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Demographic change, the IMPACT model, and food security in sub-Saharan Africa

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A. Introduction

Sub-Saharan African populations face a number of challenges that increase their vulnerability to the causes and consequences of food insecurity. Within the region, progress towards improving human welfare is constrained by the high prevalence of hunger, malnutrition, and wide-spread poverty. Not surprisingly, African countries have collectively made the least progress towards achieving the Millennium Development Goal of reducing hunger by half by 2015 (Clemens, Kenny, and Moss 2007). In fact, Africa is the only region in which levels of hunger increased in recent decades (Sanchez et. al 2005), and currently, close to one third of its population lives in chronic hunger (Lobell et al. 2008). On the whole, these constraints can have deleterious consequences for human development in the region. They also underscore the fact that there are still significant challenges to achieving food security in sub-Saharan Africa. At the same time, these challenges are not insurmountable. Progress towards the goal of food security requires new efforts to develop appropriate interventions for mitigating its causes and consequences for populations at risk. For these efforts to succeed, policy makers need to develop a comprehensive understanding of the demographic factors that will affect food security in sub-Saharan Africa in the coming decades.

In this paper, the implications of demographic processes for future changes in the demand and access to food are evaluated. Given the fact that population growth is a major influence on the consumption and availability of food (Alexandratos 2005; Godfray et al. 2010), particular attention is given to the ways in which sub-Saharan Africa's exceptionally high growth rates are likely to affect prospects for achieving food security. Furthermore, the chapter discusses the extent to which the impacts of growth-induced changes on population composition will mediate the influence of population growth on food security among economically vulnerable populations.

In what ways, for example, will changes in Africa's population living in poverty affect the dynamics of food security over the next four decades? Moreover, how will the changing size of Africa's child population affect children's exposure to the risks of malnutrition?

Several studies have used demographic projections to provide empirical descriptions of the ways in which food trends are likely to be affected by population growth (Alexandratos 2005). A recent study, using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), employs population growth projections to assess trends in various indicators of food insecurity (Tokgoz and Rosegrant, unpublished). According to this model, high population growth rates will have the most severe impacts on caloric availability, malnutrition, and overall food security in Least Developed Countries (LDCs). Most of the LDCs referred to are in Africa. Yet, limited attention has been given to assessing the utility of the IMPACT model for understanding how the dynamics of demographic change will affect food security in geographic sub-regions within sub-Saharan Africa. Using population projection estimates and information from the Climate, Agricultural, and Socio-Economic (CASE) database (IFPRI 2010), the chapter provides an overview of the relationship between population growth rates, population composition and a range of food security indicators in Africa over the next four decades.

B. Population projections, the IMPACT model, and food security

Africa's population is expected to increase from 1.01 billion in 2009 to 2 billion in 2050 if current demographic conditions remain constant (UN 2011). Much of this growth will be concentrated in sub-Saharan Africa, where annual population growth rates are expected to range from between 1.6% to slightly more than 2.4% between 2010 and 2050 (UN 2011). These

growth rates will be unmatched by those observed in other world regions. Within Africa, significant variations in demographic change are expected to occur across geographic regions. In East and West Africa, which have Africa's fastest growth rates, projected growth between 2010 and 2050 is expected to occur at rate of about 2.2% per year, according to the UN's medium growth rate assumptions. In absolute terms, annual growth rates in East Africa will be systematically followed by those observed in Central (2%), North (1.07%), and Southern Africa (0.38%) (UN 2011). Although population growth rates are expected to decline in all world regions, including Africa, in the first half of the twenty-first century, sub-Saharan African countries will also have some of the world's fastest population growth rates during this period. By 2050, for example, eight of the top ten fastest growing countries in the world will be found in the sub-Saharan African region (UN 2010).

Projections of population growth are among several inputs used by the IMPACT model to analyze the conceptual links between global demographic change and food security. As such, growth rate variations across Africa's geographic regions have important implications for understanding the conceptual links between demographic change and indicators such as crop yields, food supply, and the prevalence of hunger. Another population-related process captured in the IMPACT model's conceptual framework is urban growth (Tokgoz and Rosegrant, unpublished). As noted in the previous chapter[2], sub-Saharan Africa has the world's fastest urbanization rates and its changing urban dynamics are important for understanding future changes in the production, availability, and consumption of food.

