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Agriculture for Nutrition

Getting Policies Right

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Introduction

The past 50 years have been a period of extraordinary food crop productivity growth, despite rising populations and increasing land scarcity, largely due to the Green Revolution (GR). Despite these massive gains in productivity and agricultural development, malnutrition has persisted across the developing world. Undernourishment (insufficient calorie and protein intake) and micronutrient malnutrition continue to plague sub-Saharan Africa and South Asia, while overnutrition (excess calories leading to obesity and overweight) is a major emerging concern in the middle- and higher-income countries. Enlightened agricultural policies, implemented in association with complementary policies for improved health, water and sanitation, and household behavior change, can have significant positive nutritional impacts.

The nutrition community has coalesced around the first 1,000 days of a child's life, from conception through the first 2 years, as the critical window for averting stunting. Many question the role of agriculture in redressing the problems of stunting in the first 1,000 days. This chapter argues that sustainable gains in childhood stunting are inextricably linked to the health, nutritional status, and empowerment of the mother. A society of healthy women of childbearing age—those between 15–45 years of age—will witness significant long-term reductions in the prevalence of child stunting. Rural women—who are overwhelmingly dependent on agriculture for employment, income, and food—draw an undeniable link between agriculture and nutrition.

Rarely, however, are agricultural interventions defined or driven by nutritional goals, particularly with a focus on rural women and children. We

introduce a typology of agricultural systems that reflect the particular stage of structural transformation of a country and highlight the necessary agricultural initiatives that can potentially reduce undernutrition and micronutrient malnutrition. Our typology includes low-productive agricultural systems, such as those prevalent in sub-Saharan Africa; modernizing agricultural systems, primarily found in Asia; and commercialized systems, typically found in advanced economies. This chapter focuses on low-productive and modernizing agricultural systems.

Low-productive agricultural systems, predominantly in sub-Saharan Africa, include those that experienced little or none of the staple-crop productivity gains experienced during the Green Revolution. Rapid growth in population makes several parts of sub-Saharan Africa conducive to investments in intensification today. The challenge, however, is to promote sustainable intensification based on crops (and livestock) that are important to the food systems of the poor rather than crowding them out, as happened during the Green Revolution in Asia. Identifying policies that promote crop-neutral intensification, that is, providing the conditions for yield enhancement, while maintaining crop and food system diversity, should be a priority for these countries. Since women are the primary food producers in sub-Saharan Africa, identifying opportunities for reducing the labor burden in pre- and post-harvest operations would contribute significantly to their health. Given the continued importance, and the large share of staple crops in the diets of the poor, identifying mechanisms for enhancing the micronutrient density of grains through biofortification can potentially be a high-return strategy.

Countries with modernizing agricultural systems have advanced along the structural transformation pathway by using agriculture as an engine of growth. These countries focused on increasing staple food crop supply and expanding smallholder incomes. However, many of these countries have seen a significant drop in the cultivation of traditional micronutrient-rich crops, such as lentils and pulses. The relative price of fresh fruit and vegetables is high and deters diversification of diets of the poor. Sustained investments in productivity growth and diversification out of staple cereals toward micronutrient-dense foods remain areas of agricultural policy that can have a direct impact on the availability (supply) and affordability of dietary diversity. Much of this diversification away from cereal crops requires policy attention in infrastructure and extension, as well as market access. We highlight the policy opportunities and evidence for pro-poor integration of smallholders to domestic/global markets through modern food value chains and various public–private partnerships. Meanwhile, kitchen gardens and backyard livestock production remain critical areas of policy promotion, and we provide examples of successful implementation in South Asia and elsewhere.

Finally, our chapter emphasizes the need for complimentary development policies that promote clean drinking water, access to toilets, and sanitation education. The importance of equity in intra-house food allocation and behavior change interventions in this regard are also addressed.

Structural Transformation and the Nutrition Transition

There exists a strong connection between stage of economic transition—the process of structural transformation—and population-level nutrition patterns. Structural transformation refers to the process whereby agriculture, through higher productivity, provides food, labor, and savings to the process of urbanization and industrialization. The four processes outlining a country's movement within structural transformation include a declining share of agriculture in gross domestic product (GDP), a rural-to-urban migration that stimulates the process of urbanization, the rise of a modern industrial service economy, and a demographic transition from high to low rates of birth and death (i.e., rising health standards) (Timmer and Akkus 2008). More recently, there has been recognition of the connection between the stage of structural transformation and nutritional outcomes, particularly the decline in stunting and wasting rates and the rise in obesity rates (Webb and Block 2012).

Cross-country comparisons indicate that there are a large number of developing countries progressing along the structural transformation continuum. However, there are also a large number of countries that have stalled in the transformation process or have yet to "get agriculture moving." These are almost always countries that are classified as the "least developed." They are also ranked extremely low on the United Nations Development Programme's (UNDP) Human Development Index. Even within countries that are well on the pathway toward agricultural transformation, there are significant interregional differences (Eastern India, for example). Some of the reasons for poor agricultural performance include the following: low and inelastic demand for agricultural products, poor provision of public goods (including R&D), high share of agroclimatically constrained land resources, institutional barriers, and governance problems (Pingali 2010).

