LEVERAGING AGRICULTURE FOR IMPROVING NUTRITION & HEALTH

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GROWTH IS GOOD, BUT IS NOT ENOUGH TO IMPROVE NUTRITION

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Foreword

In recent years we have learned a great deal about how agriculture, nutrition, and health are linked. We experience that policies designed to increase agricultural production can either improve or threaten people's nutrition and health—and conversely that people's nutrition and health status can contribute to or interfere with agricultural production. Researchers have shed light on some of the specific paths through which these links play out, but gaps in our knowledge remain. There is still much to be learned about how agriculture, nutrition, and health are connected, how they interact and, especially, how we can use those interactions to advance goals in all three sectors.

To help close the knowledge gaps, the 2020 Vision Initiative of the International Food Policy Research Institute (IFPRI) has commissioned a series of papers as part of a larger global consultation that includes the February 2011 international conference "Leveraging Agriculture for Improving Nutrition and Health" (http://2020conference.ifpri.info/). Developing effective policies in agriculture, nutrition, and health will require a strong foundation of evidence. It is our hope that these papers will help lay the groundwork for greater understanding of the issues and lead to policies that will enhance healthy, productive lives for all people.

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Director General

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Growth is Good, but is not Enough to Improve Nutrition

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Abstract

NUTRITION IS INCREASINGLY RECOGNIZED AS AN IMPORTANT DIMENSION OF economic development, yet relatively little is known about the relationship among development policies, economic growth, and nutrition outcomes. Advancing the knowledge in this field can help policymakers to design strategies and prioritize action for accelerating growth *and* improving nutrition. To contribute to this process, this paper uses cross-country analysis and an innovative analytical framework applied to two case study countries. We find that policies that foster growth are important for improving nutrition. Agricultural *or* non-agricultural growth can contribute to improved nutrition, depending on the country's economic structure and the characteristics of the malnourished people. Agriculture has a strong potential to contribute to the reduction of malnutrition in agriculture-based economies, such as Malawi, whereas in mineral resource-based countries with limited agricultural potential, such as Yemen, industry and service sector-led growth leads to better nutrition outcomes. However, we also find that growth is not enough for improving child nutrition and reducing micronutrient malnutrition. Therefore, pro-growth policy reform needs to be complemented by strategic health and education investments and targeted nutrition programs.

1. Introduction

There is broad consensus in the development economics literature that growth is a necessary condition for poverty reduction (Ravallion and Chen 1997, Dollar and Kraay 2002, Kraay 2004). However, the extent to which growth translates into reductions in poverty largely depends on the structure of growth and the characteristics of the poor (Ravallion and Chen 1997, Deininger and Squire 1998, Bourguignon 2002). Compared to growth in other sectors, agricultural growth has been shown to be more effective at reducing poverty, especially in countries with large agricultural sectors and a large concentration of agricultural households among the poor (Delgado et al. 1998, Diao et al. 2010, World Bank 2007). Manufacturing and service-sector led growth becomes more important for poverty reduction during the process of economic transformation, when the share of agriculture in the economy declines and people migrate to urban areas (Breisinger and Diao 2008, World Bank 2009).

While the connection between growth and poverty reduction is well established, relatively little is known about the relationship between economic growth and nutrition and, hence, how economic policies can be leveraged for improving nutrition. Some household-level studies have looked at the relationship between changes in household incomes and calorie and micronutrient deficiency (e.g., Abdulai and Aubert 2004, Ecker and Qaim 2011, Skoufias et al. 2009). Other studies (e.g., Haddad et al. 2003, Alderman 2001) have analyzed the effects of changes in incomes on child nutrition. Results of these household-level studies generally show a positive relationship between growing incomes and nutrition outcomes, albeit to various degrees. Even fewer studies exist on the relationship between economic growth and nutrition improvement. Headey (2011) uses cross-country regressions to explain changes in children's nutritional status as an outcome of economic growth and finds a positive but weak relationship between growth and reductions in child malnutrition. However, there is also evidence that economic growth does not always translate into improved nutrition such as in India. Deaton (2010) finds that per capita calorie consumption in India has been falling for a quarter of a century in spite of high rates of per capita income and consumption growth in recent years. India's annual GDP growth averaged 7.2 percent over the period 1997-2007, and poverty dropped from 39 percent in 1998 to 30 percent in 2006 (according to the international $1.25-a-day poverty line), but undernourishment (measured on the basis of per capita calorie availability) increased from 17 percent in 1997 to 21 percent in 2007 (WDI 2010).

Against this background, several important questions remain, the answers to which may provide important insights to policymakers on how to improve nutrition. First, are there other countries in addition to India where growth and nutrition may be de-linked? Second, does the structure of growth matter (as in the case of poverty) for nutritional outcomes and, if so, how? Finally, how do different policies affect nutrition and what can governments do to improve nutrition?

This paper aims at to provide evidence to shed light on these questions. We present a comprehensive conceptual framework that links economic growth and policies to their nutrition outcomes. We also propose an innovative methodological approach that allows modeling the effects of overall and (sub)sectoral growth and economic policies on people's nutritional status, consistent with our conceptual framework. We then apply the methodology to two case study countries to simulate the nutritional impacts of economic policies. We have chosen Yemen and Malawi as two countries that are low-income with high levels of malnutrition. Yemen represents an oil-based economy with a relatively small agricultural sector and Malawi an agriculture-based economy with limited diversification. These countries therefore span a broad range of possible growth-nutrition relationships so that findings are relevant for variety of other countries, particularly in the Middle East and North African region and Sub-Saharan Africa.

The paper is structured as follows: Section 2 uses cross-country analysis to explore the general relationships between economic and agricultural growth and the prevalence of malnutrition over time. It serves as a background for the sections that follow and helps to understand the (dis)connection between economic growth and nutrition by country. Section 3 presents the conceptual framework and the methodology linking economic growth and policies to nutrition outcomes. Section 4 comprises the case studies, and Section 5 presents conclusions and policy recommendations based on the analyses of the paper.

2. Economic Growth and the (Dis)Connection to Nutrition

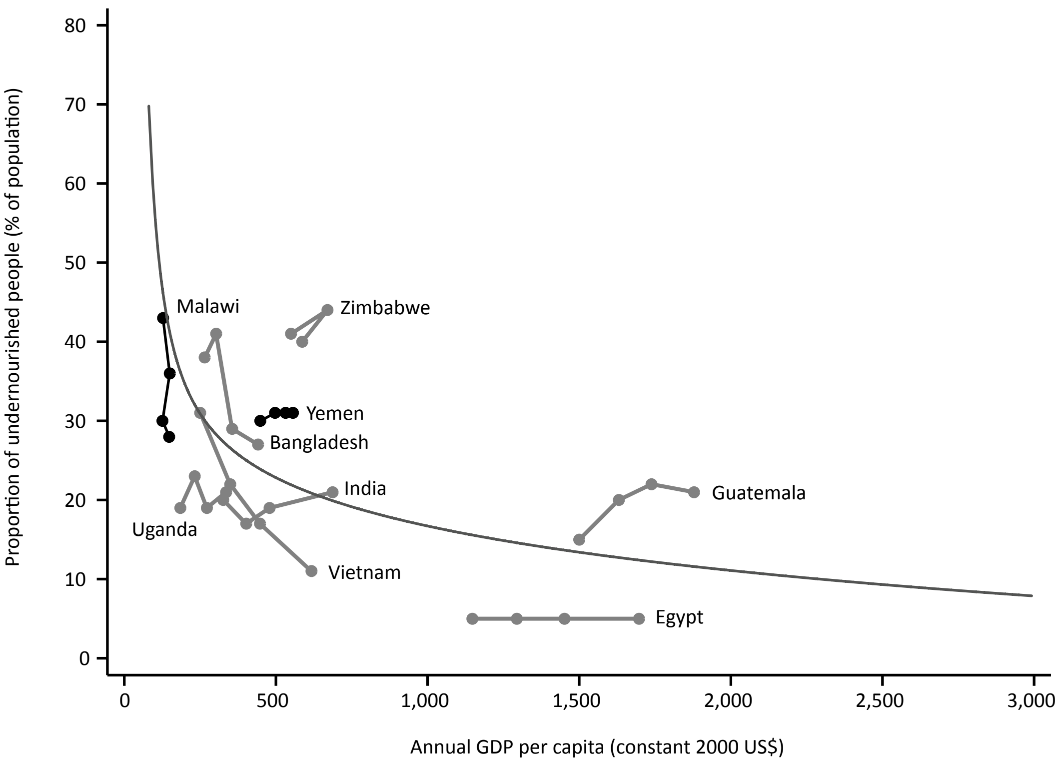
To explore the general relationship between economic growth and nutrition outcomes in the process of development, we draw on results from cross-country data analyses. In addition, given agriculture's important role in poverty reduction, we specifically analyze this sector's impact on nutrition over time. The analysis is based on economic and nutrition data available from the World Development Indicators (WDI) database of the World Bank (WDI 2010). We assess a country's stage of economic progression based on its annual gross domestic product (GDP) per capita (at constant 2000 prices), and the contribution of the agricultural sector by the sector's annual value added per worker (at constant 2000 prices). The nutrition outcome indicators that we apply for this analysis are the prevalence of undernourishment in the countries' populations, estimated on a per capita calorie availability basis by the Food and Agriculture Organization (FAO)'s statistics division (FAOSTAT 2010), and the prevalence of child stunting—an anthropometric indicator measuring the physical growth retardation in children under five caused by long-term malnutrition and poor health conditions—provided by the World Health Organization (WHO) Global Database on Child Growth and Malnutrition (GDCGM 2010); both are included in the WDI database.

Figure 1 shows the general relationship between undernourishment and national GDP across (almost) all low-income and lower middle-income countries (the red curve) and the relationships for selected countries over a period of 15 years, from the early 1990s to the middle 2000s. Figure 2 shows the same relationships for agricultural value added instead of total GDP. The red curves in both graphs mark the fitted lines using fractional polynomial estimation. They can be interpreted as the global undernourishment-growth trend and the global undernourishment-agricultural growth trend, respectively, which a "representative" country tends to follow in the process of development.

Both figures show that economic growth leads to a reduction of undernourishment (Figure 1 and Figure 2). The shape of the fitted line in Figure 1 indicates that undernourishment declines rapidly with growing national income during the early growth period, though the relationship becomes much weaker when the annual GDP per capita exceeds about US$500. Thus, growth is generally important for achieving a situation in which most people have enough food to be sufficiently supplied with calories and hence free of hunger.

However, Figure 1 also shows large differences in the prevalence of undernourishment among countries at a similar income level as well as in the countries' progress toward eradicating undernourishment (Figure 1). Some countries experienced high economic growth and managed to leverage it for reducing undernourishment substantially, such as Vietnam. Other countries grew at lower rates or stagnated in economic growth, but achieved a significant reduction in undernourishment such as Malawi and Bangladesh. Few other countries such as Yemen and Zimbabwe had a similar GDP in 1990 and 2005, and their situation of undernourishment did not change or even worsened. Many other countries including Uganda grew steadily but were less successful in translating growth into undernourishment reduction; and, few countries failed to reduce undernourishment despite high growth such as India in recent years and Guatemala throughout the 1990s.

Figure 1—Relationship between undernourishment and GDP

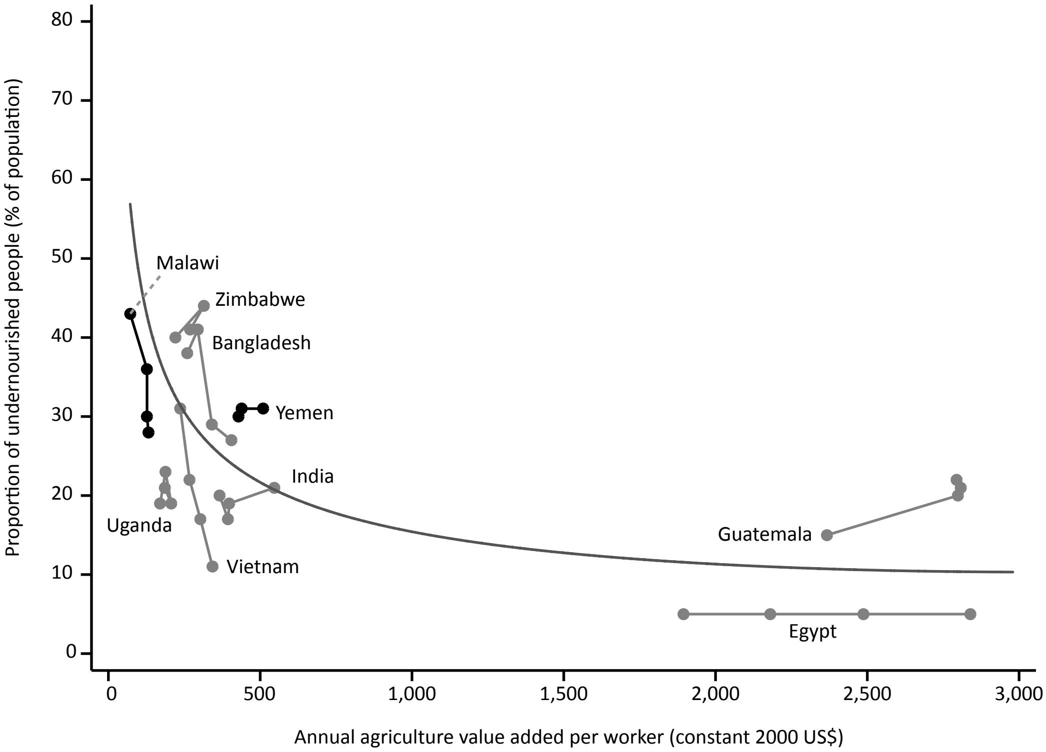


Note: The dots mark the proportion of undernourished people for selected countries in 1990-92, 1995-97, 2000-02, and 2005-07 and their annual GDP per capita in the respective years. The red curve is the fitted line using fractional polynomial estimation and data of 111 countries with annual GDP per capita below US$ 3,000 (403 observations). Figure A1 of the Appendix shows the graph for all country observations.

Source: WDI (2010).

Agricultural growth also reduces undernourishment, albeit at different rates (Figure 2). The shape of the curves of the individual countries are most alike for countries where agriculture makes up a large share of the national GDP and employs a large proportion of the undernourished population, such as in Malawi, Zimbabwe, Bangladesh, and Vietnam. However, comparing the fitted line in Figure 2 with that in Figure 1 reveals important patterns on the potential of agricultural growth against overall growth for reducing undernourishment. During the early stages of transformation, agricultural growth strongly corresponds to a reduction in undernourishment, but the marginal rates are shrinking more rapidly than those for overall growth; and, as with increasing agricultural growth, the curve converges to an undernourishment rate of 10 percent, implying that an average of 10 percent of the population cannot be freed from undernourishment by a growing agricultural sector. Thus, as development progresses, the importance of agricultural growth for reducing undernourishment declines absolutely and relative to the role of non-agricultural growth.

Figure 2—Relationship between undernourishment and agriculture value added



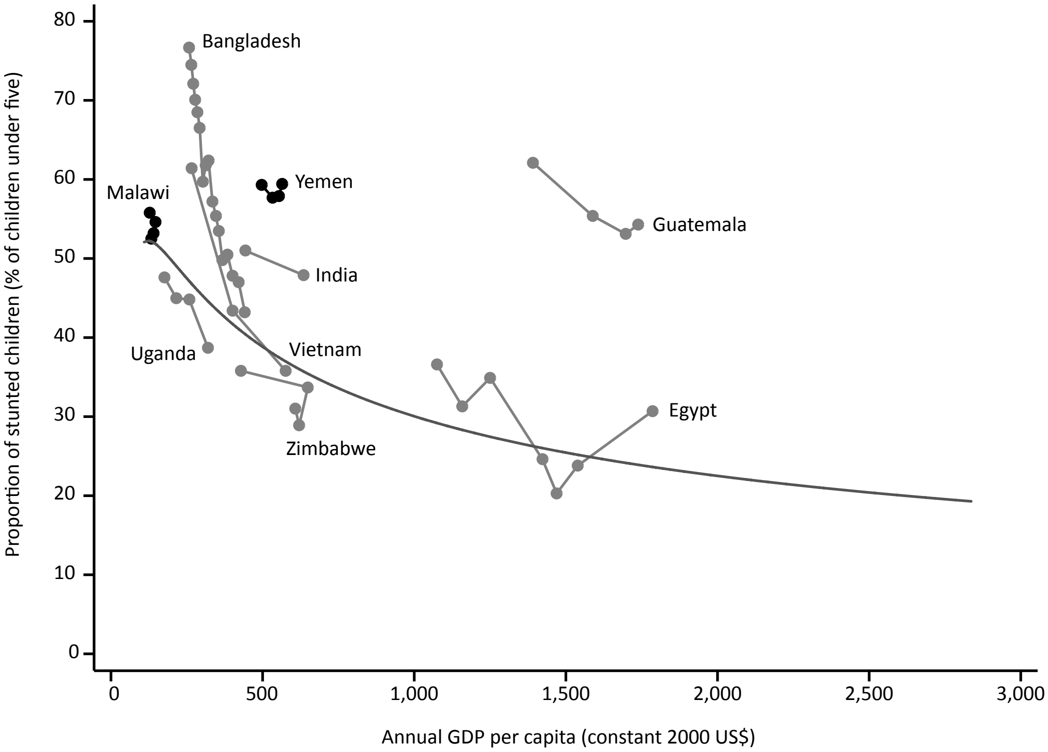
Note: The dots mark the proportion of undernourished people for selected countries in 1990-92, 1995-97, 2000-02, and 2005-07 and their annual agriculture value added per worker in the respective years. The red curve is the fitted line using fractional polynomial estimation and data of 107 countries with annual agriculture value added per worker below US$ 3,000 (375 observations). Figure A2 of the Appendix shows the graph for all country observations.

Source: WDI (2010).

The next set of figures (Figure 3 and 4) show the relationships between child malnutrition (measured by child stunting) and national GDP and agricultural value added, respectively. As in Figure 1 and Figure 2, the red curves mark the fitted lines and can be interpreted as the general child malnutrition-overall growth trend and the general child malnutrition-agricultural growth trend which a "representative" country tends following in the process of development.

As expected, Figures 3 and 4 show that overall growth and agricultural growth lead to a reduction of child malnutrition in general. The fitted lines in the two graphs are almost identical, implying that an agricultural sector growing faster than the rest of the economy has no additional beneficial effect on child nutrition, *per se*. Compared to the undernourishment curves in Figure 1 and 2, the child malnutrition curves are much flatter and slow down at much higher child malnutrition levels (converging toward a base child malnutrition rate of somewhat above 15 percent). This suggests that child malnutrition is less responsive to overall growth and agricultural growth throughout the process of economic development, giving greater prominence to the role of non-income related factors, such as information and knowledge, individual health, and care, in reducing child malnutrition, especially at later stages of development.