Conceptual links between population growth and food security are further reinforced by studies examining the ability of food production systems to keep pace with long-term

[2] This refers to the other chapter we are doing. Of course, this will change depending on how the final chapters are ordered.

demographic changes in the developing world (Conway and Toenneissen 2003; Gilland 2002; Alexandratos 2005). One such study suggests that, despite expected increases in food production in Africa, rapid population growth will lead to notable increases in the size of its population living in food insecurity (Conway and Toenneissen 2003). Similar links are found in policy recommendations that target population growth reduction as a cornerstone for developing interventions for improving food security outcomes in Africa (Jarosz 2011). However, the relationship between population and food security is likely to present a more complex policy challenge for efforts to improve sub-Saharan Africa's food security disadvantage relative to other regions. In other words, as a result of its underlying high fertility regimes and expected decreases in mortality trends, sub-Saharan Africa's population will still grow faster than populations in other regions (UN 2009). Yet, some studies suggest that trends in its food supply will considerably lag behind those found in other developing regions (Long et al 2006; Muller et. al. 2011).

In the IMPACT model, however, the significance of population growth is primarily conceptualized in terms of its direct impact on the demand for food. These demand projections are considered as subsequent determinants of food imports, food supply, and malnutrition. This conceptualization framework provides a limited perspective on the demographic influences of food security in sub-Saharan Africa. A much broader understanding of the impacts of projected demographic changes can be derived from an examination of the ways in which population growth is likely to affect food security through its impact on other population components.

For example, future population growth will affect population densities, age-composition, dependency ratios, and other related demographic indicators. Consequently, consideration of these influences needs to be given in any comprehensive analysis of the demographic

determinants of food security in Africa. Growth-induced changes in age-composition, for example, have specific implications for future trends in the demand and availability of food. As population ages the demand for food will change. The age composition of the population is in fact an important input in estimating population level needs. In addition, mortality improvements expected to occur over the next four decades will ensure that a significant proportion of Africa's birth cohorts, produced by the high fertility regimes of the first decade of this century, will survive into adulthood by 2050. Life-course transitions associated with entry into adolescence, marriage formation, and labor force participation will further correspond with important changes in food choices that will affect prospects for achieving food security (Devine 2005). Furthermore, across Africa, regional variations in projected population densities are likely to affect natural resource use for agricultural production in ways that will affect local supply and access to food. African societies will therefore need to respond to much broader impacts of population growth on the demand for food as they seek to achieve food security in the first half of the twentieth century.

C. Specific impacts of projected demographic changes

1. Population and the demand for food

How are projected population trends likely to affect the future demand for food in sub-Saharan Africa? In general, variations on demographic trends, conditional on existing patterns of socioeconomic inequality, will mediate the influence of population growth on the demand for food. Over the next four decades, the fastest growth rates are expected to occur among Africa's socioeconomically disadvantaged populations. We know, for example, that high fertility will be the predominant influence on population growth in Africa over the next four decades (UN 2009).

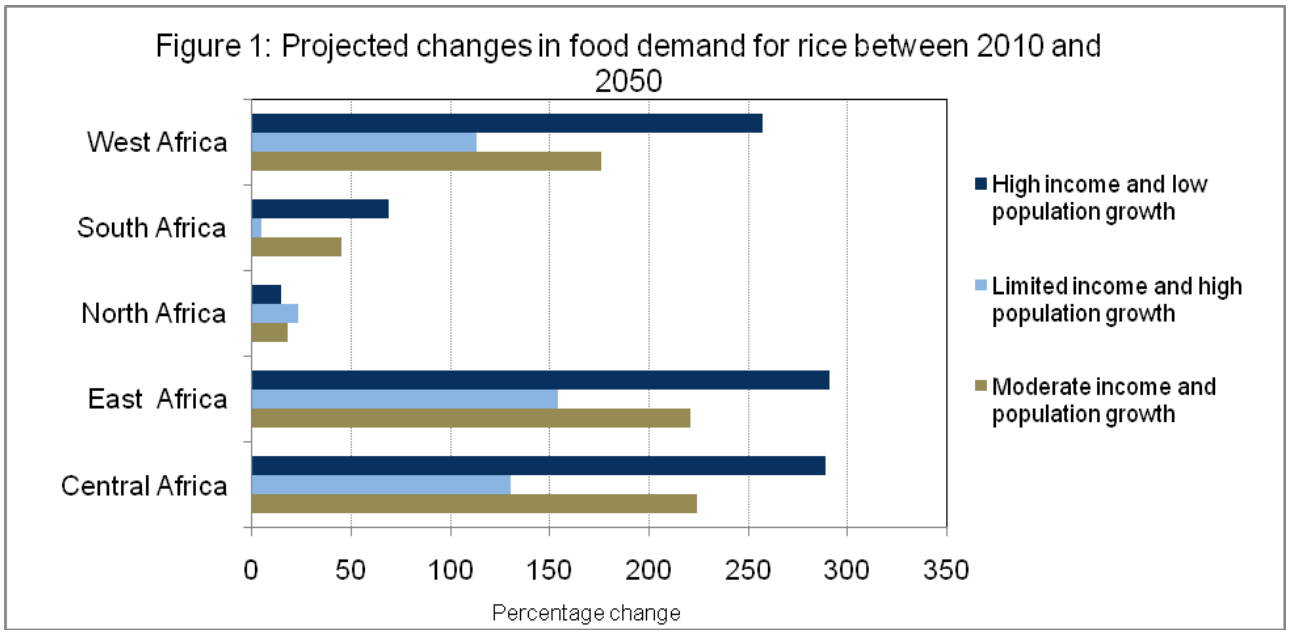
However, fertility levels are higher among the poor than among the non-poor in sub-Saharan Africa (dos Santos and Beral 1997; Kirk and Pillet 1998; Schoumaker 2004), while both fertility and poverty levels are higher in sub-Saharan Africa than in other developing regions (Caldwell and Caldwell 1990; Moser and Ichida 2001). Birth rates are also higher in Africa's rural than urban areas (Kirk and Pillet 1998), and despite its increasing urbanization trends, growth rates among sub-Saharan Africa's rural populations are not expected to decline until 2045 (IFAD 2011).