In virtually all underdeveloped countries, agriculture is an existing industry of major proportions. As countries enact policies that contribute to a more productive agriculture sector, generally through improved productivity of staple grains, GDP per capita rises and agriculture's share of GDP falls as other industries begin to expand and become more competitive (Figure 7.1). As these productivity gains in agriculture enable the transfer of wealth and resources (e.g., labor) from agriculture to non-agricultural industries, rises in per capita GDP and food affordability and availability are correlated with declines in stunting

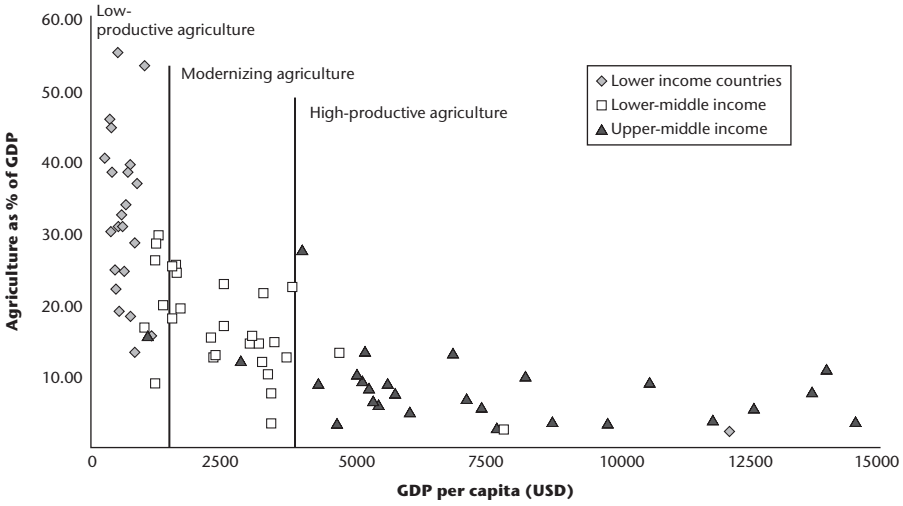

Figure 7.1 Structural transformation, human development, and agricultural performance

Source: Authors creation from The World Bank, World Development Indicators, 2011. <http://data.worldbank.org>.

and wasting (Webb and Block 2012). However, as Webb and Block (2012) pointed out in a multi-country study on income and nutritional outcomes, increased wealth alone does not predict good nutritional outcomes for a population. The same study shows that, after controlling for income effects, stunting declines at a faster pace for countries supporting and sustaining agricultural development through targeted policies aimed at smallholders, further underscoring the crucial role that agriculture plays in improved nutrition outcomes.

Yet as structural transformation continues and agricultural systems modernize, a different set of nutritional challenges emerge with increased GDP and agricultural productivity. These include, specifically, obesity and other associated conditions with overnutrition. Once again, agricultural policies have a role to play. In modernizing systems, agricultural policies can sustain reductions in stunting but also encourage diversification away from staple-intensive production and into higher-value, micronutrient-dense foods.

The Contribution of Nutrition and Health to Agricultural Productivity and Development

The above discussion is not meant to imply that the relationship between agricultural growth and nutrition outcomes is unidimensional. The relationship goes both ways—food security and good nutrition are important *inputs*

into a productive agricultural system, reflecting the role that health plays in human capital development and productive work. That the nutritional well-being of workers is essential to economic growth is a concept that dates back to perhaps the most notable economics treatise ever written: Adam Smith's *The Wealth of Nations*, which first appeared in 1776. In that influential work, Smith discusses how sickness and hunger can be expected to reduce worker productivity (Smith [1776] 1960).

After the 1992 International Conference on Nutrition (ICN), the literature on this relationship really burgeoned. The seminal work of Robert Fogel (1994, 2004a, 2004b), as well as other economic historians, has provided persuasive evidence that nutrition and health have contributed in an important way to increases in productivity and economic growth. Fogel showed how inadequacies in diet contributed to disease and early mortality, greatly limiting the possibility for productive work in 18th-century England and France. His estimates indicate that 50 percent of Britain's growth since 1800 was attributable to increases in dietary energy available for work and improvements in the efficiency in the transformation of nutrients, particularly calories, into work (Fogel 2004b).

Our expectation of the paramount importance of food security and nutrition in enabling a healthy agriculture and food sector in developing countries is predicated on several facts. First, agriculture dominates as a source of income and employment in developing countries where nutritional problems are most acute. Second is the simple spatial argument: nutrition problems are most severe and hard physical labor most important in rural areas where agriculture is the predominant sector.

Third, own production and self-provisioning are of particular importance in these same geographic areas; and under such circumstances, reduced levels of output from hunger and malnutrition can contribute to large consumption shortfalls—an outcome less likely to occur in more market-oriented economies. Fourth, the propensity for market failures, such as in credit markets, will also simultaneously contribute to economic inefficiencies, as mediated by the underinvestment in nutrition and agricultural capital. Reinforcing this low-level equilibrium are binding time constraints, in terms of the time available to devote to the production of health, home production (e.g., care of children), and farm production. Thus shocks, whether they are health-related or other exogenous shocks such as pests or adverse weather conditions, jointly have an adverse affect on health and agriculture.

Fifth, the prospect of early mortality related to hunger and disease reduces the incentives for parents to invest in the education of their children, as these factors lower the returns to schooling. Thus, illness or death resulting from poor health and nutrition will not only limit future productivity in the labor market, but also the incentives for parents to care for children, greatly

increasing the risk that adverse health events that will have long-lasting consequences.

Sixth, there is a related investment story that results from the expectations for a short lifespan. This will reduce saving, and thus investment in physical capital, particularly land and technological advances in agriculture. Like the reduced incentives to invest in children, such failure to invest in land and physical capital will have intergenerational impacts that are only starting to be fully appreciated, in part due to the challenging data and empirical demands of such analysis.

Conceptual Framework

We posit that agricultural policies for enhanced nutrition can be most effectively undertaken when the particular agriculture context (stage of agricultural development) and nutritional challenges of a particular country are understood. In order to recommend such appropriate policies, we put forth (1) a typology of agricultural systems based on the stage of agricultural development, and (2) a conceptual framework useful for thinking about the specific pathways between agriculture and nutrition. This approach offers policymakers the opportunity to think about the consequences that structural transformation has for both poverty and nutrition, and the ways that policy support for agriculture might impact food affordability, availability, diet quality, and rural income growth for improved nutrition.

Agricultural System Typologies

We identify three types of countries, based on the level of agricultural development, that exist along the structural transformation continuum. This classification is useful, given our premise that the stage of agricultural development illuminates specific agricultural policies and programs capable of influencing nutritional outcomes within the agricultural system context. Our classification includes: (1) low-productive agricultural systems, (2) modernizing agricultural systems, and (3) commercialized systems.