Figure 3—Relationship between child malnutrition and GDP



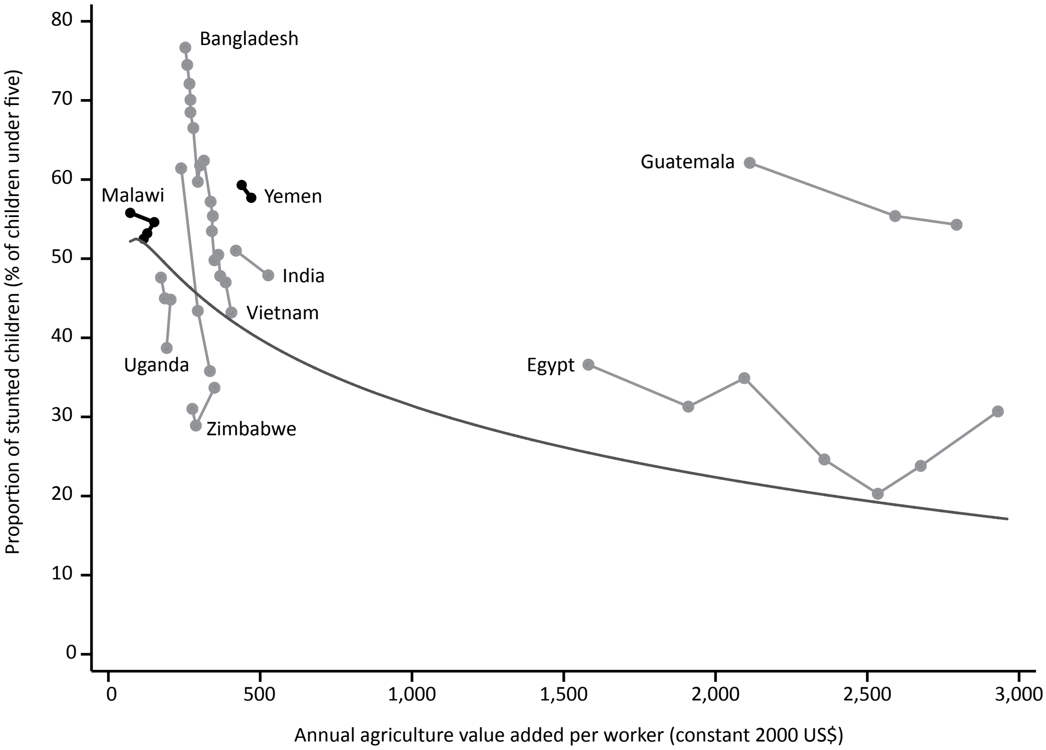
Note: The dots mark the proportion of stunted children (as determined by the height-for-age measure) for selected countries from different years over the past three decades and their annual GDP per capita in the respective years. The red curve is the fitted line using fractional polynomial estimation and data of 95 countries with annual GDP per capita below US$ 3,000 (266 observations). Figure A3 of the Appendix shows the graph for all country observations.

Source: WDI (2010).

The weaker relationship between growth and child nutrition is also supported by the observation of greater variations between countries in the growth-child nutrition relationship versus the growth-undernourishment relationship. For example, despite relatively low growth, Bangladesh has achieved impressive results in cutting back child malnutrition constantly over time. In contrast, Egypt has experienced relatively high and steady growth over the past three decades with a low rate of poverty and undernourishment. However, the prevalence of child malnutrition is largely unrelated to growth and even increased in recent years back to its early 1990s levels. Over the period 2000-2008, Egypt's GDP grew at an average rate of 4.8 percent per annum. Poverty (measured by the international $1.25-a-day poverty line) and undernourishment affect less than 5 percent of the population since the early 1990s, but child stunting increased from 23 percent in 2000 to 29 percent in 2009 (WDI 2010). In Guatemala, child malnutrition remains among the highest in the world in spite of the country's high GDP level compared to other countries with similarly adverse child nutrition situations.[1]

1 We could not find any published studies that convincingly explain Bangladesh's success in reducing child malnutrition and the worsening of child nutrition in Egypt against the background of the countries' economic development.

Figure 4—Relationship between child malnutrition and agriculture value added



Note: The dots mark the proportion of stunted children (as determined by the height-for-age measure) for selected countries from different years over the past three decades and their annual agriculture value added per worker in the respective years. The red curve is the fitted line using fractional polynomial estimation and data of 91 countries with annual agriculture value added per worker below US$ 3,000 (252 observations). Figure A4 of the Appendix shows the graph for all country observations.

Source: WDI (2010).

3. Linking Growth and Economic Policies to Nutrition Outcomes: A New Approach for Strategy Planning and Analysis

The cross country-level analysis in the previous section has revealed four major findings: First, growth is important for reducing undernourishment. Second, the impact declines as development progresses. Third, especially at early stages of a country's development, agricultural growth is critical for lowering undernourishment, indicating that the structure of growth matters for nutrition outcomes. Fourth, malnutrition among young children—an important dimension of overall nutrition—seems to be highly unresponsive to economic growth, an important difference in evidence on the growth-poverty relationship.

In addition, the analysis shows considerable differences in the nutrition situation between countries at a similar development stage and that some countries have been more successful in leveraging overall growth and agricultural growth for improving people's nutrition than others. These results pose two key research questions: In what way and to what extent does growth contribute to nutrition outcomes? Second, and more important, how can economic policies and programs be designed to better leverage growth for improved nutrition outcomes? To analyze these questions, we introduce a new conceptual framework that is based on the concept of food security and propose an innovative methodology that links growth and economic policies to their nutrition outcomes.

3.1 A Conceptual Framework for Food Security Analysis

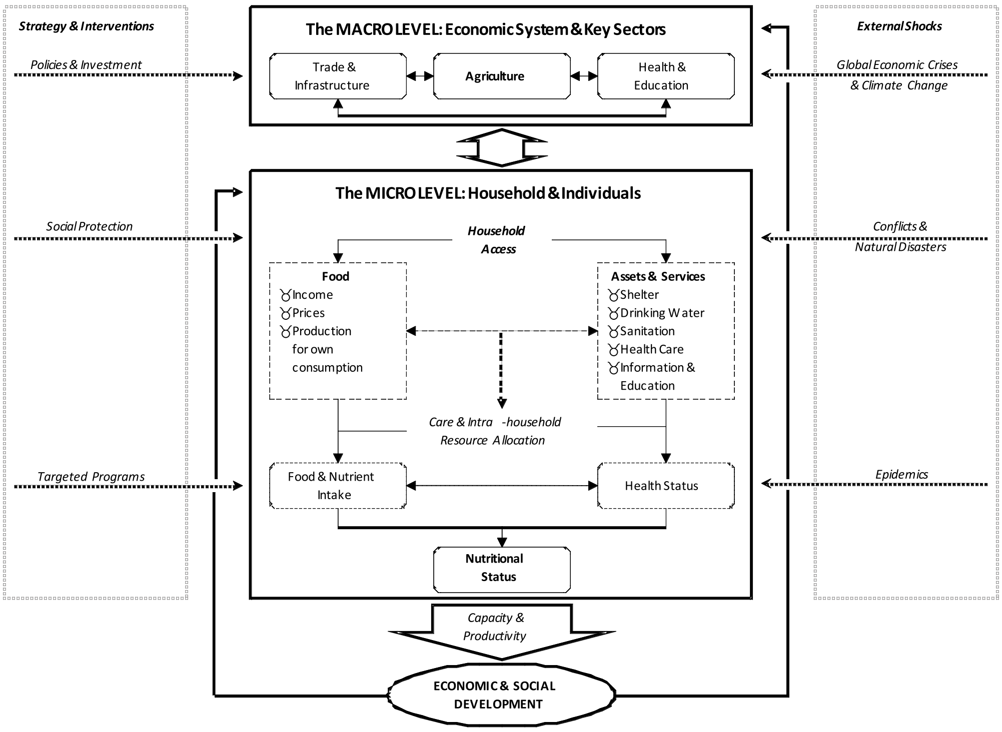
The concept of food security—as understood today—offers a good basis for analyzing people's food and nutrition situation and understanding its key causes and drivers. Food security is commonly considered as a situation "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996: World Food Summit Plan of Action, para. 1); whereby "the nutritional dimension is integral to the concept of food security" (FAO 2009, footnote 1, p. 1). Achieving food security requires concerted action across sectors and intervention at the individual, household, national, regional, and global levels (FAO 1996).

The conceptualization of our framework follows this definition of food security and expands existing frameworks.[2] In consideration of the serious impacts of the 2007/08 food price crisis at both macro- and microeconomic levels, our framework extends the common perspective of food security as primarily a household-level issue by including macroeconomic factors. The framework considers the many factors that influence food security and explicitly accounts for sectors that are most relevant for people's nutritional status, namely agriculture, trade and infrastructure, and health and education. As such, it emphasizes the need for an integrated, cross-sector approach for improving food security effectively. It is particularly designed for analyzing country development strategies and specific intervention options in the form of policies, investments, and programs to reduce malnutrition. It also allows for assessing the impacts of external events (or shocks), such food price crises, climate change, natural disasters or epidemics.

The framework builds upon the notion that success in national policies or other interventions can be assessed in terms their impact on people's nutritional status, given that nutrition is a fundamental human need with important long-term development implications (World Bank 2006). In determining food security, the availability of and access to food in terms of quantity *and* quality matters, with quality referring to adequate macro- and micronutrients and types of food (including breast milk for infants). Due to a close relationship between individual nutritional status and health condition, factors that affect nutrition indirectly through changes of individuals' health are integral components of our framework.

Figure 5 presents our conceptual framework. It outlines pathways in the food security system through which policies and external shocks translate into nutrition outcomes and the key factors determining the outcomes. For analytical purposes, the framework differentiates food security at the national and regional (subnational) level—the macro level—and at the household and individual level—the micro level. The factors at each level are horizontally and vertically interconnected through various linkages; the major ones will be outlined in the following paragraphs. Given the focus of this paper, the case studies in the next section look at the nutrition outcomes and do not analyze the food security situation at the macro and micro level in detail. Nonetheless, it is important to understand the multidimensionality of the food security problem in search of effective, integrated solutions which are key for improving nutrition.

Figure 5—Conceptual framework of food security for country development strategy analysis



Source: Constructed by authors.

2 The framework draws on the United Nations' Children Fund (UNICEF)'s framework of the causes of child malnutrition and death (UNCEF 1990) and the concept of macro-level food security by Diaz-Bonilla et al. (2002).

Macro-level food security refers to the balance of food supply and demand for a particular country in which populations' food needs can be met through domestic production, imports, or—usually—a combination of the two. Thus, macro-level food security refers to the availability of food for the population, which is a necessary but insufficient condition for the individual's access to food. Food imports have to be financed through the exports of other goods and services. Therefore, the structure of the domestic economy and the output of the various sectors matters for macro-level food security.

The macro level links to the micro level through providing goods and services and via the factor market, where households earn incomes from factors of production such as capital, labor, and land. Households then spend their incomes on food and other goods and services. These vertical links can mutually contribute to achieving food security at the macro and the micro level. Agriculture is the key sector for achieving food security in early stages of economic development and plays an important role in the development process in many ways; however, the sector's relevance for food security changes during the process of transformation. Depending on a country's stage of development, agriculture's primary role in contributing to household food security can be in supplying food, employment, and/or income (Haddad 2000). Agricultural growth has strong linkage effects thus driving overall growth and often reduces food prices, which especially benefits net food consumers with a high share of spending on food (Diao et al. 2010, World Bank 2007). Agriculture also has a high potential to cushion rising income inequalities often observed during structural transformation, which often leads to high adjustment costs and can become a binding constraint for development (Breisinger and Diao 2008). At the macro-level, agricultural exports often provide substantial export earnings, thus improving macro-level food security.

Other key sectors for achieving food security are trade and infrastructure and health and education. In the course of labor diversification and market integration driving a country's economic development, an efficient trading system, functioning market institutions, and physical infrastructure become increasingly important to establish a food supply chain that moves food through the market from producers to consumers. Roads and transportation are also needed to enable people's access to health and education services (Fay 2005, Smith et al. 2005, Strauss and Thomas 1998). The health and education sectors are critical for people's nutritional status, since malnutrition is often caused by preventable diseases and a lack of nutritional information, and knowledge determines households' food choice, intra-household food distribution and children's feeding practices, among others (Lopez et al. 2006, Walker et al. 2007)

The micro level comprises the household and all its individual members. Micro-level food security is determined by the access to sufficient and nutritious food, to basic assets, and to (public) services that can promote individuals' good nutrition and health. Most cases of limited access are due to limited financial resources, thus explaining the strong association between income poverty and hunger or malnutrition. Thus, the most important—but not sole—factor affecting food access is household income and, in subsistence households, food production for household consumption. In addition, the higher the income of a household, the larger the buffer against food volatility. Food prices are another key factor for food security, particularly for the poor in developing countries, who are often net food buyers and often spend more than half their income on food, High prices reduce a household's real income, and relative food price changes affect food consumption patterns that might lead to a reduction of the diet quality and give rise to increasing micronutrient deficiencies (Ecker and Qaim 2011).

Beyond the availability of sufficient and nutritious food in the household, individual food and nutrient intake is determined by a set of non-income factors. Individual access to proper food is subject to intra-household resource allocation and care for the individual, both of which in turn depend on the characteristics of the decision maker and gender roles, information and education, cultural and social customs, and others (Frangillo et al. 1997, Rogers 1996, Thomas and Frankberger 2002, Wolfe and Behrman 1982). Especially for the nutrition and health of young children, mothers' (or caretakers') health, capability and knowledge are critical (Block 2004, Garrett and Ruel 1999, Ruel et al. 1992). Since the children's mother is usually also the person responsible for meal preparation, her knowledge also matters for the nutrition of all household members (Popkin 2003, Tanumihardjo et al. 2007, WHO/FAO 2003).

Besides adequate food intake, an individual's health condition affects the nutritional status substantially. For example, highly prevalent infectious diseases such as malaria or parasite-caused diarrhea reduce the absorption of nutrients, necessitating higher nutrient intake and thus more food to cover the losses, if such compensation is possible at all. At the same time, poor nutrition weakens the human immune system and therewith increases the risk of infection with diseases (Murray 1997, Chandra 2002). Hence, people's access to assets and basic (public) services, including proper shelter, hygienic sanitation, clean drinking water, and basic health care such as disease treatment, vaccination, and mother and child care programs, affect people's nutrition indirectly, through the link with health.

Good nutrition is a fundamental need for individuals to realize both their maximum physical and intellectual potential. It is the basis for the well-being of individuals and households and for human capital formation and, as such, key for economic development and the formation of societies in communities and countries. Conversely, poor nutrition and health have serious, long-lasting economic consequences at the micro and the macro level. Malnutrition and illness reduce household income earning ability, perpetuate poverty, and slow economic growth through three routes: (1) direct losses in productivity from poor physical and mental performance or death, (2) indirect losses from reduced working and cognitive capacity and related deficits in schooling, and (3) losses in resources due to increased health care costs. Even temporary malnutrition can cause irreversible health impairments, particularly in children, limiting the development potential of future generations (World Bank 2006).

External shocks, such as global economic crises, climate change, conflicts, natural disasters, and epidemics, can threaten food security. While it is often difficult or even impossible to prevent such external shocks, appropriate risk management strategies are important to ensure food security during crises. Given the fact that higher income countries possess more means to respond to external shocks, policies that support shared growth in themselves can contribute to risk management. Other food security risk management tools include physical grain storage facilities, hedging in international markets, micro-insurance schemes, and social safety nets, among others.

3.2 Estimating the Nutritional Impacts of Growth and Economic Policies: The Food Security Framework Applied

The conceptual framework presented above serves as the basis of a quantitative modeling approach for estimating the nutritional impacts of growth and economic policies. Economic growth can affect households directly and indirectly. The extent to which households directly benefit from growth depends on the factors of production they possess and the demand for these factors by growing sectors and/or regions. Indirect benefits work via redistribution, where the households that do not benefit or even lose out in the growth process are compensated by the government, for example through direct transfers and other government spending.

Sound policies and public investments play an important role in promoting and accelerating economic growth. For example, a sound investment climate is key for attracting private (foreign and domestic) investments. Foreign direct investments (FDI) in particular not only increase the capital stock, but often also come with important knowledge spill-over effects (Markusen and Venables 1999, Torvik 2001). Public investments that support the private sector in increasing productivity, such as through improved infrastructure and public services, also have been key in the transformation process of most successful countries (Breisinger and Diao 2008). For example, the Green Revolution not only reinforced the view that technology-led productivity growth facilitated by public investments can transform traditional agriculture into a modern sector, but also showed that agriculture helps accelerate the economywide transformation process (Diao et al. 2010).

These and other economic policies and investments translate into household income changes through various linkages between sectors and institutions which are governed by factor and commodity markets. Subject to a variety of individual and household-specific factors, household income changes might then lead to adjustments of people's food consumption, asset stocks, and demand for nutrition-relevant services and therewith their nutritional status. To quantify this sequence of effects and estimate the final nutritional impact of growth and economic policies, a comprehensive and integrated model is needed that captures all interactions between sectors and institutions of an economy and their multiplier effects and translates them into changes in household incomes and, in turn, links those to the nutritional status of the individual household members.

In this paper, we present such a model and apply it in two case studies (see next section). Consistent with the conceptual framework presented in the previous subsection, this model approach treats people's nutritional status as a direct outcome of household income and non-income factors and an indirect outcome of growth, economic policies, and other external factors. For estimating the effects of growth and policies on the economy and the incomes of different household groups, we use dynamic computable general equilibrium (DCGE) models. DCGE models are economy-wide models that are based on disaggregated social accounting matrices

(SAMs) which capture all economic linkages and interactions between all sectors and institutions within the domestic economy and the relationships with the rest of the world. SAMs are composed of various data sources, including balance of payments, trade statistics, national accounts, and nationally representative household surveys. For example, the DCGE model used in the Yemen case study includes 65 sectors, of which 22 are in agriculture; and the DCGE model employed for the Malawi case study is disaggregated into 36 sectors, of which 17 are in agriculture. The Yemen DCGE model is described in detail in Breisinger et al. (2010), and the Malawi DCGE model (which SAM has been updated for this study) can be found in Benin et al. (2008).

In both country studies, we use the DCGE models to estimate the impact of economic policies on growth and household incomes. The simulations take a forward-looking perspective and run until 2020, i.e. the DCGE models are recursive dynamic. The DCGE models are constructed consistently with the neoclassical general equilibrium theory. The theoretical background and the analytical framework of computable general equilibrium (CGE) models are well documented in Dervis, de Melo, and Robinson (1982), while the detailed mathematical presentation of a static CGE model is described in Lofgren, Harris, and Robinson (2002). The recursive dynamic version of the CGE model is based on this standard CGE model, with the incorporation of a series of dynamic factors. The early version of this dynamic CGE model can be found in Thurlow (2004), while its recent applications include Diao et al. (2007) and Breisinger, Diao, and Thurlow (2009).

