically limited to one crop or nutrient, these interventions have demonstrated effects on the consumption of vitamin A rich foods and provide some of the most robust evidence of effectiveness ([Webb-Girard et al., 2012](#)). In addition to household activities, Diversification interventions goals are broadly defined around dietary diversity and quality and engage multiple pathways to diversify livelihoods, with households, and especially women, adding to their livelihood strategies and time burden. Further, in creating new or alternative livelihoods, Substitution

interventions provide for a much greater shift in livelihoods, with the possibility of a commensurate shift in incomes and nutrition. In expanding the body of literature we must appreciate the heterogeneity in what has often been considered a set of interventions operating along the same pathway of impact.

Underpinning assessments of agricultural interventions' effectiveness are trade-offs in the extent to which they replace other livelihood activities. For example, the introduction of diverse crops to an existing home garden (Enhancement) impacts livelihoods less than the addition of small animal rearing to a gardening home (Diversification) or the introduction of cash cropping (Substitution). Further, affecting nutritional improvements through nutrition-sensitive approaches is inherently challenging ([Ruel et al., 2013](#)). If households shift to home gardening from a similarly lucrative activity, evaluations may well observe neutral nutrition effects. Similarly, targeting women with these interventions often requires targeting them with more work, with possible negative effects for time spent on child care ([Njuki et al., 2015](#)).

Altering nutritional status through agricultural interventions also entails changing households' patterns of food consumption. Acceptability of new products and market development is a persistent challenge for changing consumption behaviors. Further, the production of high value foods, many of which are animal source, may more directly affect income than nutrition, with slower benefits to nutritional status.

The relative differences in intervention typologies further suggest metrics by which we might assess the effectiveness on

Box 1—Aquaculture and food security in Bangladesh ([Murshed-e-Jahan et al., 2010](#))

Background: A nationwide aquaculture program was implemented in rural Bangladesh to improve food security among the poor. The fastest growing sector in Bangladesh, aquaculture provides for income, employment opportunities, and fish for consumption.

Intervention: The five-year program disseminated low-cost technologies and facilitated trainings using a participatory adaptive learning approach. Information about pond management, harvest cycles, water quality, and fish behavior were provided to farmers in formal and informal sessions that emphasized female as well as male participation. Technical support was also provided to project farmers.

In shifting farmer livelihoods through an intensive intervention to make nutrient-rich animal-source foods more available, Bangladesh's aquaculture program represents a Substitution intervention.

Impact: Project farmers' per capita consumption of self-produced and all fish was greater. Further, rural fish producing households had significantly higher net incomes from fish sales. The intervention also increased sectoral employment and improved labor returns with better management practices and technical resources.

The impacts assessed reflect both income and consumption pathways to improved nutrition.

nutrition outcomes. Outcome measures, and whether evaluations focus on intermediary indicators (e.g. quantity and quality of foods consumed) or anthropometric and biophysical measures (e.g. stunting, wasting, serum retinol) may be tailored by the particular aims of a typology (Table 1). Assessing how interventions alter income, expenditures, and time burden would also strengthen many interventions, and be particularly useful in understanding null findings.

To date, however, the overall quality of evidence for agricultural interventions on nutrition outcomes remains very low (Webb-Girard et al., 2012; Masset et al., 2012), so we limit our generalizations about the nutritional effects of different typologies, though whether they provide for relative differences in effectiveness merits further study. The preponderance of evidence regarding the effect of agricultural interventions on nutrition outcomes has been derived from Enhancement and Diversification interventions focused on vitamin A rich food production, home gardening, and small animal production. Despite the paucity of studies of the nutrition effects of Substitution interventions, these constitute a substantial portion of development efforts and particularly warrant further study of nutritional effects. Assessing the landscape of agricultural interventions that may affect nutrition remains challenging; while some information about specific sets of agricultural interventions (e.g. IFAD, Feed the Future) is available, we know of no comprehensive source of information about such interventions. Further, a range of interventions emerging from environmental organizations aim to shift livelihoods and improve food security, often relying on strategies that spare forests or fisheries by intensifying or diversifying production, but are also rarely evaluated for livelihood and nutrition impacts (Milner-Gulland et al., 2014; Wright et al., 2016).

The integration of nutritional goals and evaluation into agricultural or conservation projects is non-trivial. Such integration requires many stakeholders, including public and private actors, civil society, and health, agriculture, and environmental sectors, to collaborate in reshaping food production systems and post-harvest value chains (van den Bold et al., 2015; Ruel et al., 2013). Such integration requires we clearly define and measure outcomes, use contextually relevant strategies, and ensure adequate operational capacity, governance systems, accountability, and flexible financing (Ruel et al., 2013; Gillespie et al., 2015). Creation of such an enabling environment with individual, organizational, and systematic capacity and financial resources is necessary for effective nutrition-sensitive programs (van den Bold et al., 2015; Gillespie et al., 2013), and a substantial reorientation of inquiry in agricultural systems may be necessary to foster nutrition outcomes (McDermott et al., 2015).

The political, economic, and environmental context in which agricultural interventions operate undoubtedly shapes patterns of household livelihoods, food consumption, and interventions' success in enhancing, diversifying, or altering these. The role of markets, increasingly appreciated in understanding the nutritional impacts of agriculture (Hoddinott et al. 2015), and the environmental and climatic context (Dillon et al. 2015), represent two such key factors in the links between agriculture and nutrition. Yet the evaluations of interventions reviewed rarely engaged the political economy and socio-environmental context. Our typologies suggest the methods through which livelihoods are shifted, and the costs and benefits of such shifts must be evaluated with an appreciation of their ramifications within complex and variable ecological conditions, such as rainfall, temperature, weather shocks, pests, and water constraints, and political economic conditions, such as market access, gender dynamics, food prices, and commodity value chains.

Complicating the ways our typologies engage with contextual factors, these factors are myriad, and influenced by history and

culture. Neither ecological nor economic factors are apolitical; international and state policies and programs integrally shape the context in which interventions operate. Of particular note in considering agricultural interventions is access to land. While agricultural intervention strategies largely target those with land, who has access to what land is of widespread concern. In particular, landless food producers are often among the most food insecure and are entirely omitted from this class of interventions.

Engaging the realities of these complex contextual factors is of critical importance to generalizing conclusions and building an improved understanding of agricultural interventions' effects on nutrition. Even with more robust studies and improved outcome measures, the environmental, market, and political context in which these interventions succeed and fail merits far more substantial consideration. Though we recognize the challenge in measurement, we advocate greater attention to the socio-environmental and political economic contexts (e.g. resource access, ecological feedbacks, land tenure, prices, government policies) and changing environments (e.g. weather, pests, etc.) in which interventions are rolled out. Ultimately, typologies of interventions can be best understood within the enabling or restrictive factors in different contexts.

7. Conclusions

Agricultural interventions represent a promising set of strategies to improve maternal and child nutrition. The diversity of these food-based strategies, though a strength in tailoring them to local contexts, provides for challenges in generalizing evaluations and impacts. The typologies we propose above and apply to existing evaluations of agricultural interventions provide a nuanced view of the impacts of such interventions on household livelihoods and food consumption behavior. Importantly these typologies have implications for the intervention intensity, potential for displacement effects, and pathways of impact. Though the evidence base for agricultural interventions to improve nutrition is quickly expanding, generalizing the effects of specific interventions requires a broader set of strategies that still provides for nuance in appreciating the extent to which such interventions and the complex contexts in which they operate differ.

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