LOW-PRODUCTIVE AGRICULTURAL SYSTEMS

Countries in the low-productive agriculture category are invariably low-income, least developed countries, with the major share of their national GDP in small-scale agriculture. Most of the nations in this category are in sub-Saharan Africa. These nations experience some of the highest global prevalence of childhood stunting, wasting, and micronutrient deficiencies (including iron and vitamin A deficiency). Productivity in agriculture remains

hampered by poor nutrition and health, especially for women who assume a predominant role in the production of food crops.

Low-productive agricultural systems face a unique set of agricultural development and nutrition problems. In these systems, large quantities of resources—land and labor—are committed to agriculture and yet are used at very low levels of productivity. Positive income elasticity for staple crop consumption suggests that higher productivity for these crops will be met by an eager market; but without the productivity gains, these agriculture-based countries face low prospects for meeting the Millennium Development Goals of hunger and poverty reduction. Prices of non-staples, including micronutrient-rich fruits and vegetables and macronutrient-rich meat and dairy, remain relatively high, and quantities are limited seasonally or year round. In these systems, agricultural productivity growth is essential for expanding access to staple foods, jumpstarting overall growth, and reducing rural poverty.

MODERNIZING AGRICULTURAL SYSTEMS

Modernizing agricultural systems include many countries in Asia and parts of Latin America, where agriculture-led policies and GR technologies were promoted to increase the availability and supply of cereals and staple grains. These productivity-focused policies promoted agriculture as an engine of growth and sought to expand basic calorie access, elevate producer incomes, reduce real cereal food prices, and utilize scarce resources more efficiently (Scobie and Posada 1978; Stevenson et al. 2013). In addition to lowering food prices and expanding the available supply of calories, staple food productivity growth drove the process of structural transformation and stimulated growth in the non-agricultural sectors (Pingali 2010). Decades later, many of these regions face completely different demand side factors and nutritional realities. Today, negative income elasticity of demand for staples (given the current market supply in these regions), ensures that the policies enacted to "get agriculture moving" must be reimagined for an agricultural system that has moved beyond the conditions that characterized the GR era. Positive demand elasticity for protein and micronutrient-rich food suggests the potential to ignite agriculture once again as a growth sector, link smallholder farmers to new market opportunities, and expand the dietary quality of the food supply in order tackle micronutrient and protein malnutrition (Dorjee et al. 2003; Joshi et al. 2004; Pingali 2010).

COMMERCIALIZED AGRICULTURAL SYSTEMS

The third category—commercialized agriculture—which we spend the least time discussing in this chapter—constitute agricultural systems of the developed world. These high-income countries have relatively small rural

populations, and agriculture typically accounts for less than 10 percent of GDP (Pingali 2010). However, when we do discuss these systems, we underscore insights that even when agriculture has less of a proportional impact on total GDP and is no longer the primary engine of growth, agricultural policies are still necessary to ensure human nutrition through the promotion of food safety, competitive markets, and obesity prevention.

Pathways Connecting Agriculture to Nutrition

Using this classification, we now present a framework for thinking through specific types of agricultural policies. We premise this discussion by asserting that different stages of agricultural development merit different types of policy approaches for influencing nutritional outcomes. Understanding how these pathways evolve and intersect, based on the stage of agricultural development, is essential for developing and prioritizing policies that respond to the unique nutritional challenges and food supply constraints that occur throughout a country's development process. We identify four interlocking pathways between agriculture and nutrition. These pathways to improved nutrition include: (1) the income pathway, where gains in household income can translate to better food affordability (among other impacts); (2) the food supply pathway, including the availability of quality, quantity, and diversity of food year round and for vulnerable subpopulations; (3) the intra-household access pathway, where interventions attempt to equalize food allocation among individuals within a common household; and finally (4) the health environment pathway, which links access to clean water and improved sanitation/hygiene practices to better nutritional health.

Our framework for understanding the pathways between agriculture and nutrition has, on the one hand, *household food access* and on the other, *individual nutrient uptake and access*. Household food access rests on the ability for a family unit to access the quantity, quality, and diversity of food needed to achieve daily micronutrient, energy, and protein needs. Individual nutrition access demands intra-household food distribution equality and a healthy environment that allows the person to metabolically absorb and utilize the food consumed (Figure 7.2).

On the left-hand side of Figure 7.2, we see that food access is premised on the ability to afford and access an array of nutrient-dense foods. Food affordability requires the expansion of household budgets to allow rural farmers to purchase the quantity, quality, and diversity of food needed. Household incomes are determined by the productivity of smallholder farmer operations and the opportunities available for increased income opportunities (i.e., linking farmers to domestic and global food value chains) and non-farm income

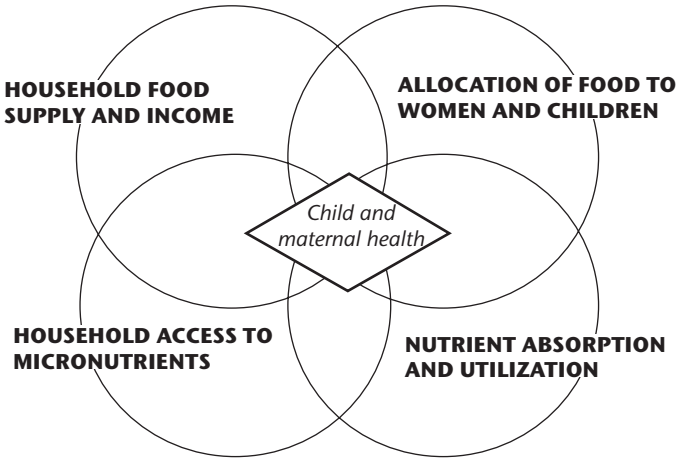

Figure 7.2 Agriculture-nutrition pathways

Source: Adapted from Tata-Cornell Agriculture and Nutrition Initiative (TCi) 2014. <http://tci.cals.cornell.edu>.

opportunities. The seasonality and volatility of these market opportunities are of special consideration and importance.