For assessing changes in people's nutrition levels as a response to changes in their income levels (measured on the basis of household total expenditure), we use an expenditure elasticity-based approach that captures the percentage change in certain nutrition indicators to a one percent change in household total expenditure. We use a variety of different nutrition indicators. Specifically, the nutrition indicators in the Yemen study are the dietary energy status of all people, measured in calories, and the height-for-age anthropometric measure for children under five, which identifies child stunting—a manifestation of long-term malnutrition (and poor health). In the Malawi study, we analyze the impacts on people's micronutrient status in addition to their calorie sufficiency level. The chosen micronutrients are iron, zinc, vitamin A, and folate, which are essential for physical and mental human development and for which deficiencies are widespread and particularly critical from a development policy perspective.[3] The econometric models that produced these nutrition-income elasticities, the theory underlying the models, the calculation method of the nutrition indicators, and the data used are presented and discussed in Ecker et al. (2010) for Yemen and Ecker and Qaim (2011) for Malawi. The elasticity estimates are presented in Table A1 and A2 in the Appendix. In addition to income variables from which the nutrition-income elasticities are derived, the econometric models include various sociodemographic variables (and, in the case of Malawi, price variables for all food groups consumed). Hence, the econometric models control for structural differences between households in their gender and age composition, educational level, regional location, and access to markets or health-relevant assets and services.

To estimate the nutrition-growth effects and to simulate the nutritional impacts of policy options over time, we combine the annual income changes obtained from the DCGE model simulations with the nutrition-income elasticity estimates from the econometric models for each household individually. Assuming specific changes in different macroeconomic parameters under different policy scenarios, we predict a new nutrition level for each person per annum, subject to the estimated annual income changes. The nutrition simulation equation is:

$$\hat{y}_{N,i,j} = y_{N,i,j-1} \bullet (1 + E_N \bullet C_{i,j}),$$

where $\hat{y}_{N,i,j}$ is a person's predicted nutrition level for the nutrition indicator *N* under scenario *i* and in year *j*, $y_{N,i,j-1}$ is the nutrition level in the previous year, E_N is the expenditure elasticity with respect to the nutrition indicator *N*, and $C_{i,j}$ is the annual income change of the household the person belongs to under scenario *i* and in year *j*. A person's new nutrition level is then related to his/her individual requirement level to identify whether the person is malnourished or adequately nourished according to the specific nutrition indicator. The individual requirement levels are calculated based on the individual physiological nutrition needs using standard reference levels from WHO and FAO sources (FAO/WHO/UNU 2001, WHO/FAO 2004, WHO/FAO 2006, WHO 2006). Finally, based on the person's new nutritional status, we calculate the new prevalence rates of nutritional deficiencies and the new number of malnourished people in the country's total population and the population of specific groups of individuals. For Yemen, the nutrition assessment methodology is described in detail in Ecker et al. (2010) and Breisinger et al. (2010), and for Malawi in Ecker and Qaim (2011).

3 See next section for the justification of the choice of the nutrition indicators.

4. Impact of Economic Policies on Nutrition: Lessons from Case Studies

The two case study countries are low income countries with high levels of malnutrition. Yemen represents an oil-based economy with a relatively small agricultural sector and Malawi an agriculture-based economy with limited diversification. While levels of malnutrition in both countries are among the highest in the world, the nature of the nutrition challenges differ and span a broad range of nutrition-related issues that are typical for many other developing countries, particularly those in the Middle East and North African region and Sub-Saharan Africa. Therefore, in addition to providing country-specific policy analyses, the results of the case studies are expected to provide important insights relevant for a broad range of countries.

4.1 The Nutrition Problem in Yemen and Malawi: A Comparative Overview

Food insecurity and malnutrition is widespread in both Yemen and Malawi. IFPRI's Global Hunger Index (GHI) considers Yemen's food insecurity situation as "alarming" and ranks it at 73 of 84 analyzed developing countries (von Grebmer et al. 2010), making it the most food insecure country in the Arab world. Although Yemen's national GDP is more than three times higher than Malawi's, Yemen's food security situation is worse, according to the GHI.4 The GHI ranks Malawi 48th, which classifies its food insecurity situation as "serious."

As a consequence of the recent food and financial crises, the proportion of people suffering from calorie deficiency in Yemen has increased by 3 percentage points from 2006 to 32 percent in 2009. This means that about 7.5 million Yemeni do not have enough food to be free from hunger. Calorie deficiency is particularly widespread in rural areas, where 37 percent of the population was deficient in 2009, compared with 18 percent in urban areas. The absolute number of calorie-deficient people living in rural areas is more than five times higher than in urban areas—6.4 million rural people versus 1.1 million urban people in 2009 (Ecker et al. 2010). In Malawi, calorie deficiency is also more prevalent in rural areas, but the differences are less pronounced. Ecker and Qaim (2011) report that 35 percent of the population was deficient in calories in 2005, though the proportion is expected to have declined in recent years due to Malawi's impressive agricultural growth (discussed further below). In 2004, 36 percent of the rural population, or about 4 million, were deficient in calories, while the proportion of calorie-deficient people in urban areas was 25 percent, equivalent to about 0.4 million people. Thus, calorie deficiency is largely a rural problem in Malawi, where only 12 percent of the total population lives urban areas or cities (Government of Malawi and World Bank 2007).

Diet quality is lower in Malawi than in Yemen. Using data from the food consumption modules of the latest household surveys from 2004/05 for Malawi and 2005/06 for Yemen, comparison of dietary diversity suggests that the risk of micronutrient deficiencies is higher in Malawi than in Yemen. The Food Variety Score (FVS)—calculated as the count of different food items consumed over seven days—equals 15.9 in Malawi and 17.3 in Yemen (Ecker and Qaim 2011, Ecker et al. 2010). A more diversified diet typically contains more vegetables, fruits, and animal products and therefore higher (bioavailable) amounts of essential vitamins and minerals than a staple food-dominated diet. Particularly when animal-source foods are scarce in the diet, low consumption of vegetables and fruits is often the main cause of micronutrient malnutrition (Ruel et al. 2005). In 2005, the average Malawian household consumed only 50 grams of animal products (including meat, fish, eggs, and dairy products) per capita per day, and the average consumed quantity of vegetables and fruits was less than 200 grams per capita per day (Ecker and Qaim 2011)—significantly less than half of the minimum recommended intake of 400 grams for a healthy diet (WHO/FAO 2003). Accordingly, Ecker and Qaim (2011) estimate that 47 percent of the Malawian population suffered from iron deficiency in 2005, 55 percent from zinc deficiency, 66 percent from vitamin A deficiency, and 37 percent from folate deficiency.[5]

In contrast, child malnutrition, and particularly the severe forms of its manifestations, is by far more widespread in Yemen than Malawi. In Yemen, 58 percent of all children under five were stunted, 43 percent underweight, and 16 percent wasted in 2006 (Ecker et al. 2010); while in Malawi, 48 percent of all children of the same age group were stunted, 22 percent underweight, and 5 percent wasted (NSO and ORC Macro 2005). Taking child stunting as an example, 35 percent of the Yemeni children were severely stunted, while the prevalence rate of the severe form was less than half of that (16 percent) in Malawi (Ecker et al. 2010, NSO and ORC Macro 2005). Moreover, unlike in Malawi, children's nutritional status in Yemen is considerably worse relative to the

4 In 2009, Yemen's GDP equaled US$ 565 per capita and Malawi's GDP US$ 166 per capita (at constant 2000 US$ prices) (WDI 2010).

5 Several previous studies (e.g., Hatloy et al. 1998, Steyn et al. 2006, Torheim et al. 2004) have shown that FVS is highly correlated with mineral and vitamin intakes and a good first-cut indicator of micronutrient adequacy.

country's economic development stage, as Figure 3 shows (in Section 2). Malawi seems to reflect the average in the general relationship between child malnutrition and national GDP.

Given these differences in the nature of the nutrition problem, the Yemen case study uses the proportion of stunted children under five as one nutrition outcome indicator, whereas the Malawi case study looks particularly at micronutrient deficiencies in the population at large. Stunting in children is identified by the height-for-age measure—a standard anthropometric indicator. Stunting, or gaining insufficient height relative to age, reflects a process of failure to reach linear growth potential as a result of long-term malnutrition or illness, or a combination of both (WHO 1995). Thus, in the Yemen study, we particularly consider the long-term nutritional status of infants and young children, because they are most vulnerable to adverse nutrition (and health) conditions. The chosen micronutrients in the Malawi study are iron, zinc, vitamin A, and folate. The deficiencies of these vitamins are widespread globally and present serious consequences for the physical and mental development of human beings and, by extension, a country's economic and social development. They are also particularly challenging to eradicate. In addition, in both countries we analyze the impact on calorie deficiency, which identifies the primary dimension of the nutrition problem (i.e. lacking staple foods).[6]

4.2 Impact and Lessons from Policy Reforms Options in Yemen

The Yemeni economy is highly dependent on oil and has little diversification. In 2009, the hydrocarbon sector accounted for about one-fourth of GDP, and oil exports generated three-fourth of the foreign exchange earnings and government revenues. By contrast, agriculture's contribution to GDP is about 10 percent, with about 30 percent of the rural population living off of farming. Moreover, agriculture is dominated by *qat,* which uses about 40-50 percent of the countries' dwindling water resources and which has negative side effects for food security, including diverting household resources away from food and health expenditures.7 As in many resource-rich developing countries, the manufacturing sector is relatively small and makes up about 10 percent of the economy. Services is the biggest sector, constituting about 50 percent of GDP. Economic growth has been relatively low, averaging 3.8 percent over the past years and 0.8 percent per capita. Furthermore, growth did not trickle down to food insecure people, especially those in rural areas (Breisinger et al. 2010).

To accelerate growth and make growth more pro-food secure, policy reform is urgently needed. The government of Yemen has identified a set of policy actions to foster growth in both agricultural and non-oil sectors. Key policies include a reformed agricultural policy that combines a reduction in *qat* with the promotion of alternative crops and their processing and marketing, and a policy that improves the business climate to attract private investments in the manufacturing and service sectors.

In the remainder of this section, we analyze the potential effects of these policies on nutrition outcomes. The two policy scenarios described above represent an agricultural growth versus a non-agricultural growth strategy, thus providing important insights into the debate on the role of agriculture for improving nutrition. The results of both scenarios are presented against the counterfactual where no policy action is taken. This is referred to as a "business-as-usual" scenario, which serves as baseline against which growth effects and the resulting nutrition impact will be measured.

4.2.1 A BUSINESS-AS-USUAL SCENARIO (NO POLICY CHANGE)

In the baseline scenario (which reflects past growth patterns), Yemen's economy continues to grow at 3.8 percent annually from 2010 to 2020, with average annual growth of 5.1 percent in the nonhydrocarbon sector and –2.3 percent growth in the hydrocarbon sector, taking into account depleting oil resources. In 2009/2010, GDP spiked briefly due to the development of off-shore gas resources. Under this scenario, the share of the hydrocarbon sector in the economy falls from about 23 percent in 2009 to 12 percent in 2020.

In this baseline scenario, the proportion of calorie-deficient people will decrease (Table 1). The prevalence of calorie deficiency will drop to pre-global food price crisis rates during the first two years of the simulation

6 Figure A5 in the Appendix shows the proportion of calorie-deficient people by district in Yemen, Figure A6 the spatial distribution of the calorie-deficient population, and Figure A7 the proportion of stunted children under five by governorate. Figure A8 gives a political map of Malawi. Figure A9 shows the proportion of calorie, iron, and zinc-deficient people by district in Malawi and Figure A9 the proportion of vitamin A and folate-deficient people.

7 The young, fresh leaves of the qat tree are narcotic and widely consumed as a stimulant. Nationwide, 56 percent of males and 27 percent of females aged ten years and older chew *qat*. *Qat* consumption poses serious health risks, and the treatment related illnesses increases public health expenditure. *Qat* chewing increases the risk of gum and stomach cancer (likely caused by the intake of pesticides applied on the *qat* leaves) and can cause painful stomach sickness. The consumption of the leaves is also likely to interfere with the absorption of nutrients from food. Moreover, *qat* chewing eases consumers' appetite, which might have negative effects on food preparation and child feeding practices; and it lower adults' attention and care given to their children (Ecker et al. 2010).

(2010 and 2011), and it will then slowly decline almost linearly. This decrease notwithstanding, the proportion of calorie-deficient people will remain high, at 24 percent overall and 29 percent in rural areas by 2020. In addition, due to continuing high population growth (of 3 percent per annum), the number of calorie-deficient people will increase to 7.8 million nationwide in 2020, up from 7.5 million in 2009. Consistent with historical patterns, urban households will benefit most from economic growth. The proportion of calorie-deficient people will decline at the lowest rates among the non-farm (landless) households, among whom poverty and malnutrition is most widespread (Ecker et al. 2010). Despite the modest national GDP growth and decline in calorie deficiency, child malnutrition will not improve markedly under a business-as-usual policy. The proportion of stunted children will decline by less than 2 percentage points to 62 percent in rural areas and 46 percent in urban areas by 2020.

Table 1—Baseline scenario

	2009	2015	2020
Growth (percent)			
National GDP	6.6	3.9	3.6
Hydrocarbon	4.3	-2.3	-2.3
Nonhydrocarbon	7.3	5.2	4.5
Agriculture	5.1	2.6	2.1
Industry	11.2	6.4	4.5
Services	6.3	5.1	4.7
Malnutrition			
Proportion of calorie-deficient people (percent)	32.1	25.3	24.3
Rural	37.3	31.0	29.7
Farm	33.4	26.7	25.4
Nonfarm	39.2	33.0	31.8
Urban	17.8	9.7	9.3
Number of calorie-deficient people (in thousands)	7,483	7,038	7,831
Proportion of stunted children under five (percent)	59.4	58.1	57.8
Rural	63.4	62.3	61.9
Urban	47.9	46.3	46.0

Source: Constructed by authors.

4.2.2 AGRICULTURAL POLICY REFORM

Agricultural policy reform aims at accelerating agricultural growth and improving food security, thus increasing agricultural output for rural income generation. The reform plans take into account that the reduction of *qat* is closely linked to non-*qat* agricultural development. This is because both expansion of agricultural production area and the increase of agricultural productivity are severely constrained by the availability of water.8 Current annual water consumption is almost 30 percent above the renewable water supply, and groundwater tables are falling rapidly. Taking into account that non-agricultural water use, which currently only represents 10 percent of total use, is likely to dramatically increase in the future, water will be the single most important constraint for agricultural growth in the future.

Qat uses 40-50 percent of all water resources. Therefore, saving water in Yemen and using more water for accelerating non-*qat* agricultural growth will only be possible through a significant reduction of *qat* consumption and production. To this end, the agricultural policy reform scenario includes an excise tax on *qat*, consistent with the government's reform plans. In addition to the unsustainable use of groundwater for *qat* production, several externalities of *qat* consumption relevant for improving nutrition justify the implementation of a *qat* tax. Beyond direct and indirect health impairments, *qat* diverts a large share of income away from households that could otherwise be spent on food and child nutrition.

8 Many households lack sufficient water for drinking, washing, and cooking, and the available water is often polluted. More than one-third of the population (37 percent) suffers from water scarcity. And, only 41 percent of the population is connected to a water network (of whom three-fourths live in urban areas). Poor hygiene and a high risk of infection with water-borne diseases are consequences (Ecker et al. 2010).

Consistent with the national plan, tax revenues are used to promote agricultural alternatives to *qat* production, including coffee and cereal production in particular. Yemen's potential for boosting high-quality coffee production and marketing is high (considering that the Mocha coffee bean originates in Yemen). Components of such a policy include expanding agricultural extension services, investment in agricultural research and development, introduction of improved seeds (especially drought-resistance cereals), investment in water harvesting and irrigation systems, and promotion of farmer's unions and effective processing and marketing systems. These measures are assumed to increase agricultural productivity (TFP) by 5 percent annually in cereals, coffee, trade and related food processing sectors from 2011 to 2020—through higher yields, more effective input use, reduced post-harvest losses, and more efficient supply chains. To ease the introduction of the *qat* tax, we assume its implementation in two steps. The initial tax is set at an equivalent of 14 percent of *qat* value in 2011 and 20 percent afterwards. The results of the simulation are summarized in Table 2.

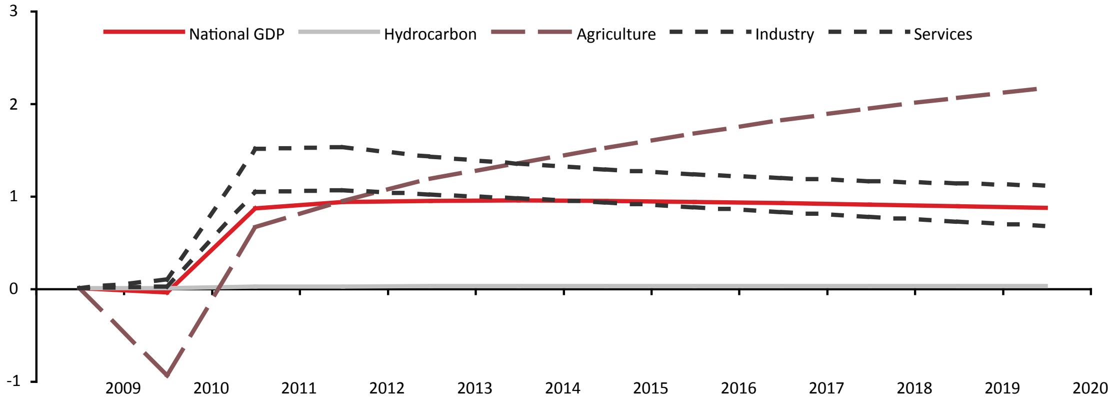
Table 2—Agricultural policy reform—Scenario summary

	2009	2015	2020
Growth (percent)			
National GDP	6.6	4.8	4.4
Hydrocarbon	4.3	-2.3	-2.3
Nonhydrocarbon	7.3	6.3	5.4
Malnutrition			
Proportion of calorie-deficient people (percent)	32.1	24.1	21.9
Number of calorie-deficient people (in thousands)	7,483	6,700	7,056
Proportion of stunted children under five (percent)	59.4	57.9	57.5
Rural	63.4	61.9	61.6
Urban	47.9	46.1	45.6

Source: Constructed by authors.