However, increases in income and expansion of food budgets, must be matched by actual food availability, in particular the availability of diverse, micronutrient-rich food. Micronutrient-rich food availability is determined by the spatial location of the household, its proximity to diverse food retailers, or on-farm diversification and home cultivation of micronutrient-rich food (e.g., kitchen gardens and backyard livestock). Micronutrient-rich food availability may also be increased through policy efforts to increase rural access to food diversity with food and cash transfer programs and safety net programs.

On the right-hand side of Figure 7.2, barriers to individual nutrition access and absorption, including intra-household food allocation and nutrient absorption, are identified. A household is made up of individuals who may differ in terms of individual food intake and individual food needs—even if a household can access and afford food sufficiency and dietary diversity, individual nutrition within a household is not always equal. Distribution within a household may favor men and older boys, allowing them to eat first and select the amount and quality they desire. Women and young children are often left with the food that remains.

Yet even if an individual comes from a household that is able to afford and access a diversity of nutrient-rich food and is distributed enough food for her needs, the environment she lives in can determine her biological ability to absorb energy and nutrients. Drinking water supply and sanitation around the world continues to be inadequate, and intestinal inflammation

and infection due to water contaminated with worms, parasites, viruses, and bacteria, lead to partial or complete malabsorption of essential nutrients and calories, in addition to life-threatening dehydration.

Certainly, agricultural policies are only one critical dimension of the policy puzzle for improving nutrition. A number of mediating factors influence household income, micronutrient availability, nutrient absorption and utilization, and household food allocation. The income (Pathway 1) and the food supply (Pathway 2) have the most obvious connections to agriculture, given the dependency of the poor on these activities for income, as well as the ability to influence the quality, quantity, and diversity of the overall food supply. However, improvements along some pathways can create ripple effects for others. For example, improvements in women's income-earning opportunities, say, through investment in agricultural technologies for women, can promote women as decision-makers within the household and lead to more equal access to household resources—including better quality or quantities of food. Similarly, public investments in clean water access can support rural communities to comply with the food quality and safety regulations that are otherwise a barrier to entering higher-value agricultural markets. Nutrition, like agriculture, is multidimensional and capable of promoting and affecting multiple facets of life, and development across these areas must occur simultaneously.

In short, all of these pathways are important to improving nutrition. However, the relevance of a particular agriculture–nutrition pathway, and the types of useful agricultural interventions within that pathway, depend on the stage of agricultural transformation. Thus, in order to understand and use agriculture as a tool for improving nutrition, one needs to understand the role of agriculture in a particular system and adjust policies along the various agriculture–nutrition pathways accordingly. Agricultural policies for improved nutrition are specific to context and should not been seen as a homogeneous set of policies for use in any and every situation. Countries in each of the three typologies we have described interact with the agriculture nutrition pathways differently, based on production constraints and current supply, as well as demand drivers that influence new market opportunities and future supply potential. The nutritional goals may also differ by the stage of transformation, ranging from reduction in stunting to managing obesity.

Agricultural Policies for Improved Nutrition

Low-Productive Agricultural Systems

Low-productive agricultural systems face a negative cycle: low-productive agriculture in staple crops contributes to widespread hunger (calorie deficiency) and low dietary diversity. Together, these nutrition outcomes translate

to inefficient labor investment, and thereby, reduce overall farm productivity. Productivity-focused investments in staple crop production have the ability to reduce widespread hunger by making staple grains more affordable and available in the short-term. After agriculture "gets moving" and transitions from a low-productive agricultural system to a modernizing system, policies that invest in non-staple crop diversification can begin to tackle the issue of dietary diversity access. Options to pursue biofortification of staple grains with key nutrients, as we suggest in a later section, offers a chance to address micronutrient malnutrition in the short term.

Low-productive agricultural systems, which are found primarily in low-income countries, exist in a unique economic context. One must consider the role of agriculture in explaining the quantity and quality of the food supplied, *in addition* to explaining the persistence of rural poverty. Both are inextricably tied to nutrition through the income and food supply pathways (Pathways 1 and 2). Given that most smallholder farmers are net food buyers (Barrett and Dorosh 1996), impoverished households generate weak demand for the relatively higher priced micronutrient- and protein-dense food, which further depresses production and reduces diversity in the overall food supply. Under such circumstances, expansions in food supply without simultaneous increases in consumer incomes—most importantly, the incomes of the poor—will contribute relatively little to the elimination of malnutrition (Pinstrup-Andersen and Caicedo 1978).

SYNERGISTIC IMPROVEMENTS IN PATHWAYS 1 AND 2: AGRICULTURE AS AN ENGINE OF GROWTH THAT IMPROVES INCOME AND EXPANDS CALORIE ACCESS

Investments that improve agricultural productivity have the potential to both grow producer incomes (Pathway 1) while elevating the quantity of food available (Pathway 2). To achieve this, however, agricultural policies capable of "kick-starting" economic growth through improvements in productivity must be pursued. The world, however, has encountered this problem before: the rapid increase in agricultural output resulting from the Green Revolution (GR) provided impressive staple grain yields for many developing countries in Asia and Latin America, including a 208 percent increase in wheat production, 109 percent in rice production, and 157 percent in maize production (Pingali 2012). This contributed to a significant shift in the food supply function, which, in turn, contributed to a decrease in real food prices and an increase in cereal production (between 12–13 percent) (Hayami and Herdt 1977; Scobie and Posada 1978).

Unfortunately, much of the African continent never reaped the benefits of the GR. Many countries continue to suffer from low-producing agriculture, and some of the highest rates of poverty and malnutrition

persist. Downstream issues of governance and marketing, viable input supply systems, and sustained provision of productivity-enhancing seed and fertilizer technologies and market outlets for absorbing surplus production have all contributed to a "GR failure" of increased productivity of staple grains in Africa (Pingali 2012). A new push for cereal-based strategies for improving income and the food supply must be pursued in order to get agriculture to kick-start the engine of economic transformation.