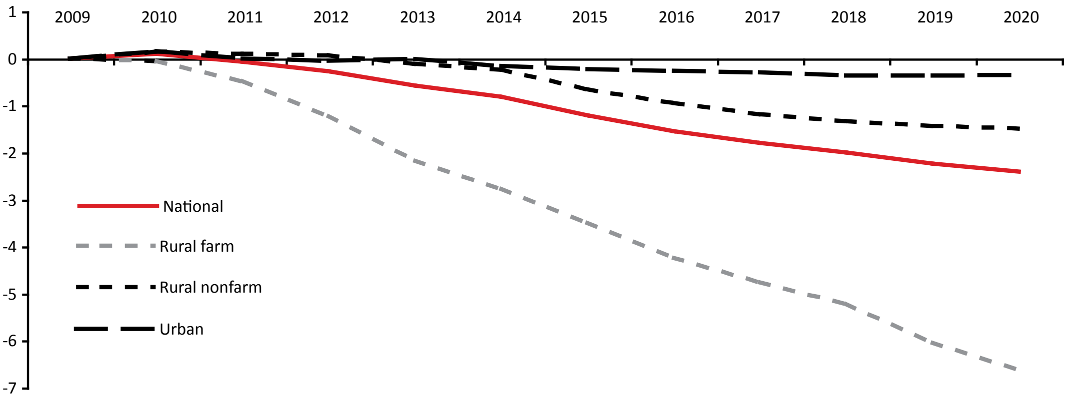
The implementation of a *qat* excise tax increases its price for consumers, which likely will lower demand. This will lead to reduced *qat* production, freeing up land and water resources for alternative use. Furthermore, the tax will reduce the profitability of *qat* relative to other crops, and its production will attract less private investment as a consequence. Alternative crops will become more competitive and more attractive for farmers to grow. However, during the first year of implementation, the *qat* tax will have a negative effect on agricultural growth (Figure 6). Agriculture will grow by about one percentage point below the baseline level in the first year. After that, agricultural growth will accelerate and exceed baseline growth levels as a result of the productivity-enhancing investments in the targeted sectors. Manufacturing and service sectors also will benefit from agriculture-led growth due to linkage effects and productivity-enhancing effects in processing and marketing sectors. Growth in these sectors stabilize at about one percentage point above baseline levels, whereas the agriculture sector will grow at 2.1 percentage points above baseline level in 2020. The agricultural policy reform will result in a GDP growth increase of about 0.9 percentage points from the second year of the reform onwards.

Figure 6—Agricultural policy reform—Growth change from baseline levels (in percentage points)



Source: Constructed by authors.

Figure 7—Agriculture policy reform—Change of the proportion of calorie-deficient people from baseline levels (in percentage points)



Source: Constructed by authors.

The income growth resulting from the reform will reduce the proportion of calorie-deficient people nationwide and among farmers in particular. In 2020, calorie deficiency will affect 2 percent less of the population than under a business-as-usual policy (22 percent versus 24 percent). The prevalence rate among farmers will drop by almost 7 percentage points to 20 percent, but calorie deficiency among non-farm households in rural areas will barely decline, so that 30 percent of the rural nonfarm population will remain calorie-deficient by 2020. The number of calorie-deficient people in 2020 will be lower than in 2009 by about 400,000 people. In addition, as with the business-as-usual scenario, children's nutritional status will not notably improve under the agricultural policy scenario.

The benefits of reduced *qat* consumption will go beyond the nutritional impacts translated through household income changes, as modeled in this simulation. They might include lower cancer rates, lower public health costs, and better care given to the nutrition and health of children. Yet these impacts, as well as the resulting long-term consequences for economic and social development, are difficult to quantify. Thus, the positive impact of a *qat* reduction policy on child nutrition might be underrated here. Finally, it is important to note that any measures for reducing *qat* consumption will require a careful and credible communication strategy, given that *qat* consumption is deeply rooted in the society, with influential policymakers and other key stakeholders among its biggest consumers.

4.2.3 PROMISING SECTOR GROWTH POLICY

To promote growth in manufacturing and service sectors, the Government of Yemen has declared the improvement of the investment climate as a high priority. Results from the World Bank's Doing Business project suggests that there is scope to do so; according to the 2010 report, Yemen ranks 99 out of 183 countries in creating a favorable investment climate (World Bank 2010). More specifically, several key indicators are significantly below the international average. Although Yemen ranks relatively favorably (53) in terms of starting a business, dealing with construction permits (50), and registering property (50), there is much scope for improvement in the provision of access to credit (ranking 150), investor protection (132), taxation (148), and cross-border trade procedure (120). The unfavorable investment climate is exacerbated by the tenuous security situation, which further discourages domestic and foreign investors. Improving the investment climate is widely expected to attract additional investments, thus raising productivity and creating jobs. Creating jobs is especially important for improving nutrition, given the high and growing unemployment rate and the fact that more than half of all rural households and all food-insecure households draw their main income from off-farm employment.

Several sectors have been identified as having high potential for attracting investment and accelerating growth. Sectors are considered "promising" if they have high potential to grow by at least 5-6 percent annually. They include (non-mineral) mining, food processing, tourism, and the transportation and communication service sectors (Breisinger et. al. 2010). While it is important to note that "picking winner" strategies have almost always failed—growth in successful countries has mostly been driven by the private sector—governments have always played an important indirect role by providing infrastructure and services important for initiating the transformation and growth process (Breisinger and Diao 2008). In this context, we design a scenario where policy reform and investments improve the business climate and spark growth in promising sectors. Specifically, we assume that productivity in the promising industry and service sectors will increase from 2 to 7 percent between 2010 and 2020. We also assume that policy reform will attract FDI inflows, which we assume to rise by 5 percent annually during the considered period.

Table 3 shows that growth in promising sectors will significantly contribute to national GDP growth. Driven by the growth in these sectors and its linkages to other sectors, the GDP growth rate will increase by more than 3 percent annually above baseline levels from 2013 onward (Figure 8). The nonhydrocarbon sectors will grow by 8.5 annually between 2010 and 2020, which is 3.6 percent more per year between 2013 and 2020 than under a business-as-usual scenario; growth in the industry and service sectors will average 10.6 and 8.3 percent annually. Despite higher food demand resulting from higher household incomes and higher demand from the food processing sector, agricultural growth will remain severely constrained by natural resources, so that the sector's growth will accelerate only by about 1 percentage point above baseline growth (Figure 8).

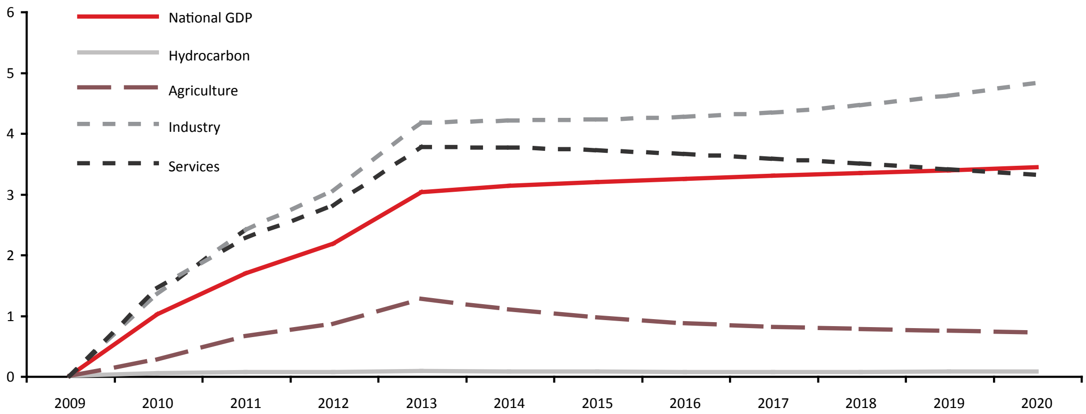
Table 3—Promising sector growth policy—Scenario summary

	2009	2015	2020
Growth (percent)			
National GDP	6.6	7.1	7.0
Hydrocarbon	4.3	-2.3	-2.2
Nonhydrocarbon	7.3	8.8	8.0
Malnutrition			
Proportion of calorie-deficient people (percent)	32.1	20.4	15.2
Number of calorie-deficient people (in thousands)	7,483	5,666	4,904
Proportion of stunted children under five (percent)	59.4	57.0	55.3
Rural	63.4	61.2	59.7
Urban	47.9	44.7	42.5

Source: Constructed by authors.

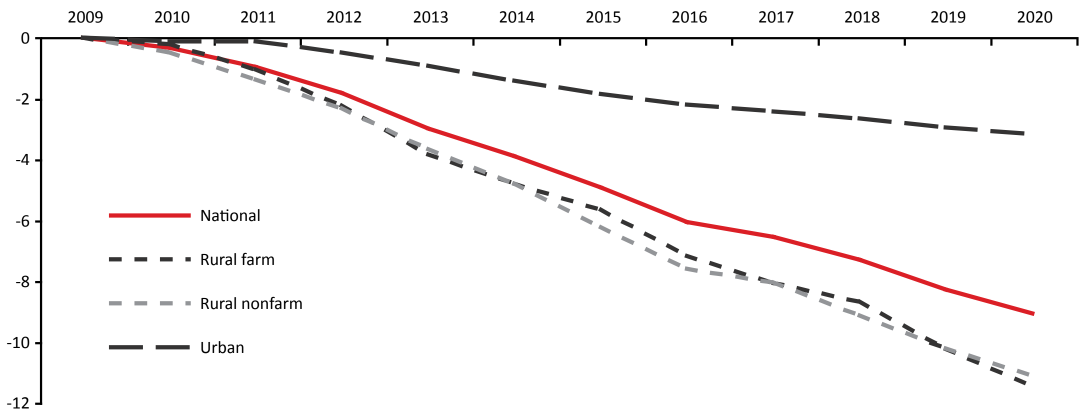
This promising sectors-led growth translates into higher household incomes and substantially contributes to improving nutrition as measured by calorie sufficiency, primarily in rural areas. Given that many promising sectors such as mining, food processing, and tourism generate income and create employment in rural areas and especially among the landless nonfarm households, among whom malnutrition is most widespread, this nonagricultural growth has high beneficial effects for reducing calorie deficiency. Model results show that growth in promising sectors reduces malnutrition among rural non-farm households by about 11 percentage points by 2020 compared to the baseline (Figure 9). Rural farm households also benefit from this type of growth, mainly due to the availability of off-farm employment, but also by the increase in agricultural growth driven by an increased demand for their products from the rural and urban population. Growth in promising sectors will not lead to similar reduction rates of calorie deficiency among urban households, largely because the initial proportion of urban calorie-deficient people is already low. This result is consistent with the cross-country empirical evidence presented in Figures 1-4, which show that the less prevalent malnutrition becomes, the more difficult it is to further reduce its spread by economic growth alone. The "remaining" malnourished are often unable to participate in the labor market or do not possess the right skills to reap the benefits of growth.

Figure 8—Promising sector growth policy—Growth change from baseline levels (in percentage points)



Source: Constructed by authors.

Figure 9—Promising sector growth policy—Change of the proportion of calorie-deficient people from baseline levels (in percentage points)



Source: Constructed by authors.

It is important to keep in mind that, despite the sharp drop of the prevalence of calorie deficiency in Yemen's rural areas under the promising sector growth policy, the rural nonfarm households will remain the most calorie-deficient group. According to our simulation, the proportion of calorie-deficient people among the nonfarming rural households will remain at 21 percent, compared to 14 percent among farmers and 6 percent among the urban population by 2020. Nationwide, the prevalence of calorie deficiency will reach a rate of 9 percentage points below the level under the business-as-usual scenario, or a rate of 15 percent in absolute terms.

Yet, the great improvement in nutrition in terms of calorie deficiency is not matched by reductions in child malnutrition. Results show that growth driven by non-agricultural sectors will only translate to a modest improvement of children's nutritional status. From 2009 to 2020, the proportion of child stunting will decline by only about 4 percentage points nationwide and slightly above 5 percentage points in urban areas. Thus, child malnutrition will remain at extremely high levels, with 55 percent of the under-5 children stunted by 2020.

4.2.4 COMPARING AGRICULTURE-LED GROWTH WITH NON-AGRICULTURE SECTOR-LED GROWTH

Empirical evidence has shown that the structure of growth and the multiplier effects of different sectors matters for improving people's nutrition. According to the simulations in previous sections, the Yemeni economy grows at 4.0 percent under the business-as-usual scenario over the period 2010-2020, while agriculture-led growth and promising sector-led growth accelerate overall growth to 4.9 percent and 6.8 percent, respectively. To make these scenarios comparable and to evaluate which policy is most effective in improving nutrition—agricultural reform versus business climate improvement—we calculate the average annual reduction rate of the prevalence of calorie deficiency and child stunting in percentage points when subject to one percent GDP growth over the simulation period (Table 4).

Table 4—Average annual reduction of the proportion of calorie-deficient people and stunted children under five (percentage points) with one percent GDP growth

	Business-as-usual scenario	Agricultural policy reform	Promising sector growth policy
Calorie deficiency	-0.176	-0.191	-0.224
Child stunting	-0.036	-0.036	-0.055

Source: Constructed by authors.

These estimates suggest that policies fostering growth in promising sectors (mining, food processing, tourism, transportation, and communication) reduce calorie deficiency and child stunting more than agricultural policy reform (accelerating agricultural growth through cereals and coffee production and processing and reduced *qat* production). An additional one percent annual growth in GDP driven by the promising sectors leads to an average annual reduction of the proportion of calorie-deficient people by 0.22 percentage points and of the proportion of stunted children by 0.06 percentage points. The annual reduction rate for calorie deficiency is 21 percent higher than under the business-as-usual policy and 15 percent higher than under the agricultural policy reform scenario; for child stunting, the reduction rate under the promising sectors scenario is higher by about one-third than under the other two scenarios. Consequently, a policy fostering growth in promising industry and service sectors is more beneficial for improving nutrition because the absolute impact is higher, and the structure of growth enables the malnourished population to reap greater gains from the growth compared to agricultural growth.

The lower nutritional impact of agricultural growth can be mainly explained by the role of Yemen's agriculture for income generation and domestic food supply. Due to the water scarcity, the growth potential of the agricultural sector is limited. Even if agriculture grows, the effects on reducing malnutrition are limited because the majority of the population draws their income from nonfarming activities, and the nonfarming rural population—not farmers—are the most malnourished population group. In addition, most foods and particularly staple foods, which constitute a large share of household budgets, are imported, thereby limiting the potential consumer benefit of decreased food prices that typically would accompany agricultural productivity growth.

That said, neither agriculture nor promising sector-led growth can significantly reduce child malnutrition. Table 4 underlines the growth inelasticity of child stunting. Reduction rates of the proportion of stunted children account for only one-fifth to one-fourth of the reduction rates of the proportion of calorie-deficient people. Most of that is explained by the low elasticity of household income to children's anthropometrics. Yemeni children's height-for-age measure increases by only 0.09 percent with a one percent increase in household expenditure on average, with rural areas slightly lower than urban areas (Table A1 in the Appendix). This inelasticity can be explained by a combination of at least three possible causes. First, since anthropometrics measure a child's physical growth, there is a time lag between the appearance and the measurable impact of a nutrition improvement. Second, and related to that, child anthropometrics, and especially stunting, is influenced by the nutrition history of a child as well as factors such as health condition, knowledge, and ingrained habits (see Section 3.1) that do not change with a marginal increase in income. Third, the distribution of available resources within the household matters. This might be of particular importance in the case of Yemen with its male-dominated society, where traditionally the (male) household head and the oldest son are seen as deserving the most attention. Moreover, the high consumption of *qat* and the associated costs might take away money that could otherwise be invested in ensuring the optimal nutrition and health of young children. In fact, the elasticities of GDP to child nutrition in Yemen are significantly below the international average. Using cross-country regressions, Headey (2011) finds an average elasticity for the relationship between GDP per capita and child stunting of -0.12, which is more than two and three times higher than our estimates, depending on the policy scenario.

Given the limited and insufficient impacts of growth on nutrition, especially on child malnutrition, additional and more targeted measures are needed for reducing child malnutrition. These measures must include awareness and education campaigns and targeted nutrition and health programs. Given the scale and the nature of the nutrition problem in Yemen, these campaigns need to be national and at the highest political level (for example, as "presidential campaigns"), accessible to the general public, and targeted toward the malnourished population. The lack of information and nutrition and health-related knowledge is especially high in rural areas, where more than 80 percent of women and more than half of all men never attended school or dropped out before completing the primary education level, and where traditional customs are most deeply rooted

(Ecker et al. 2010).[9] Key topics of these campaigns should be women's empowerment, child feeding practices (especially breastfeeding) and household nutrition, hygiene and disease prevention, *qat* consumption, and family planning.

The evidence clearly shows that gender inequality goes hand in hand with malnutrition. Therefore, efforts are needed to ensure women's empowerment as a means to improved nutrition. Initiatives to this end could include improving women's educational attainment, economic participation, health status, and social and political empowerment. Since men are typically the household decisionmakers, it is important to involve them along with women in any gender, nutrition, and health-related measure to gain their support. To achieve a large-scale, sustainable impact, a credible communications strategy is crucial. The strategy should provide widespread information frequently throughout the country, involve local communities, and be backed by policymakers and other influential people. The religious leaders, Friday prayers, and the local traditional leaders (sheiks) are important venues for communication, beyond conventional communication channels such as radio and television. Impact through public awareness and education campaigns can be achieved at relatively low costs. Close collaboration among the government, non-governmental organizations (NGOs), and international donors also can help reduce public expenditure, in addition to allowing for "buying in" of expertise (Breisinger et al. 2010).

Intervention programs must focus on the nutrition and health of pregnant and lactating women and children under two years of age, spanning the "window of opportunity" during the life cycle (Victoria et al. 2008, von Grebmer et al. 2010). Programs are particularly needed for pregnancy and after-birth care, birth assistance, immunization, early child growth monitoring, and education on breastfeeding, infant feeding practice, hygiene, and disease and illness prevention and treatment (Breisinger et al. 2010). Launching these programs at effective scale requires significant public investment, but the rates of return are high. Behrman et al. (2004) report that, for example, the benefit-cost ratio for programs promoting breastfeeding in hospitals varies between 5 and 7 and for integrated child care programs between 9 and 16. Beyond the cost effectiveness of these programs, there is also a strong intrinsic argument for their population-wide implementation. These programs provide basic health care that should be freely accessible by everybody, including the extreme poor, and they should be paid from government revenues. To generate sufficient revenues for financing this public good, economic growth is indispensible. While some of these measures are specific for Yemen (such as a *qat* reduction campaign), most of these interventions are critical in all countries with an economic growth-nutrition disconnection.