Emerging success stories from Africa that highlight agricultural productivity growth in recent decades show that: (1) context for agricultural development has shifted; and (2) investments in research to address the crops and constraints relevant to the continent's agriculture are yielding high returns. For example, productivity gains in cassava and improved varieties of sorghum and millet have risen close to 40 percent between 1980 and 2005 (Binswanger-Mkhize and McCalla 2010). For cassava, a major west, central, and southern African staple crop, virus and pest issues once nearly eradicated this important locally consumed food. Investments in crop research (by the International Institute of Tropical Agriculture in Nigeria) played a critical role in creating mosaic disease-resistant varieties and establishing mealybug control programs that resulted not only in sustained cassava production, but enabled cassava expansion across Africa into new processing opportunities and industry activities for smallholder producers.

For Africa, reprioritizing investments into productive agricultural development can improve nutrition by increasing farm-level profitability that can ultimately mobilize the process of structural transformation. High rates of return for improvements in crop breeding and genetics, farm management techniques and extension, as well as investments in irrigation and credit infrastructure have been found to extend far beyond the short-term and influence both food availability and rural household income (Datt and Ravallion 1998; Gómez et al. 2013). For example, in Asia, significant public investment in the 1960s, and continuing through the 1980s, in irrigation infrastructure and input access laid the foundation for rapid adoption of GR technologies that enabled the proliferation of cereal intensification and calorie access across the region (Pingali 2012).

Today, improvements are being made in Africa, but change must be accelerated and enacted on multiple fronts. In the early 1990s, the Kenyan government launched a series of reforms designed to spur productivity by encouraging private investment in fertilizer distribution and removing fertilizer import restrictions (Ariga and Jayne 2010). Ariga and Jayne (2010) provided evidence showing how the average transit distance from farmer to fertilizer outlet and the average travel distance to hybrid seed retailers declined from 8.1 to 3.4 kilometers and from 5.6 to 3.4 kilometers, respectively. The authors point out the simultaneous improvements in productivity

and diets: yield increases rose by roughly 18 percent (1997–2007), and price decreases for critical maize food products like maize meal also occurred.

Despite these upward trends, many countries in sub-Saharan Africa still have very low-productive agricultural systems. In these areas, chronic hunger and poverty continue to be daunting problems; and lack of technology, poor market infrastructure, inappropriate institutions, and a disabling policy environment depress nutrition and stagnate economic growth (Pingali 2012). Exacerbated by poor health, agricultural productivity surely suffers. Renewed private sector interest is combining with a public interest to invest and improve agricultural productivity, especially through public–private extension efforts and institution building. Increasingly, public, public–private, private, and non-governmental organization intervention in extension services are creating new ways to upgrade and assist farmers. These organizations are providing business advising services, agronomy support, and market opportunities, as well as facilitating the distribution and adoption of improved inputs and credit (IFPRI and The World Bank 2010; Ricketts et al. 2013). In addition to improving the quality and quantity of food produced by small-scale farmers, extension can also be enacted to improve food-borne illnesses, pathogens, and diseases, which complicate individual nutrition uptake, disrupt trading relationships, and reduce smallholder market opportunities.

ENSURING PROGRESS ALONG PATHWAY 1 FOR THE PRIMARY FOOD PRODUCERS: RURAL WOMEN

Women's vulnerability results from their special role not only of food producers, but also from their unique reproductive roles, and the associated demands of motherhood. Health and nutrition shocks that adversely affect women not only adversely affect their productive role as workers in the agricultural sector, but also impact their joint production role as caregivers for their children, and thus induce a recurrent and intergenerational cycle of crisis and deprivation. In terms of accessing essential inputs for productive agriculture, women face serious barriers in obtaining credit, machinery, education (agricultural knowledge), and improved inputs (Gladwin et al. 1997; Quisumbing and Pandolfelli 2010).

Policies that invest in the expansion of peer-to-peer learning networks, extension systems, and input access can have significant effects on agricultural productivity and profitability, especially for women. Among rural women, the organization, expansion, and support of women's groups can help foster demand for critical agricultural inputs (credit, improved seeds, and inputs), and support entrepreneurial ambition and empowerment. Research has suggested that depressed credit demand and reduced entrepreneurial activity for women exists in many communities because of social norms that prescribe what kinds of market-oriented activities are appropriate (Fletschner

and Carter 2008; Fletschner 2009), and because women lack access to collateral, education (literacy), markets and contracts, land and water, among other things (see a review in Quisumbing and Pandolfelli [2010]).

Advancements and investment in extension and infrastructure can be especially important for reducing the barriers that women face in entering higher-value markets and intensifying their land with adequate inputs. A study in 2010 highlighted gains in income and per-acre productivity for participants with new access to extension personnel in Kenya, Tanzania, and Uganda—a finding that was particularly true for women participants (Davis et al. 2012). Despite this success, a 2009 review of women and extension activities (India, Ghana, Ethiopia), undertaken by the International Food and Policy Research Institute (IFPRI), illustrated that extension workers tended to be overwhelmingly male, and that only a fraction of female-headed households had access to extension and livestock services over the previous year (IFPRI and The World Bank 2010).

IMPROVING MICRONUTRIENT-RICH FOOD ACCESS WHILE PURSUING STAPLE GRAIN (CALORIE) PRODUCTIVITY GOALS

In tandem with these staple grain intensification goals, micronutrient and protein interventions can concurrently be pursued in order to ensure that hunger (calorie deficiency) is not addressed at the expense of reducing micronutrient malnutrition. Biofortification of staple grains can enable access to essential micronutrients like iron, vitamin A, and zinc (among others). Biofortification of staples offers an integrated, food system approach aimed at reducing micronutrient deficiency until the longer-term, most sustainable solution (i.e., dietary diversification) can be achieved. A review of biofortification efforts has underscored that this approach is an efficacious and cost-effective strategy in rural areas of several developing countries (Asare-Marfo et al. 2013). In 2012, HarvestPlus technologies enabled trials of vitamin A-biofortified maize in Zambia. In Benin, iron-biofortified pearl millet has been shown to bolster bioavailable iron compared with regular millet (Cercamondi et al. 2013). In addition to enhancing the content of various nutrients, attempts to breed in positive agronomic traits have also been undertaken. Disease resistance, drought tolerance, and acid soil tolerance qualities suggest that improved nutrition can go hand in hand with improved productivity and farm management, and that agronomically competitive varieties are possible (Bouis et al. 2011).