4.3 Impact and Lessons from Agricultural Policies in Malawi

The Malawian economy expanded at a modest rate between 1990 and 2005. National GDP grew at an annual average of 2.8 percent over this period (Benin et al. 2008). This is below the long-run population growth rate of over 3 percent per annum, thus suggesting that per capita GDP levels declined over the period. The agriculture sector performed better, growing at 4.6 percent per year during the same period. However, agricultural growth has been volatile, with the agricultural sector contracting during four of the 15 years between 1990 and 2005 (Benin et al. 2008). This volatility also affected the national GDP growth rate, as the agricultural sector has historically contributed up to 40 percent to national GDP. Currently the sector contributes about one-third to GDP (WDI 2010), which means the national growth rate is still highly susceptible to growth fluctuations in the agricultural sector. Growth in the agricultural sector, in turn, is strongly influenced by the maize and tobacco subsectors. Maize contributes one-quarter to agricultural GDP and is grown mostly by smallholders for own consumption. Tobacco is Malawi's major export crop, contributing a further 14.6 percent to agricultural GDP and accounting for almost one-third of export revenue. Combined, these two agricultural subsectors contribute almost 15 percent to national GDP, which suggests that growth volatility can often be traced directly back to volatility in maize production or tobacco export prices.

The volatility of the agricultural sector can also be linked to the frequent occurrence of droughts and floods. Less than 5 percent of the cultivated land is irrigated, which makes agricultural output and food supply heavily dependent on rainfall levels. Between 1990 and 2005 Malawi suffered at least three severe droughts and four major flood events (Pauw et al. 2010). During the widespread 1994 drought the agricultural sector contracted by 29 percent. Regular poor harvests combined with poor management of grain stocks during good years has meant that Malawi has undergone at least two major food deficits since the turn of the millennium, leading to a famine in 2002 and a serious food emergency situation in 2005 (Denning et al 2009; Devereux 2007).

9 In urban areas, about half of all women and about one-third have no primary education (Ecker et al. 2010).

In response to particularly severe food supply problems experienced during the 2004/05 harvest, the government of Malawi launched its Farm Input Subsidy Program (FISP) prior to the start of the 2005/06 growing season. FISP is a large-scale subsidy program aimed at lowering the cost of fertilizer and modern maize seed varieties to resource-poor farmers. Despite legitimate concerns about the fiscal sustainability of the program, which costs about 5 percent of GDP and is considered one of the most ambitious and expensive programs in Malawi's history (Buffie & Atolia 2009), it has been lauded for its success in raising maize yields. Maize production almost tripled in the first two years since inception (MOAFS 2010). Because maize is a primary staple in Malawi—about 60 percent of households' calories are obtained from maize dishes—the strong growth in maize production is thought to have had a major impact on caloric intake (Ecker and Qaim 2011).

Dorward et al. (2008) attribute at least some of the gains to the favorable growing conditions experienced in the 2005/06 and 2006/07 seasons. Production growth has nevertheless been remarkable, with output increasing from about 1.2 to 3.2 million tons over three years. The most recent crop estimates for 2009/10 suggest that national maize output remains at the same level achieved in 2006/07 (about 3.2 million tons of maize) (MOAFS 2010). Over the 2004/05 to 2009/10 period, the maize production area increased only marginally, from 1.51 to 1.64 million hectares. Chibwana et al. (2010) argue that at least some of this increase in land allocation resulted from a displacement of other crops such as groundnuts, soybeans, and dry beans. National data (MOAFS 2010) suggest, however, that output increases have been driven largely by strong growth in yields, with maize yields increasing from as little as 0.81 tons per hectare in 2004/05 (this was low compared to average maize yields of around 1.2 tons per hectare achieved during the 1990s) to around two tons per hectare in 2009/10.

While the reliability of recent maize production statistics has been questioned by some observers, FISP undeniably has had a major impact on agricultural and national growth. Preliminary estimates reported by the Ministry of Development Planning and Cooperation (MODPC) show that national GDP grew by about 7.9 percent in 2006. The growth rate has increased steadily since, reaching 8.7 percent in 2009 (MODPC 2009).

After a period of rapid maize-led growth, Malawian policymakers are now grappling with the question of how to maintain the momentum. Even if the FISP budget remains intact, it is unlikely that maize yield growth rates, which averaged 15-20 percent per annum during 2004/05 to 2009/10 seasons, can be sustained. The agricultural sector now faces the real danger of returning to its long-run growth path of about 3-4 percent. This is well below the 6 percent target set under Comprehensive African Agricultural Development Program (CAADP) of which Malawi is a co-signee and is insufficient to ensure positive per capita GDP growth unless the nonagricultural sector grows strongly. That said, FISP has had some important economywide effects; nonagricultural growth improved dramatically from historical levels of 3-4 percent (Benin et al. 2008), with early estimates suggesting an average annual growth rate in excess of 7 percent during 2005-2010 (NSO 2010). Nonagricultural growth now contributes significantly to overall growth, signifying a steady decline in the importance of the agriculture sector, a process that is likely to continue as the economy develops and modernizes. Growth in the construction sector has been particularly impressive (11.1 percent), which could indicate that at least some of the surplus generated during the period of maize-led growth has been reinvested in the economy, which in turn would help to maintain the recent high levels of nonagricultural growth.

While nonagricultural growth is becoming more important, the government should not lose focus on the agricultural sector. Much of the sector remains primitive in terms of farming methods, the level of mechanization, the use of modern inputs, and irrigation; hence there is still scope for rapid expansion in the long run. The focus of agricultural policy, however, should be broadened to include more agricultural subsectors. Current agricultural policy promotes maize production through seed and fertilizer subsidies with the aim of achieving food self-sufficiency. It also focuses on tobacco, the country's major export crop, through fertilizer subsidies.

This narrow focus on maize and tobacco is potentially dangerous from both a growth and household welfare perspective, especially since the two crops represent such a significant portion of agricultural (40 percent) and national GDP (16 percent) (Benin et al. 2008). Malawi has limited cereals storage capacity. A continued focus on maize will require the government's marketing agency to consider exporting maize (which until now it has been reluctant to do), not ideal with maize being a bulky, low-value crop. Furthermore, widespread adoption of fertilizer subsidy programs elsewhere in southern and eastern Africa (Tanzania, Kenya, Zambia, and Mozambique; see Sanchez et al. 2009) means that trade opportunities in the region might be limited due to oversupply and weak prices. The tobacco sector is also under threat. At the World Health Organization's Framework Convention on Tobacco Control in November 2010 in Uruguay, all members agreed to ban the use of additives and sweeteners commonly used in blended burley tobacco products. Although no timeline has been attached to this agreement, Malawi's burley tobacco sector, one of the largest in the world in terms of export volume, is set to suffer major losses once the ban is put into effect (Diao et al. 2002, NKC 2010). A more broad-based agricultural growth strategy will ensure that the economy is less vulnerable to economic shocks or policies affecting the maize and/or tobacco sectors in particular.

Agricultural policy should also ideally shift away from its current emphasis on the fertilizer subsidy program to more sustainable options such as shoring up rural and agricultural infrastructure, providing effective extension services, and spending on research and development. The growth potential under FISP has arguably been exhausted, having realized most of the gains in 2006 and 2007 shortly after its introduction. While the policy is effectively maintaining production at its current high levels, it is unlikely to lead to further productivity gains. Therefore, without land expansion maize output growth is likely to stagnate. Outside of maize, most Malawian farmers continue to produce crops for own consumption only, partly because of primitive production methods, and partly because they are unable to access markets. This needs to be addressed under a revised agricultural policy.

A broader spending focus is in fact provided for under Malawi's Agriculture Sector Wide Approach (ASWAp), which draws on elements of the Malawi Growth and Development Strategy (MGDS) in setting a priority investment strategy for the agricultural sector (MOAFS 2010). Through promotion of research and development, capacity building, and strategic infrastructural investments, ASWAp aims to achieve the 6 percent agricultural growth target of CAADP. About 40 percent of the ASWAp budget will be spent on technology generation and dissemination (research and extension services), as well as institutional strengthening and capacity building in public and private sectors; the remainder is allocated directly to investment projects (MOAFS 2010). The largest single component of ASWAp is the Greenbelt Initiative (GBI), a large-scale irrigation scheme that also incorporates elements such as infrastructural development and rehabilitation, land administration and environmental management, technology development and dissemination, institutional development and capacity building, agro-processing and marketing development, and monitoring and evaluation. The scheme is motivated by the fact that Malawi has abundant sources of unutilized water, with Lake Malawi constituting one of world's largest bodies of fresh water. The cost of the GBI alone will account for more than 78 percent of the ASWAp budget in the first year of operation (started in June 2010). The budget allocation declines in subsequent years, but will still contribute over 43% to the total cost of ASWAp over the first four years of implementation. In addition to crop productivity gains brought about by improved irrigation, the initiative also hopes to contribute to livestock and fisheries production, improve value chain linkages, and promote value addition through processing of raw materials. While ambitious—the GBI budget will supposedly be double that of FISP—it is a truly "broad-based" agricultural initiative.

Most analysts agree that the fertilizer subsidy has accelerated growth and that agriculture will remain important for overall growth in Malawi for the years to come. However, it is not clear what impact the subsidy policy has had on nutrition and how agricultural growth may help to improve nutrition in the future. To shed light on these questions, we look at the nutritional impact of Malawi's historical and possible future growth paths. We first simulate the country's maize-led growth path during 2005-2010. We then consider two scenarios for 2010-2020. In the baseline scenario we assume the economy loses momentum, with agricultural and non-agricultural growth returning to the long-run growth trends identified by Benin et al. (2008). We compare these results against a broad-based agricultural growth path in which cereals growth still slows down as expected, but overall agricultural growth is maintained through promotion of a larger range of subsectors under ASWAp and the GBI. For the nutrition outcome indicators, we focus on the deficiencies of calories and key micronutrients, as discussed Section 4.1.

4.3.1 PAST MAIZE-LED GROWTH PATH

Malawi's growth performance from 2005-2010 represents a marked improvement over the previous one and a half decades. Preliminary estimates of MODPC (2009) suggest that national growth averaged more than 8 percent, driven largely by strong growth in agriculture, which in turn was driven by maize yield growth of about 20 percent per annum (MOAFS 2010). Official figures also show a much improved nonagricultural growth performance, with growth averaging about 7 percent per annum between 2005 and 2010.

We use the DCGE model for Malawi with base-year 2004 to roughly reproduce this growth path over the period 2005-2010, although we assume a slightly more conservative growth trajectory than what preliminary national accounts estimates suggest. Thus, over the period 2005-2010, we allow national GDP to grow at 7.2

percent. This is driven largely by strong growth in the cereals subsector (16.5 percent), which allows agricultural GDP to expand at 9.1 percent per annum. In reproducing national accounts growth statistics (as reported by NSO 2010) we closely approximate reported crop production statistics (as reported by MOAFS 2010). Non-agricultural sectors also perform well, with growth exceeding 5 percent in the mining and industry sectors (5.5 percent) and construction and services sectors (5.9 percent). We consider Malawi's rapidly growing population using official annual growth rates by district (as reported by NSO 2010) that average 3.3 percent over the period 2005-2010.

Our results suggest that Malawi's rapid maize-led growth over the past six years has brought down malnutrition rates substantially. The proportion of calorie-deficient people dropped by more than half, from 35 percent in 2004 to 17 percent in 2010, and the proportion of people affected by iron, zinc, or folate deficiency declined by more than one-third (Table 5). In spite of these improvements, iron deficiency still affects 4.2 million people (27 percent of the population), zinc deficiency 5.1 million people (33 percent), and folate deficiency 3.5 million (23 percent) by 2010. In contrast to iron, zinc, and folate, vitamin A deficiency did not improve markedly due to low consumption of meat, fish, vegetables, and fruits. In fact, though the proportion of vitamin A-deficient people decreased by 9 percentage points over the period 2005-2010, Malawi's rapidly growing population has resulted in the actual number of deficient people increasing by 400,000. In 2004, 8.4 million people, or two-thirds of the population, were deficient in vitamin A in 2004; by 2010 this increased to about 8.8 million people, or more than half the population (Table 5). Thus, over the second half of the past decade, FISP, coupled with favorable weather conditions, was successful in reducing calorie and micronutrient deficiencies in relative and absolute terms, with the exception of vitamin A.

Table 5—Growth and malnutrition under different agricultural policies—Scenario summary

	Past maize-led growth path		Return to long-run growth		Broad-based agricultural growth	
	2004	2010	2015	2020	2015	2020
Growth (percent)						
National GDP	6.8	5.9	4.0	4.1	6.4	6.0
Agriculture	8.5	6.0	3.3	3.4	6.5	5.1
Cereals	17.3	8.3	3.0	3.0	8.9	4.4
Export crops	4.9	5.5	4.1	4.0	5.2	7.7
Mining & industry	5.4	5.5	4.6	4.5	6.2	6.8
Construction & services	5.7	5.9	4.6	4.6	6.3	6.8
Malnutrition						
PROPORTION OF DEFICIENT PEOPLE (PERCENT)						
Calories	34.8	17.1	10.3	5.9	8.1	3.5
Iron	47.1	27.0	17.1	10.8	14.3	6.6
Zinc	54.5	32.8	20.8	12.9	16.9	7.9
Vitamin A	65.6	56.5	50.6	44.8	48.0	39.5
Folate	37.3	22.7	16.0	10.4	13.4	6.5
NUMBER OF DEFICIENT PEOPLE (MILLIONS)						
Calories	4.46	2.67	1.88	1.27	1.48	0.74
Iron	6.04	4.21	3.13	2.32	2.62	1.42
Zinc	6.99	5.11	3.81	2.78	3.09	1.71
Vitamin A	8.41	8.81	9.26	9.63	8.79	8.49
Folate	4.79	3.54	2.93	2.23	2.46	1.39

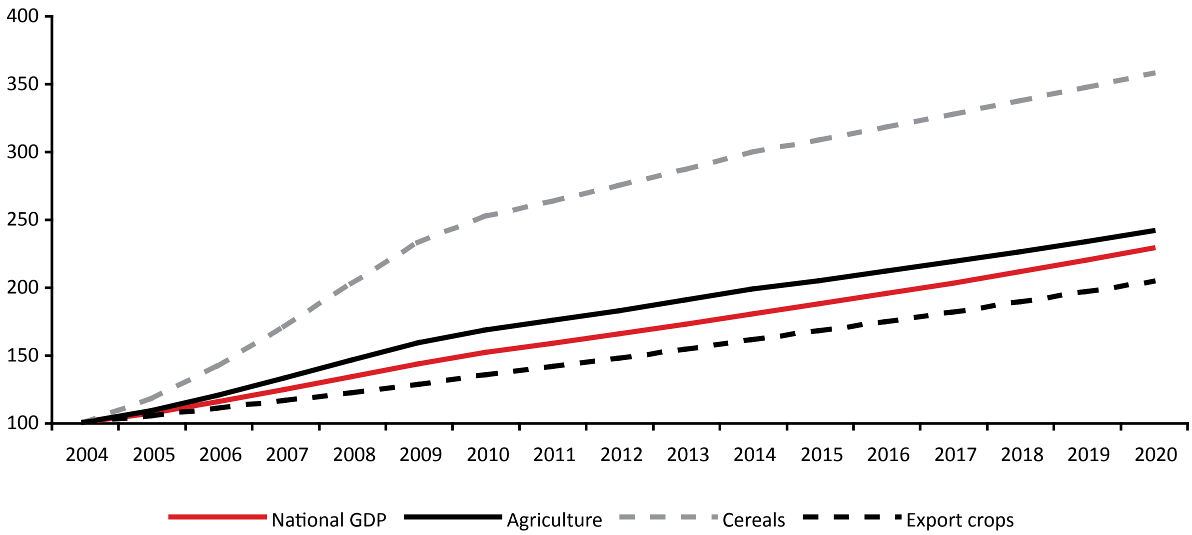
Source: Constructed by authors.

4.3.2 RETURN TO LONG-RUN GROWTH

Considering the fiscal burden of FISP, agriculture's high vulnerability to droughts and floods, and the lack diversification in agriculture and the entire economy, there is a certain probability that Malawi will not be able to maintain the current momentum of high economic growth and continuing reduction of malnutrition. For the 2010-2015 and 2015-2020 periods we model a baseline scenario in which we assume the economy—and the cereals subsector in particular—loses momentum as further yield growth potential under the FISP is exhausted. This causes the economy to return to its long-run growth trajectory based on trends identified by Benin et al. (2008). National GDP growth averages 4.4 percent during 2010-2015, and slows further to 4.1 percent during 2015-2020. Although somewhat pessimistic, this scenario may indeed be a reality for Malawi if it fails to identify ways to diversify agricultural and nonagricultural production as the marginal benefits of FISP begin to wear off. Figure 10 shows this growth path for the total economy, the agricultural sector, and its key subsectors, including the past development under FISP. Consistent with official figures (NSO 2010), we assume that Malawi's population continues to grow at an average rate of 3.2 percent between 2010 and 2020.

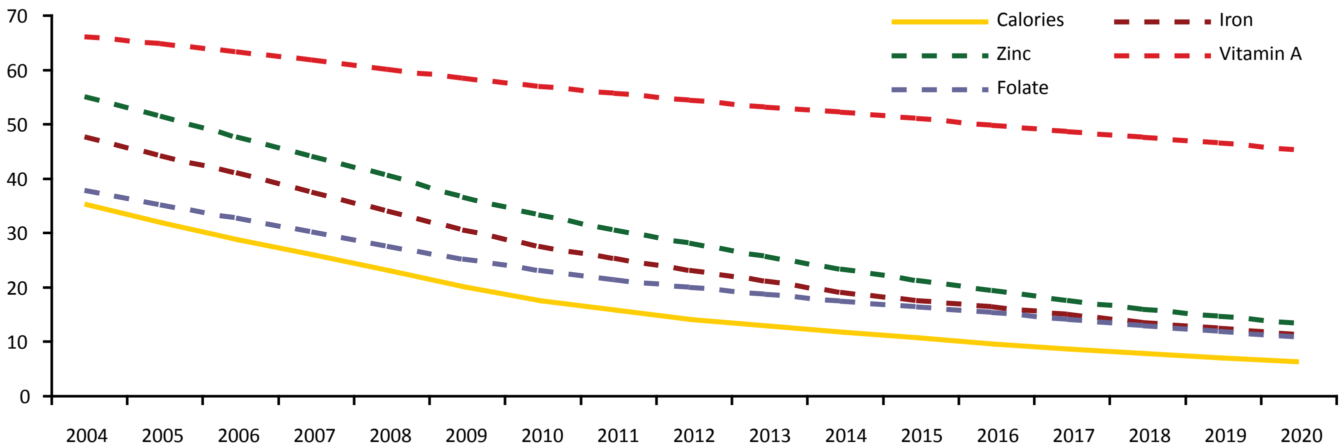
Even under this pessimistic scenario, malnutrition will continue to decline in relative terms, albeit at a low rate compared to the past period (Figure 11). According to our estimates, the proportion of calorie-deficient people will have fallen under 10 percent after 2015, and iron, zinc, and folate deficiency are estimated to affect less than 20 percent of the population after 2015 and less than 15 percent by 2020. The number of people deficient in calories and these micronutrients will also continue to decrease. However, vitamin A deficiency will remain a major nutrition problem. The number of deficient people will further rise, although their proportion in the total population will fall under 50 percent in 2015 and continue to further decline slowly.