Biofortification of non-cereal staples, like roots and tubers, have also been undertaken. In 2011, HarvestPlus technologies enabled trials of vitamin A-biofortified cassava in Nigeria and the Democratic Republic of the Congo (Bouis et al. 2011). Evidence has shown that vitamin A intake from

biofortified orange-fleshed varieties of sweet potato resulted in improved vitamin A intake among trial participants in Uganda (Hotz et al. 2012) and Mozambique (Low et al. 2007). Additional impact and evaluative studies are forthcoming.

Similarly, policies promoting backyard livestock and home garden programs can be ideal for low-productive agricultural systems that are in the early stages of structural transformation. These programs are especially useful in the short term, before demand for dietary diversity triggers a market response (or before technologies, institutions, and inputs *allow* producers to respond). As agriculture "gets moving" with staple productivity gains and household income expansions, smallholder farmers can respond to an evolving market for supplying micronutrient- and protein-dense food. In parts of Africa, the promotion of indigenous plants in home gardens has been advantageous, given that these varieties require minimum inputs, mature quickly, and can be harvested in a short period of time in soils with limited fertility (Faber and van Jaarsveld 2007). In fact, it was found that when comparing agricultural with home gardening interventions, home gardens had a higher success rate for nutritional impact than comparative agricultural interventions—especially if cultivation methods and product selection targeted women (Berti et al. 2004; Faber and van Jaarsveld 2007). Stigma against these garden crops, as a "poor person's food," requires education and a strong promotional campaign from public extension and education agencies, non-governmental organizations, and community leaders. In South Africa, use of demonstration gardens within villages developed understanding and enthusiasm about the potentials for home garden cultivation and household nutrition (Faber et al. 2001).

Modernizing Agricultural Systems

The modernizing agricultural systems of much of Asia and Latin America have experienced significant gains in agricultural productivity, staple crop food supply, and staple food price decreases. These gains were fueled by successful implementation of the GR, which were underpinned by high rates of public investment in crop research, infrastructure, market development, and appropriate policy (Pingali 2012). Gains in cereal yields are not enough to address malnutrition. Despite the intensification of grain production in these regions and the multiplicative effects that the GR had on reducing poverty, it brought these countries only so far. Poverty and food insecurity in some communities have persisted; especially in rain-fed farming areas and for communities that have been isolated due to lack of technology and extension coverage and insufficient access to credit and land. Access to staple grains and the fall in the cost of calories both illuminated and

exacerbated the problem of "hidden hunger," or micronutrient malnutrition. Today, micronutrient malnutrition plays a strong role in the elevated instances of childhood stunting, anemia, vitamin A deficiency, and other major deficiencies in South Asia (India, in particular), in Southeast Asia, and across China. Globally, these micronutrient and macronutrient deficiencies contribute significantly to the overall global disease burden for women and children (Black et al. 2008).

During the GR, productivity-focused policies for these previously low-producing agricultural systems succeeded in elevating grain supplies and placing downward pressure on real food prices, a feature that had positive nutrition effects (increased protein and calorie intake) for poor households who were net food consumers (Alston et al. 1995). A study in Bangladesh further showed how savings on food expenditures increased access to non-staple foods, and that this had a significant improvement on child nutrition status as households changed consumption patterns and spent more on non-rice foods (Torlesse et al. 2003). Of course, the linkages between household dietary diversity, socio-economic status, and income have long been established (Hoddinott and Yohannes 2002; Arimond and Ruel 2004). This seemingly complicates the connections that can be made between improved dietary diversity and nutrition outcomes, given that these other factors also have an influence. To be sure, socioeconomically higher households tend to have greater access to additional positive nutrition pathways (Pathways 3 and 4), which include access to water, sanitation, hygiene, and education. Despite this, an 11-country study on child nutritional status, controlled for these wealth and welfare factors, found dietary diversity was still significantly associated with core nutrition metrics (child height and weight) (Arimond and Ruel 2004).

Additional authors and studies have pointed to the income elasticity of staples and the inelasticity of micronutrient- and protein-dense foods (fruits, vegetables, dairy, and meat, for example), and that households with increased incomes often switch to consuming higher-quality foods (within the same food group) or consume a more diverse set of food groups (Bouis and Haddad 1992; Behrman 1998; Pingali 2004). Although this aspect of the search for diversity and quality may help address nutrient deficits other than calories, for example, proteins and micronutrients, there is also evidence that the increased diversity involves consumption of more refined carbohydrates. Recent evidence has shown that while stunting rates decrease with improvements in per capita income, levels of obesity rise (Webb and Block 2012). Macroeconomic and supply-side agricultural policy certainly has a role to play in ensuring that micronutrient- and macronutrient-rich food is both affordable and available.

ENABLING MICRONUTRIENT-RICH FOOD ACCESS THROUGH TRADITIONAL MARKET UPGRADING AND MARKET DEVELOPMENT

For modernizing systems, policy emphasis must shift from a focus on cereal intensification to one that encourages broader food supply diversification, by expanding household income via linkages to new and higher-value markets (via Pathway 1) that encourage on-farm diversification and impact the overall diversity of the food supply (impacts through Pathway 2). Non-staple crops, including fresh fruits, vegetables, meats, and dairy products, require a heightened level of infrastructure and support in order for farmers to survive. Policies that focus on market development, as we use the term here, include those that help lower food prices and increase income (Pathway 1) and improve diversity in the overall food supply (Pathway 2). In particular, this includes policies that can (1) encourage production diversification by linking smallholder farmers to new market opportunities in order to diversify out of staple crop production; (2) strengthen demand for non-staples, and (3) upgrade traditional markets.