Figure 10—Maize-led growth in 2004-2010 and return to the long-run growth path in 2010-2020 (2004 = 100)



Source: Constructed by authors.

Figure 11—Proportion of deficient people (percent) under the maize-led growth scenario for 2005-2010 and the baseline scenario for 2010-2020



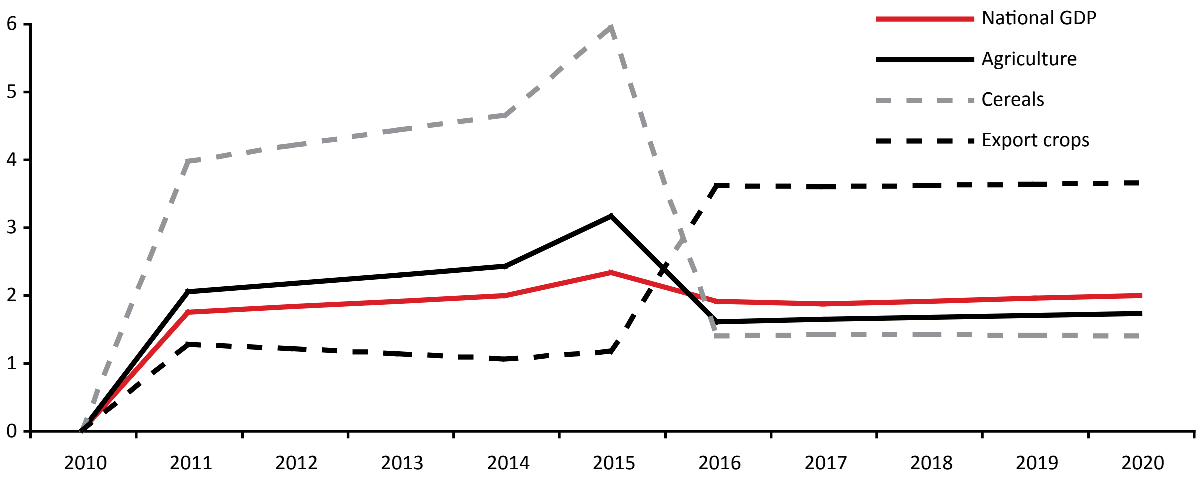
Source: Constructed by authors.

4.3.3 BROAD-BASED AGRICULTURAL GROWTH

Under an alternative broad-based growth scenario we assume that the economy—through effective implementation of ASWAp and the GBI—is able to maintain some of the growth momentum in cereals during 2010-2015, mainly by extending the area of land under irrigation. Agricultural GDP growth averages 6.5 percent during this period, which is above the CAADP growth target. As infrastructure and market linkages are further improved under the GBI, the agricultural sector shifts its focus toward export crops (in particular cotton and sugarcane), which during 2015-2020 grow strongly at 7.6 percent. By this time the slowdown in the large cereals subsector causes agricultural growth to also decline to about 5 percent per annum. However, over the 2010-2020 period as a whole the average agricultural growth rate remains close to the 6 percent level. Over both the 2010-2015 and 2015-2020 sub-periods, nonagricultural growth improves relative to the baseline scenario, with growth in the latter period reaching almost 7 percent. Under the GBI, we also expect to see an expansion of aquaculture in 2015-2020 after a decade of a very weak performing fisheries sector. There is also a renewed focus on processing and services, both of which grow rapidly from a very low base over the entire period but especially gaining momentum in 2015-2020 as the economy transforms to a semi-industrialized one. This structural shift in the economy ensures that the national GDP growth rate, although slightly lower than during 2010-2015, remains at about 6 percent per annum during 2015-2020. Under this alternative scenario, the national GDP growth rate is almost two percentage points higher than in the baseline scenario (Figure 12), while the economy as a whole is less reliant on agriculture.

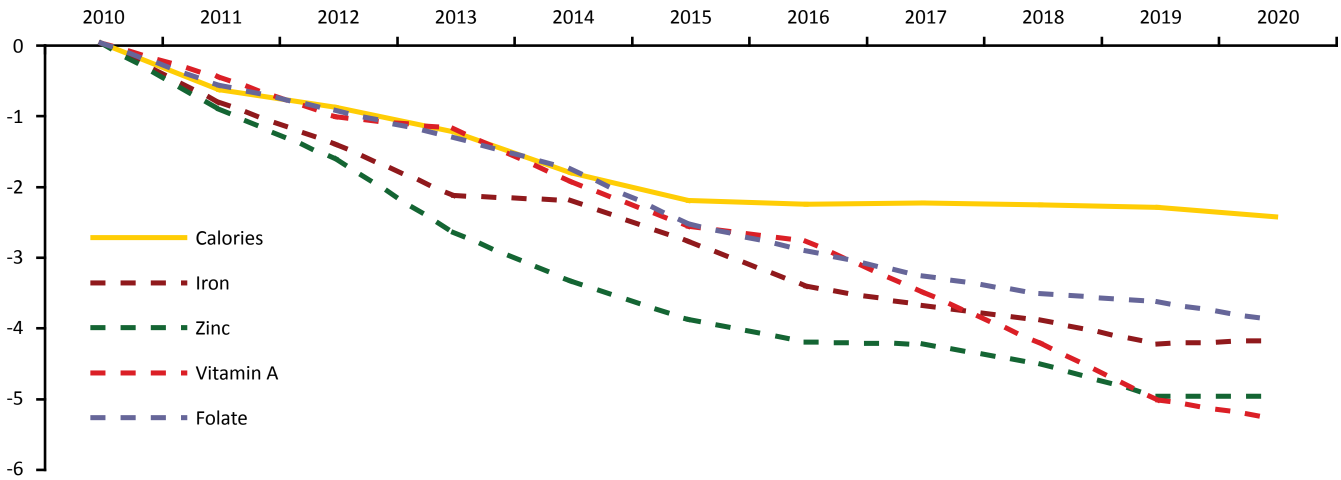
Compared to the baseline scenario, nutritional deficiency rates decline considerably faster (Figure 13). Starting off at a higher base in 2010, micronutrient deficiencies decline more rapidly than calorie deficiency. In fact, from about 2015 onwards, the relative rate of decline in calorie deficiency remains stable at about 2 percentage points. Iron, zinc, and vitamin A deficiency continue to decline at an increasing rate relative to the baseline. In 2020, micronutrient deficiency rates will be about 4-5 percentage points below the rates under the baseline scenario. This goes along with a significant reduction in the number of deficient people. Under the broad-based growth scenario, the numbers of people deficient in calories, iron, zinc, and folate are more than one-third lower than under the baseline scenario in 2020.

Figure 12—GDP growth and agricultural growth under broad-based growth—change from baseline levels (percentage points)



Source: Constructed by authors.

Figure 13—Proportion of deficient people under broad-based growth—change from baseline levels (percentage points)



Source: Constructed by authors.

4.3.4 DIVERSIFYING AGRICULTURAL GROWTH AND NUTRITION INTERVENTIONS

The simulations in this case study have clearly shown that agricultural growth is important for improving nutrition in a country like Malawi, where agriculture is a mainstay of the economy and where the majority of the population draws its livelihood from agriculture. Malawi's experience with the FISP reveals that under certain conditions, subsidizing farm inputs can lead to a significant reduction of malnutrition, particularly with respect to reducing calorie deficiency. In particular the following four components are crucial. First, the program must reach the majority of the malnourished population—in Malawi's case, farmers, most of whom are smallholders (Government of Malawi & World Bank 2007). Second, the program must have a high potential to generate income for the individual beneficiaries and foster national economic growth. Malawi's FISP mainly targeted the production of maize and tobacco. Maize is cultivated by almost all farmers (97 percent) and productivity was initially extremely low. Third and related to that, there must be a high demand for the subsidized staple food product, and higher outputs must translate into lower prices. At the time of the implementation of FISP, Malawi suffered from severe food shortages and high food prices; and, the state-owned marketing company stepped into the market as an additional source of demand (offering guaranteed prices) to fill up its empty stores. Fourth and finally, the weather conditions must by favorable in rain-fed agricultural production systems. This was also the case in Malawi during the past five seasons.

In addition to the high fiscal burden of subsidy programs, there is the risk of losing momentum. Subsidy programs can only be effective in the short run due to rapid decrease in rates of returns. Cutting back subsidies is unpopular but often inevitable to leave room for the development of alternatives for income generation. Economic diversification is key for development, especially in this context. Our results indicate that Malawi can significantly improve its nutrition situation after the period of rapid maize-led growth under FISP if it is able to maintain some of the momentum in agricultural and nonagricultural growth through diversification of its economy, starting with the agricultural sector. If implemented effectively, investments under ASWAp and GBI fostering broad-based agricultural growth have the potential to contribute substantially to household incomes, which in turn reduces malnutrition.

Given the low per capita incomes in Malawi, our expenditure elasticity estimates with respect to calorie and nutrient consumption are high (see Table A2 in the Appendix); hence, household income changes will reflect high improvement in nutrition. For example, the calorie-expenditure elasticities for Malawi are, on average, more than double those of Yemen. This means that the calorie status of Malawians will improve twice as fast as the calorie status of Yemenis when experiencing the same rate of income growth. In fact, given the findings from Section 2 that calorie deficiency (or undernourishment) is more elastic to GDP growth in countries with a low GDP (and a high prevalence rate of deficiency), and given Malawi's low per capita GDP relative to Yemen's (which is more than three times higher), we expect the calorie and nutrient-expenditure elasticities to be significantly higher for Malawi than for Yemen.

Some important, general conclusions emerge from our analysis comparing the nutritional impacts of the broad-based growth scenario and the baseline scenario. Over the 2015-2020 period, national and agricultural GDP growth under the broad-based growth scenario exceed the growth rates achieved under the baseline scenario by less than 2 percentage points; but the rates of decline in micronutrient deficiencies under the broad-based growth scenario exceed those achieved under the baseline by about 3 percentage points on average. This highlights the importance of diversification for Malawi, which will help prevent reverting back to the relatively low levels of growth experienced prior to 2005. Due to decreasing marginal rates, leveraging growth for reducing malnutrition becomes more difficult as malnutrition becomes less prevalent, as Figures 1-4 in Section 2 show. Thus, diversification in the agricultural sector and in the whole economy is critical to maintain a high transformation rate of growth into nutrition improvement. A more diversified economy allows for more broad-based and inclusive growth that also trickles down to malnourished people engaged in less dominant economic sectors.

This case study also suggests that economic and agricultural policies can help reduce calorie deficiency, but they are not effective in tackling some micronutrient deficiencies, such as vitamin A in the case of Malawi. To directly control and prevent specific vitamin and mineral deficiencies, targeted nutrition interventions are needed. Three specific nutrition intervention strategies, namely nutrient supplementation, food fortification, and biofortification, and a variety of actions aimed at dietary modification and diversification, can be identified (Ecker 2009) and have been shown to be successful with high rates of return (Allen 2003, Baltussen 2004, Bouis 1999, Qaim et al. 2007, Zimmermann and Qaim 2004). For instance, Horton et al. (2008) find that the benefit-cost ratio for vitamin A supplementation programs varies between 8:1 and 17:1 and for flour fortification with minerals around 8:1, on average.[10]

However, these strategies do not tackle the underlying causes of micronutrient malnutrition, which are either poor health and infection with diseases that cause secondary malnutrition, or an poor diet quality. The former calls for health interventions, as outlined above, and the latter calls for actions that allow and encourage people to consume a modified and more diversified diet. Beside policies that improve people's access to healthier foods and a more diversified diet, other measures have high potential to increase people's consumption of vegetables, fruits, and animal products directly and permanently, such as programs that promote home, school, and community gardens and small-scale livestock husbandry and aquaculture (Gibson and Hotz 2001, Gibson et al. 2003, Ruel 2001, Tontisirin et al. 2002). Of at least equal importance are nutrition and awareness and education campaigns that educate the malnourished population about the importance of good nutritional habits. Lack of this understanding will severely limit the potential impact of growth and policies aimed at improving people's economic access to improved sources of nutrition.

5. Conclusions and Policy Recommendations

Economic growth is important for poverty reduction. However, relatively little is known about the relationship between growth and nutrition outcomes, and how economic policies can be leveraged for improving nutrition. To contribute to a better understanding of this important development challenge, this paper has used cross-country analysis to explore the general relationship between growth and malnutrition reduction in the process of development, presented a new analytical approach for analyzing the nutritional impacts of growth and economic policies, and applied this approach to two case study countries.

We show that economic growth is good for improving nutrition, especially at early stages of development. Growth and agricultural growth in particular are crucial for reducing undernourishment and thus for improving people's calorie sufficiency. But child malnutrition—an important dimension of nutrition for long-term development—is by far less responsive to both agricultural and economy-wide growth.

We also find considerable differences among countries with similar income levels in the relationship between growth and undernourishment, and the relationship between growth and child malnutrition. Some countries have been more successful than others in leveraging overall growth and agricultural growth to improve

10 Nutrient supplementation refers to the delivery of high-dosed pharmacological nutrient preparations that are typically provided for immediate needs such as during delivery or in events of disasters, or to chronically malnourished children. Food fortification is the adding of key minerals and vitamins to regularly consumed processed foods or condiments such flour, salt, and oil, so that a large part of the population can be supplied with additional amounts of these micronutrients. Biofortification takes advantage of the natural enrichment process of minerals and vitamins in plants. It comprises techniques of conventional or transgenic breeding of common (staple) food crops to achieve high and stable contents of bioavailable nutrients in the consumed organs of the plant or reduced contents of components inhibiting the absorption of micronutrients in the human gastro-intestinal tract (Ecker 2009).

people's nutrition; in fact, in some countries' nutritional indicators seem to have deteriorated despite growth. These findings led us to further questions: In what way and to what extent does growth contribute to nutrition outcomes? Why are some countries more successful than others? How can economic policies and programs be designed to better leverage growth for improved nutrition outcomes?

To analyze these questions, we introduce a new conceptual framework that is based on the concept of food security and propose an innovative methodology that quantitatively links growth and economic policies to their nutrition outcomes. The conceptual framework expands existing frameworks, and in consideration of the serious impacts of the 2007/08 food price crisis, extends the common perspective of food security as primarily a household-level problem by incorporating macroeconomic aspects of food security. The framework incorporates the multidimensionality of food security and explicitly accounts for the role of the sectors that are most relevant for improving people's nutritional status, namely agriculture, trade and infrastructure, and health and education. It thus emphasizes the need for an integrated, cross-sector approach for improving nutrition effectively. The framework includes the major pathways in the food security system through which policies and external shocks, for example food price crises and climate change-related disasters, translate into nutrition outcomes. This framework is applied by linking economywide, dynamic computable general equilibrium (DCGE) models to household and child nutrition simulation models. These integrated models allow for consistent estimations of the effects of sector-level economic growth and policies on people's nutritional status, and their application may thus provide important information for policymakers to evaluate the potential impacts of proposed policies and prioritize them accordingly.

The case study countries, Yemen and Malawi, are low-income with high levels of malnutrition. Yemen is an oil-based economy with a relatively small agricultural sector and Malawi an agriculture-based economy with limited economic diversification. The nature of the nutrition challenges in the two countries differs. In Yemen, for example, child malnutrition, and alarmingly the severe forms of its manifestations, is extremely widespread; in Malawi, on the other hand, micronutrient deficiencies, especially in iron, zinc, vitamin A, and folate, are of particular concern. By capturing a broad range of nutritional challenges, results of these case studies provide important country-specific *and* general lessons on the links between policies, growth (agricultural and nonagricultural), and nutrition, especially for countries in Africa and the Middle East.

Results from the case studies show that growth is good for nutrition. The Yemen case study shows that (per capita) growth reduces calorie deficiency. Under both the agriculture policy reform scenario and the promising sector growth policy scenario (selected industrial and service sectors), the prevalence of calorie deficiency will fall below baseline levels and the number of calorie-deficient people in 2020 will be lower than in the post-food price crisis year (2009) under both scenarios. In Malawi, simply continuing the long-term growth trends until 2020 will lead to a further decline in malnourished people.

Depending on the country's economic structure and characteristics of the malnourished people, agricultural *or* non-agricultural growth can be better for improving nutrition. In Malawi, agriculture has a strong potential to contribute to the reduction of malnutrition. This outcome is expected for most agriculture-based economies, where, like in Malawi, agriculture contributes more than one-third to the national GDP and most people live off of farming. Nutrition improves not only among rural households, but urban households also benefit, mainly through a lowering of food prices which thus increases real household incomes. In Yemen, nonagricultural growth is better for improving nutrition outcomes than agricultural growth. The lower nutritional impact of agricultural growth largely can be attributed to the minor role of Yemen's agriculture for income generation and domestic food supply. Agricultural growth effects on reducing malnutrition are limited because the majority of the population draws their income from nonfarming activities, and farmers are not the most malnourished population group. In addition, most foods, and particularly the staple foods that constitute a large share of household budgets, are imported, limiting the degree to which improved agricultural productivity will lower local food prices. These findings clearly indicate that the structure of growth and the relationships to nutrition outcomes also matter for reducing malnutrition.

The role of growth for improving nutrition changes during the development process. In Malawi, comparisons between the broad-based agricultural growth and the baseline scenario reveal that, as malnutrition becomes less responsive to growth with declining prevalence rates, economic diversification gains importance to leverage growth for further reducing malnutrition. This result supports and extends the Yemen study finding that the structure of growth across the whole economy and within the sectors is important for improving people's nutritional status in terms of calories *and* micronutrients.

Neither agricultural nor industry and service sector-led growth is enough for improving child nutrition and reducing micronutrient malnutrition as a whole. Results from the Yemen study show that, even with decisive policy reform that results in rapid growth acceleration, child malnutrition remains at unacceptably high levels. In addition, results from the Malawi study suggest that, despite reductions in calorie, iron, zinc, and folate deficiencies, vitamin A deficiency remains largely unresponsive to growth. Although the proportion of vitamin A-deficient people declined, the number of deficient people increased due to Malawi's rapidly growing population.

Therefore, policy reform that supports agricultural and nonagricultural growth needs to be complemented by strategic investments and targeted programs to tackle child malnutrition. The persistence of widespread child malnutrition globally and the low responsiveness of child nutrition to economic development are particularly alarming, since the potential of children is the mainstay of future prosperity. Needed actions include investments in the health and education sectors; special programs to improve child and maternal nutrition and health, particularly during the period from pregnancy through early childhood; awareness building and education campaigns on aspects of child feeding practices (including breastfeeding), appropriate diets, and hygiene and disease prevention and treatment; child growth monitoring; immunization campaigns; and nutrient supplementation programs. Measures that promote gender equality, women's empowerment, and family planning will also contribute to improving nutrition in general. While evidence shows that such investments and programs have high rates of return in most cases, they require political will and financial resources, linking back to the role of growth in improving nutrition.

Specific investments and programs are also needed to reduce micronutrient malnutrition. Calorie deficiency and some micronutrient deficiencies decline in the process of economic development, but other micronutrient deficiencies are less responsive to growing incomes. Programs that distribute nutrient supplements to the most deficient people, mass fortification of commonly consumed foods and condiments, and biofortification are possible avenues to reduce these deficiencies directly. More research investments are needed to further explore and utilize the potential of biofortification in particular. Programs promoting dietary diversification are also important. To this end, awareness building and education campaigns on the importance of a nutritious and well-balanced diet are key to bringing about and sustaining behavior change. Measures to improve people's direct access to vegetables, fruits, and animal products include programs that promote home, school, and community gardens and small-scale livestock husbandry and aquaculture. In addition, investments that improve people's health and hygiene are required to reduce secondary malnutrition, which causes nutritional deficiencies through infection with diseases and illness.

Given the delinking of growth and certain dimensions of nutrition, results of this paper strongly support the use of non-income measures (such as nutrition and health status) to complement income-based measures (such as poverty) in evaluating development outcomes. In addition, it can be argued that nutrition should play a more prominent role in development. The understanding of being well-nourished or malnourished is intuitive; and, unlike poverty, the concept of nutrition considers distributional issues within the household, for example by looking at the most vulnerable groups of people (young children and women in childbearing age) and through accounting for different individual needs (and associated costs) such as food, health, and education. An even stronger argument might be that malnutrition lowers productivity and has serious long-term consequences for development (World Bank 2006). For example, Horton and Ross (2003) show for 10 developing countries that the median productivity losses from physical and cognitive impairments due to iron deficiency exceed 4 percent of GDP annually, or about US$17 per capita. Moreover, malnutrition affects children (and pregnant women) most severely, with repercussions for future generations. The United Nations' Children's Fund (UNICEF) and the Micronutrient Initiative (UNICEF/MI 2004) postulates, for example, that iron deficiency lowers the intelligence quotient (IQ) in school children by 5 to 7 points on average. These development impacts demand greater attention in policy and policy analysis.

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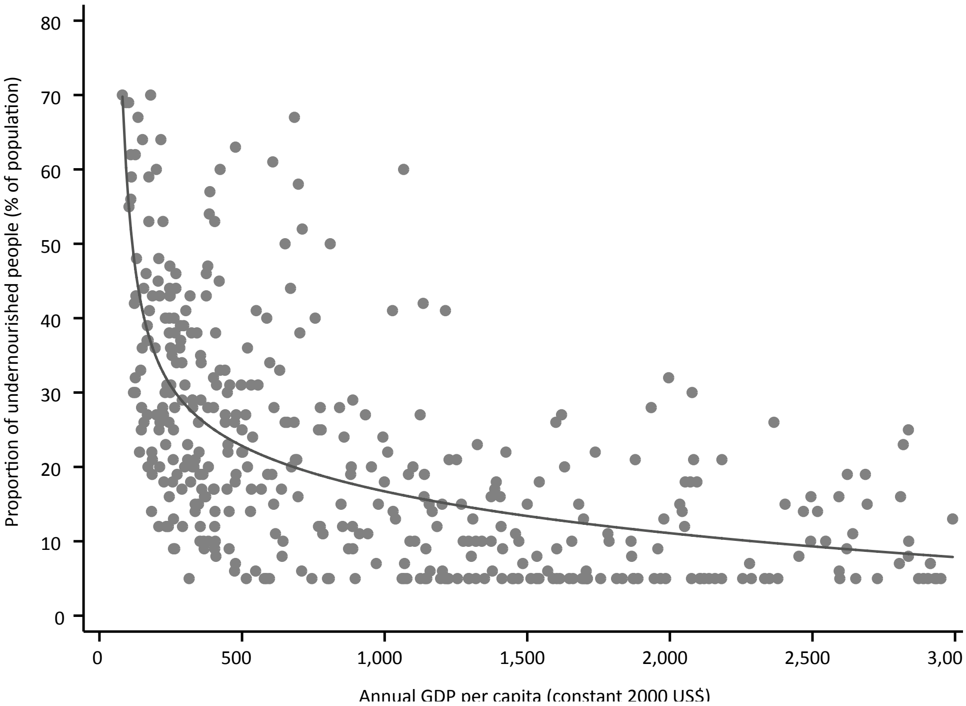
Appendix

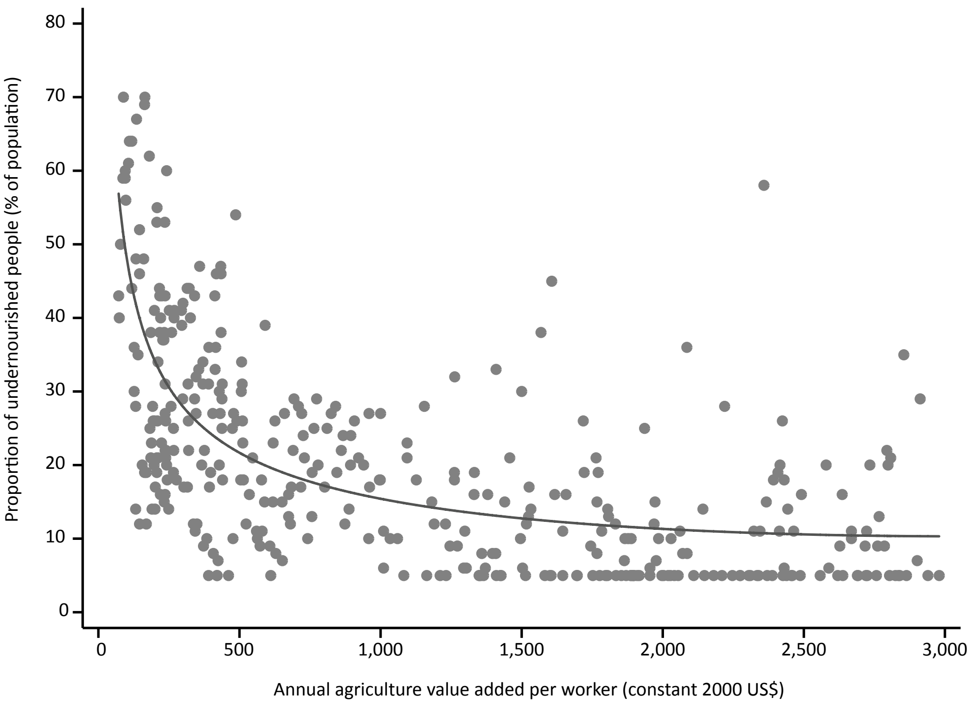
Figure A1—Relationship between undernourishment and GDP



Note: The dots mark the proportion of undernourished people for different countries in 1990-92, 1995-97, 2000-02, and 2005-07 and their annual GDP per capita in the respective years. The red curve is the fitted line using fractional polynomial estimation and data of 111 countries with annual GDP per capita below US$ 3,000 (403 observations).

Source: WDI (2010).

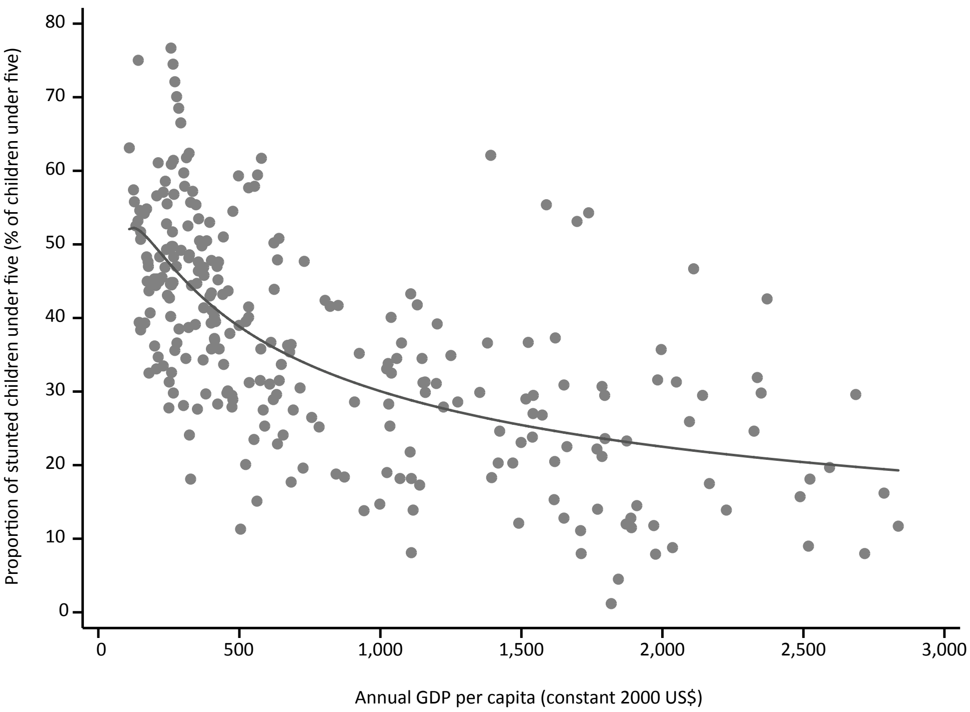
Figure A2—Relationship between undernourishment and agriculture value added



Note: The dots mark the proportion of undernourished people for different countries in 1990-92, 1995-97, 2000-02, and 2005-07 and their annual agriculture value added per worker in the respective years. The red curve is the fitted line using fractional polynomial estimation and data of 107 countries with annual agriculture value added per worker below US$ 3,000 (375 observations).

Source: WDI (2010).

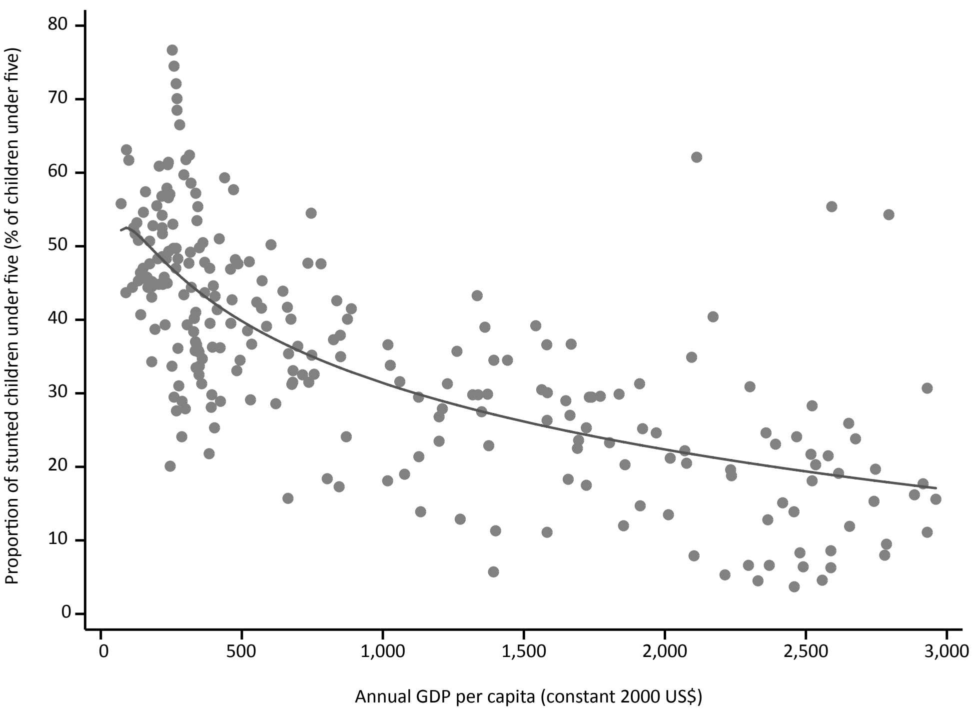
Figure A3—Relationship between child malnutrition and GDP



Note: The dots mark the proportion of stunted children (as determined by the height-for-age measure) for different countries from different years over the past three decades and their annual GDP per capita in the respective years. The red curve is the fitted line using fractional polynomial estimation and data of 95 countries with annual GDP per capita below US$ 3,000 (266 observations).

Source: WDI (2010).

Figure A4—Relationship between child malnutrition and agriculture value added



Note: The dots mark the proportion of stunted children (as determined by the height-for-age measure) for different from different years over the past three decades and their annual agriculture value added per worker in the respective years. The red curve is the fitted line using fractional polynomial estimation and data of 91 countries with annual agriculture value added per worker below US$ 3,000 (252 observations).

Source: WDI (2010).

Table A1—Expenditure elasticity with respect to people's calorie consumption level and children's height-for-age measure, Yemen

	Mean	Std. dev.	Min.	Max.	Obs.
Calorie consumption					
National	0.460	0.112	0.119	0.922	12,093
Rural	0.488	0.112	0.119	0.922	4,300
Urban	0.389	0.073	0.172	0.625	7,793
Child height-for-age					
National	0.090	0.059	0.003	0.602	5,694
Rural	0.085	0.048	0.003	0.253	2,278
Urban	0.105	0.082	0.008	0.602	3,416

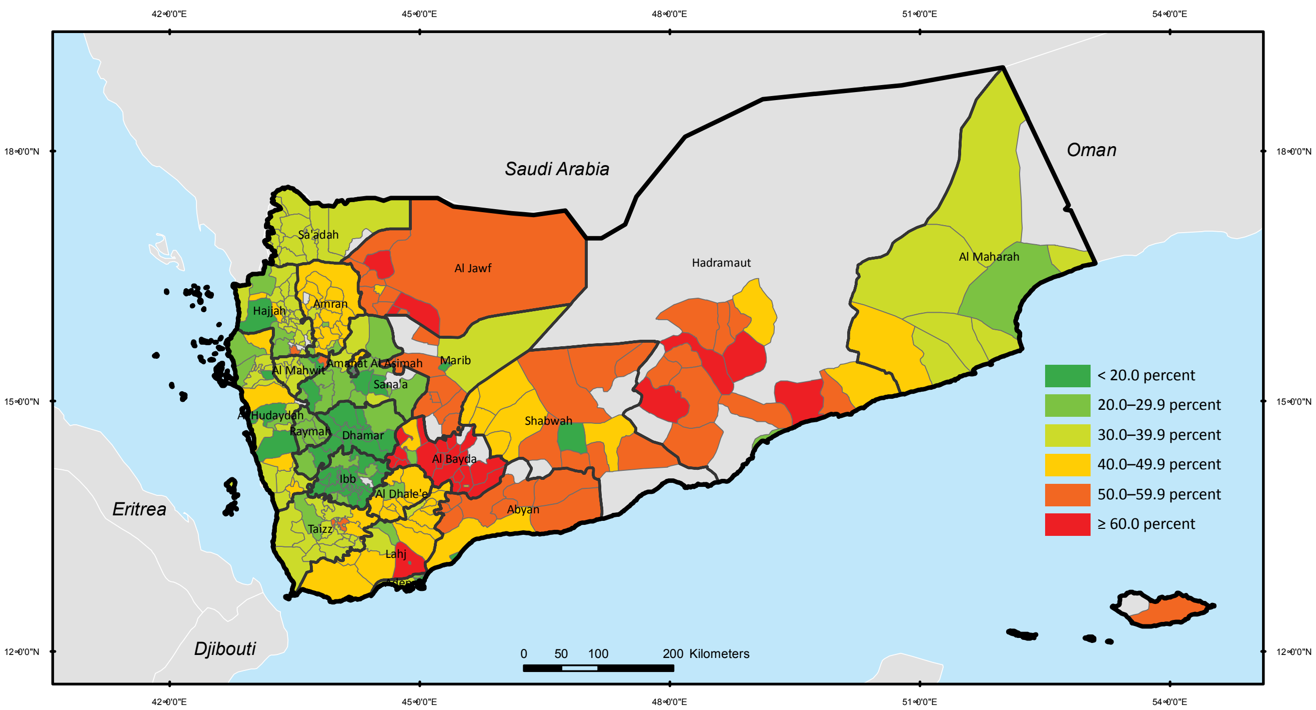
Source: Constructed by authors.

Table A2—Expenditure elasticity with respect to people's calorie and micronutrient consumption levels by expenditure quintiles, Malawi

	Rural (obs.: 9,090)					**Urban** (obs.: 1,280)				
	Poorest	**2nd**	**3rd**	**4th**	**Richest**	**Poorest**	**2nd**	**3rd**	**4th**	**Richest**
Calories	0.894	0.915	0.924	0.909	0.907	0.787	0.750	0.735	0.648	0.440
Iron	0.919	0.932	0.930	0.909	0.849	0.801	0.718	0.631	0.525	0.211
Zinc	0.925	0.936	0.930	0.906	0.850	0.856	0.792	0.724	0.626	0.400
Vitamin A	0.863	0.827	0.830	0.822	0.773	0.307	0.369	0.384	0.425	0.377
Folate	0.874	0.894	0.908	0.913	0.891	0.580	0.547	0.478	0.393	0.181

Source: Constructed by authors.