LINKING FARMERS TO HIGHER-VALUE MARKETS: EXPANDING INCOMES AND DIVERSIFYING THE FOOD SUPPLY

Linking farmers to higher value markets has long been of interest to organizations and policymakers looking to spur growth for rural areas where incomes depend on agriculture. By linking rural producers to non-staple, higher-value domestic, export, and retail markets, improvements in income (Pathway 1), as well as access to productive services and inputs have been shown to increase income and welfare (Carter et al. 1996; Kaplinsky and Morris 2001; Dolan and Sorby 2003; Humphrey 2005; Barrett et al. 2011). Critics have been quick to point out, however, that new market linkages can disrupt domestic food security, and that these market opportunities tend to be accessible to farmers who are already relatively "better off." Households that are less reliant on subsistence production and who are more oriented toward market production have been found to have more diverse diets (Jones et al. 2014). These farming households are often marked by advantageous features, including favorable socioeconomic, financial, geographic, or biophysical qualities that can help to characterize participation patterns (Barrett et al. 2011).

Agricultural policies can play a role in ensuring equal participation by developing a more level playing field. Given the connection between market linkages, economic growth, and dietary diversity, investments that can equip a diverse socioeconomic group of farmers to participate is essential. However, it is worth noting that even in instances where the poorest farmers do participate directly, positive spillovers have been shown to accrue to

non-members, including poorer farmers in the village or region. Transfers of information from members to non-members and access to productive inputs and assets have been found to reach excluded growers, and thus contribute to wider income and productivity gains (Bernard and Spielman 2009). In terms of diet, recent research continues to show a positive relationship between farm production and diversity (Jones et al. 2014).

Public policies aimed at developing new market opportunities tends to mean working with private companies in order to access and identify market opportunities and creating an "enabling environment" that focuses on developing necessary institutions in order to ensure broad-based participation. The latter includes investments in *connective* infrastructure (paved roads, telecommunication networks, known and widespread networks for distribution), as well as *mediating* infrastructure (providing credit, credit rating agencies, property titles, and other legal and regulatory institutions that can depersonalize exchange transactions and make assets fungible (De Soto 2000).

In particular, access to finance and land registration can be instrumental in enabling farmers to diversify crops, make longer-term and more efficient production decisions, and manage risk and resources more effectively. Policies supporting household access to finance and land registration have been found to improve profitability (income), ensure greater on-farm productivity, and enable market access (Bliss and Stern 1982; Atwood 1990; Morduch 1994; Zeller et al. 1998; Dercon 2002; Fafchamps 2009). Moreover, policies that succeed in creating an "enabling environment" for agriculture may disproportionally preserve opportunities for those who are the most closely tied to agriculture: those who are very poor, uneducated, recent immigrants, or women and who tend to be less likely to have access to non-farm employment (Barrett et al. 2001; Vanderpuye-Orgle and Barrett 2009). Additionally, the development of financial markets in rural areas for intermediaries (e.g., small- and medium-sized traders or wholesalers), has been found necessary to ensure that farmers diversify production (Coulter and Shepherd 1995; World Bank 2007; Dalberg 2012).

Public efforts can also be geared toward providing market information that can be essential to harnessing demand and enabling smallholder integration into new markets. Public–private partnerships (PPPs) have been shown to increase information and investment flow, as well as investment into supply chains capable of linking or integrating smallholder farmers. In some cases, evidence for improved efficiencies for smallholder farmers and traders have been identified through greater communications technologies, quality trainings, inputs, and services (de Silva and Ratnadiwakara 2008; Aker and Fafchamps 2010; Ricketts et al. 2013). Improving the transfer of information about prices and good agricultural practices can help align marketing incentives all along the food value chain. In Tanzania, collaboration between the

Tanzanian government and others developed the *First Mile* project, which aimed to facilitate learning among local groups, improve market linkages, and share locally developed best practices and information on current market supply and demanded product qualities. Information shared via phone text messages and community billboard postings created competition between intermediaries (market "spies"), who eventually began to charge and compete for providing valuable market information (World Economic Forum 2009). Additionally, PPPs can provide opportunities for governments to update and modernize extension services (see Ricketts et al. [2013] for additional examples).

STRENGTHENING DEMAND FOR NON-STAPLES

While supply-side policies and institutional investments can expand availability of diverse foods and enable smallholder income gains, agricultural policies for improved nutrition can also aim to strengthen consumer demand for foods rich in micronutrients and protein. This alignment is essential. Broadly, policy investments in market information technologies, product standardization, and food safety regulations can build consumer trust, identify new market demands, and provide meaningful opportunities for farmer response.

When product standardization and labeling initiatives are absent or poorly enforced, consumers are forced to establish their own methods of determining quality; these preferences can be difficult to measure and impossible for market actors to respond to (Jabbar et al. 2010; Gómez and Ricketts 2013). A 2010 review of demands for livestock products in developing countries pointed out that consumer perception of quality, safety, and convenience influenced the price and purchase of livestock products (Grunert [2005], as cited by Jabbar et al. [2010]). Jabbar et al. (2010) found that although no official standards for meats existed in Ethiopia and Bangladesh, poor consumers in traditional markets used informal criteria (like color and odor) to determine quality. Similar results were found by Minten (2008) regarding meat product preferences in Madagascar. Generally, however, poorly understood consumer demand ensures that the delivery of products, which could otherwise expand dietary diversity, is either not developed or improperly placed. Especially for protein-dense foods, Jabbar et al. (2010), in a study on livestock food demand in Asia and Africa, found that all consumers are willing to pay a premium price for higher standards of livestock products. For policymakers looking to strengthen demand for micronutrient- and protein-dense products, research into the preferences of the poor and basic product standardization can open up new market opportunities and set baselines for product quality indicators.