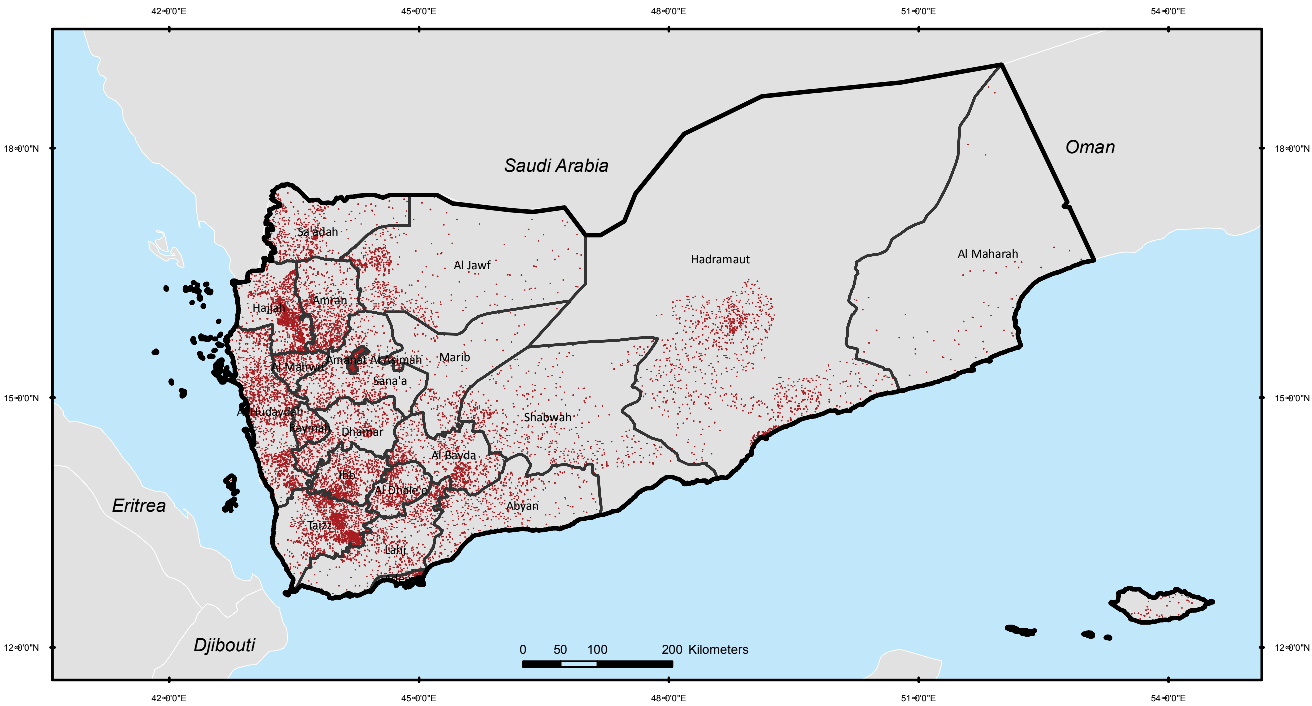
Figure A5—Proportion of calorie-deficient people by districts, Yemen 2009



Note: For more information about the estimation methodology, see Ecker et al. (2010).

Source: DFSA (2011).

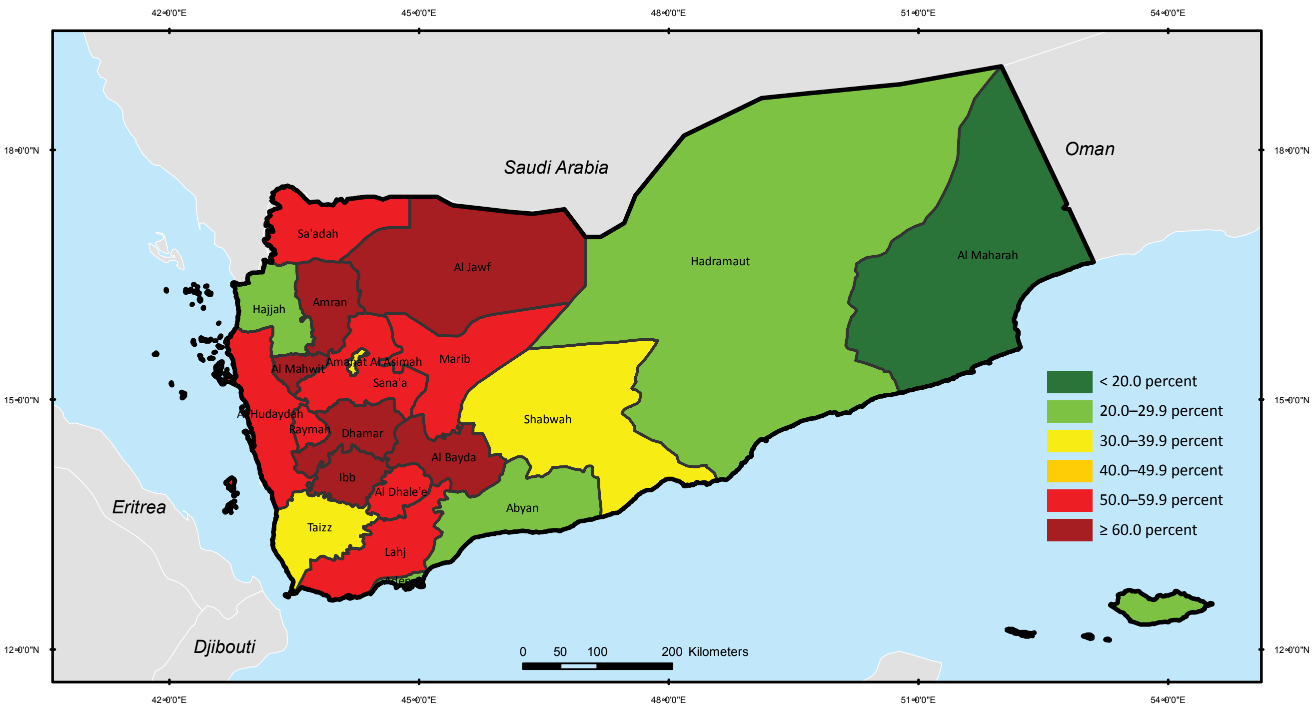
Figure A6—Spatial distribution of the calorie-deficient population (1 dot = 500 calorie-deficient people), Yemen 2009



Note: For more information about the estimation methodology, see Ecker et al. (2010).

Source: DFSA (2011).

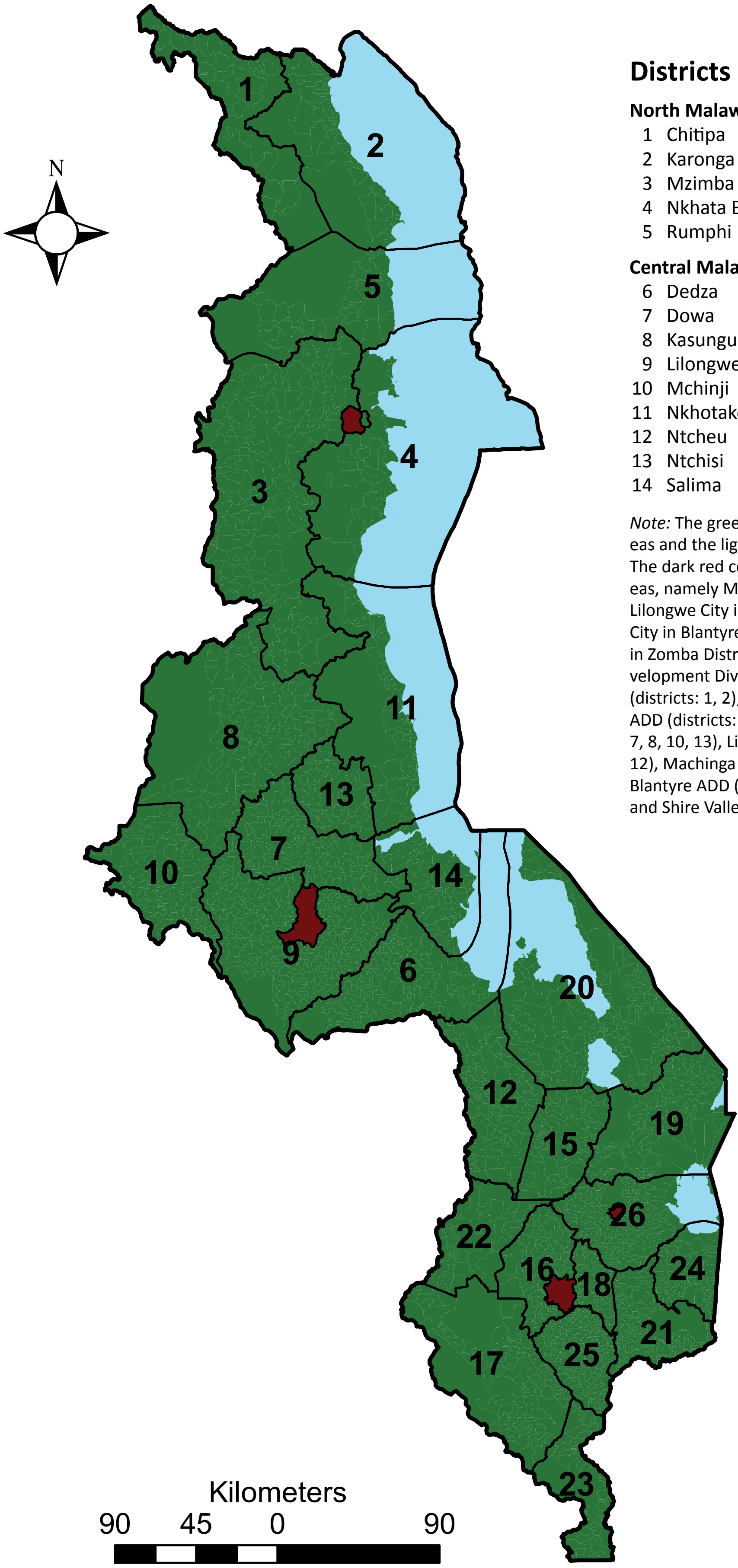
Figure A7—Proportion of stunted children under five by governorate, Yemen 2006



Note: For more information about the estimation methodology, see Ecker et al. (2010).

Source: DFSA (2011).

Figure A8—Political map of Malawi



Districts

North Malawi

1 Chitipa
2 Karonga
3 Mzimba
4 Nkhata Bay
5 Rumphi

Central Malawi

6 Dedza
7 Dowa
8 Kasungu
9 Lilongwe
10 Mchinji
11 Nkhotakota
12 Ntcheu
13 Ntchisi
14 Salima

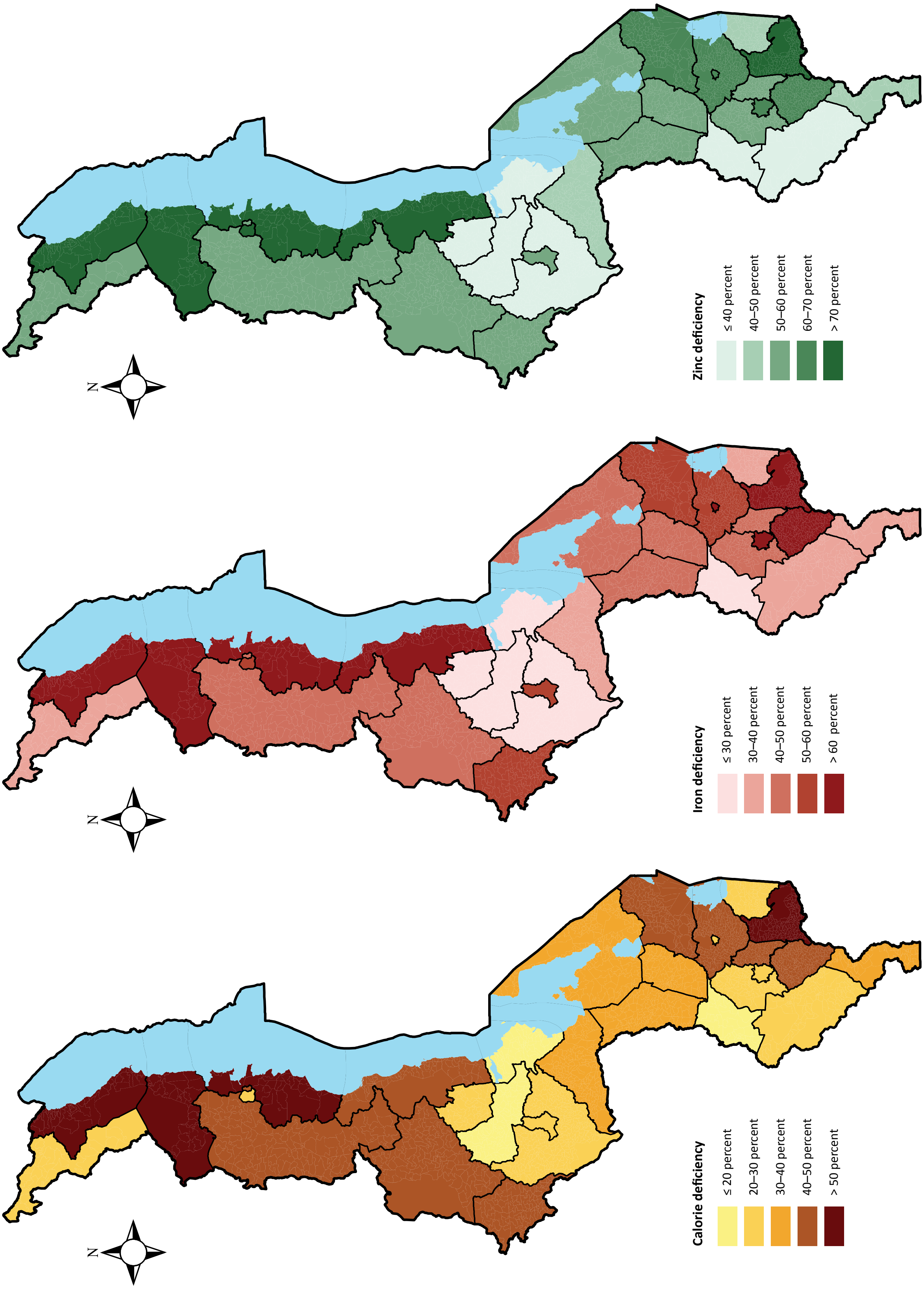
South Malawi

15 Balaka
16 Blantyre
17 Chikwawa
18 Chiradzulu
19 Machinga
20 Mangochi
21 Mulanje
22 Mwanza
23 Nsanje
24 Phalombe
25 Thyolo
26 Zomba

Note: The green colored areas are the land areas and the light blue colored areas are lakes. The dark red colored areas are the urban areas, namely Mzuzu City in Mzinba District (3), Lilongwe City in Lilongwe District (9), Blantyre City in Blantyre District (16), and Zomba City in Zomba District (26). The Agricultural Development Divisions (ADDs) are Karonga ADD (districts: 1, 2), Mzuzu ADD (3, 4, 5), Salima ADD (districts: 11, 14), Kasungu ADD (districts 7, 8, 10, 13), Lilongwe ADD (districts: 6, 9, 12), Machinga ADD (districts: 15, 19, 20, 26), Blantyre ADD (districts: 16, 18, 21, 22, 24, 25), and Shire Valley ADD (districts: 17, 25).

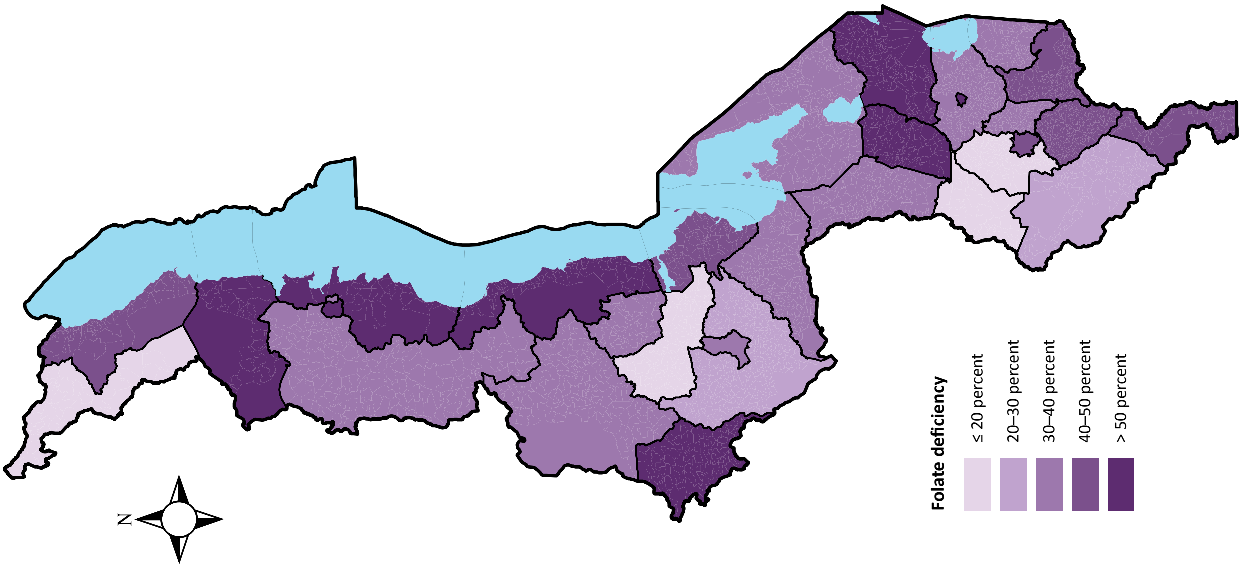
Source: Constructed by authors.

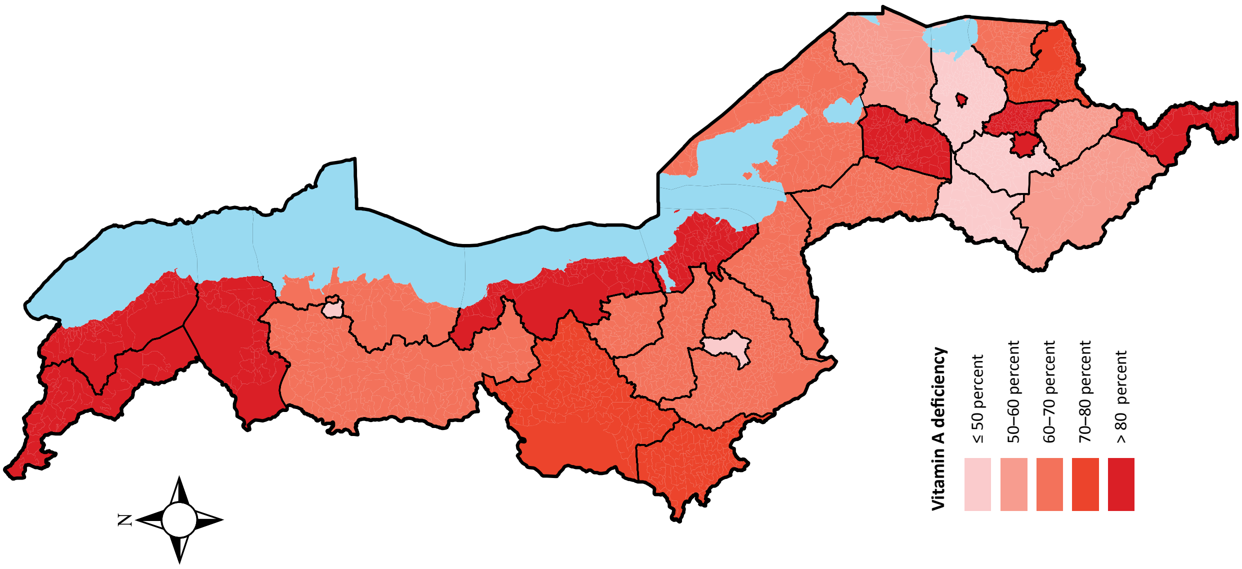
Figure A9—Proportion of calorie-deficient, iron-deficient, and zinc-deficient people by district (percent), Malawi 2005



Source: Constructed by authors.

Figure A10—Proportion of vitamin A-deficient and folate-deficient people by district (percent), Malawi 2005





Source: Constructed by authors.

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