Policy support for regulating food safety is critical for sustained access to markets for smallholder farmers, for preserving the quality of the available food supply, and for promoting human health and individual nutrition

uptake. However, food safety regulations pose a threat to the participation of smallholder growers who may find compliance difficult or impossible. Policy efforts focused on developing and maintaining producer organizations must keep in mind that some food safety standards require changes to group size and composition, as well as linkages to new sources of market information that can help farmer groups adapt (Narrod et al. 2009). In fact, policies that expand access to entities specializing in food safety trainings and certification are becoming very important conditions for maintaining competitive producer organizations. Despite this, some developing countries have yet to adapt and update policies, which may leave producer organizations with little incentive to comply or compete on providing superior food safety measures. For example, in some Indian states, laws prohibiting cooperatives from forming external linkages include those that train and provide knowledge on food safety issues (Narrod et al. 2009). Equipping farmers and farmer organizations for commercial success means revisiting policies and public investments that encourage market linkages to essential entities that could support knowledge sharing and training around food safety issues.

UPGRADING TRADITIONAL MARKETS FOR NUTRITIONAL IMPACT

Poor people in developing countries generally rely on traditional food value chains and traditional markets, both in urban and rural areas, for the bulk of their food. Historically, "traditional retail" has been undertaken similarly in different regions around the globe: food from farmers in close proximity is bought and eventually sold in small, "mom and pop" corner stores, wet markets, roadside stands, and vendors through a network of informal farmers, traders, wholesalers, and intermediaries (Ruben et al. 2006; Reardon et al. 2010; Reddy et al. 2010; Gorton et al. 2011). For modern supermarket and retail integration, adequate transportation, proper storage, volume coordination, and assurance of food safety can present insurmountable challenges for the typical smallholder farmer—so, too, can achieving the level of quality demanded by modern retailers. As a result, traditional markets that offer flexibility on price and quality have continued to be a critical marketing opportunity for small-scale producers.

Low margins and production seasonality, combined with lack of post-harvest and distribution infrastructure, however, often reduce the incomes in traditional food value chains and the quality and quantity of food available year round (Gómez and Ricketts 2013). Public investment in these markets to promote and safeguard a diverse supply of micronutrient-rich food, while protecting smallholder incomes, will remain essential to improving health and nutrition.

Public investments that legitimize and expand the availability and transparency of sectors, including entrepreneurial retailers, traders, and wholesalers, can support trade, reduce transaction costs, and improve consumer prices within traditional marketing channels. In Kenya, informal milk markets account for 86 percent of milk supplies to consumers, and many supply chain actors are small-scale producers, milk bar operators, milk transport traders, and other micro-entrepreneurs (Kaitibie et al. 2010; Omore and Baker 2011). Government policies had previously criminalized small-scale producers and traders who could not afford or access the licensing and certification process required. Prior to a policy change in 2004, small-scale dairy producers were often harassed by large, powerful dairy market players who sought to increase their relatively small market share by claiming public health concerns and zoonotic outbreaks on these small producers (Kaitibie et al. 2010). These unsubstantiated threats endangered the livelihoods of more than 1.8 million cattle producers who owned 1–2 dairy cows on areas of less than 2 hectares (Omore and Baker 2011). In 2004, policymakers responded by liberalizing the small-scale dairy sector and investing in a new system for registering and licensing for small-scale farmers. Milk quality was raised, and improvements in handling and hygiene practices changed public perceptions; an average of 9 percent reduction in milk-marketing margins showed improved competition (reflecting reductions in the monopoly that large dairy producers once enjoyed), resulting in *higher* prices for small-scale farmers and *lower* retail prices for consumers (Kaitibie et al. 2010; Omore and Baker 2011).

Policies promoting food safety should be a policy priority for upgrading traditional markets and ensuring that human health is safeguarded. In addition to reducing instances of foodborne illness and disease, food safety policies can make traditional markets a viable place for procurement by modern retailers. This can further improve smallholder incomes. Improvements can include infrastructure investments like the pouring of cement slabs for establishment of stalls and zoning of animal/livestock products away from produce, and the establishment of sanitation stations in wet markets where equipment and products can be washed and waste can be discarded safety.

Conclusion

Remarkable progress has been made in raising agricultural productivity and preventing global food shortages over the past 50 years, a success story made all the more impressive in light of the exploding global population. Malnutrition has declined, especially in Southeast Asia, as the process of

structural transformation has occurred, largely reflecting the success of the Green Revolution. The agricultural research underpinning the development of the Green Revolution, in turn, was supported by public investment in infrastructure, markets, and price policies that provided incentives for a range of farmers and entrepreneurs in the food system.

The successes we have witnessed, however, leave no room for complacency. In large regions of South Asia and Africa, hunger and malnutrition continue to afflict large shares of the population; and there is an increasing recognition that micronutrient deficits, in part a reflection of the neglect by policymakers of micronutrient-dense foods, remain a serious global threat. Perhaps more worrisome is the burgeoning global epidemic of overweight and obesity leading to chronic illnesses such as diabetes and cardiovascular disease.

In our chapter, we have focused on the future policy challenges and opportunities in agriculture in terms of a broader supply chain, as well as non-agricultural policies that will help in the fight against malnutrition. We emphasize the need for continued efforts to modernize agricultural systems in large swaths of the world, where the structural transformation has yet to occur. The challenges of investing in productivity growth in these areas remain formidable, especially in regions characterized by low-productive systems primarily found in sub-Saharan Africa and parts of South Asia. Even in countries with modernizing agricultural systems, there is a need to do more in terms of promoting diversity in production and consumption of non-staple food crops, which have until now been largely neglected by agricultural researchers. Additionally, although the focus of our chapter is on agriculture and its supply chain, by including its role in job creation and in fueling economic growth, through ensuring a steady and plentiful supply of wage goods for a modernizing industrial and service economy, we emphasize the importance of complementary investments in public and curative health services. Indeed, as the current paradigm in terms of combatting malnutrition focuses on the first 1,000 days, from conception to 2 years of age, we also emphasize the role of investing in health infrastructure and promoting care behaviors, such as breastfeeding and appropriate weaning practices. In doing so, we stress that these investments are not divorced or in conflict with the structural transformation, both because of agriculture's role in job creation and economic growth, but also because women are at the heart of both processes—caring and nurturing children, and in their roles as food producers and key workers along the food value chain. And furthermore, investing in the health and nutritional well-being of women and their children will have short- and long-term benefits, in terms of raising the productivity of the labor force and promoting economic growth.

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