Without corresponding increases in living standards, the concentration of future growth among the poor will be a major constraint to food consumption in sub-Saharan African countries. Even if technological improvements generate considerable increases in food stocks, income constraints among the poor will negatively affect their ability to buy food in local markets, resulting in increases in the prevalence of hunger. Rising food prices will further exacerbate the consequences of poverty among Africa's food consumers in ways that will severely affect their prospects for achieving food security (Wodon and Zaman 2009).

As Africa's population grows over the next four decades, poverty and income trends may have significant implications for understanding how population change affects the demand for food. For example, changes in population and income trends will affect the demand for major food staples in sub-Saharan Africa. As suggested by estimates from the Climate, Agricultural, and Socio-Economic (CASE) maps (IFPRI 2010), regional variation in these trends will mediate geographic disparities in the demand for food across Africa over the next four decades. Trends in the demand for rice illustrate this point. Regardless of whether population growth rates are moderate, high, or low between 2010 and 2050, increases in the demand for rice will be more rapid in Eastern and Central Africa. In comparison, smaller increases in rice demand are

expected to occur in North, South, and Western Africa where population growth rates are relatively lower.

Across geographic regions, however, the expected course of rice demand will further depend on the future course of income growth (Figure 1). In Central and Eastern Africa, for example, low population growth, accompanied by the increased purchasing power associated with rapid increases in income, is expected to result in about a 300 % increase in the demand for rice between 2010 and 2050. Instructively, rice demand in both regions is still expected to double (i.e. increase by at least 100%) if income growth is more limited but population growth occurs at a more rapid rate (IFPRI 2010). Regardless of what happens to incomes, however, rice demand in these regions will increase by at least 100% as population increases over the next four decades.



These influences are however not peculiar to trends in the demand for rice. According to data from the CASE maps, similar correlations exist between regional trends in population growth and changes in the demand for food staples such as wheat and maize. An exception to these

associations is found in South Africa, where the demand for maize is expected to decrease in almost all scenarios between 2010 and 2050. For almost all major food staples, however, demand is expected to significantly expand with rising incomes per capita in ways that challenge the sustainability of agricultural production systems and efforts to achieve food security (Nelson et al. 2010).

At the global level, results from the IMPACT model underscore the wider implications of rapid African population growth rates on the demand for food in Least Developed Countries (LDCs). For example, the model indicates that rapid population growth at the global level will have a lower impact on food demand in LDCs than the associated impacts of the higher growth rates in African LDCs. Specifically, rapid global population growth will lead to smaller increases in the consumption of roots, meat proteins, and cereals in all LDCs than the respective increases in consumption associated with population growth in LDCs in Africa (Tokgoz and Rosegrant, unpublished). Most of the LDC consumption increases resulting from rapid population growth will however be associated with food staples native to sub-Saharan Africa. For example, among LDCs, population growth in Africa is associated with greater increases in the consumption of groundnuts (9%), sweet potatoes and yams (9.8%), and sorghum (9.2%) than in the consumption of temperate fruits (1.78%) (Tokgoz and Rosegrant, unpublished). These patterns of consumption increases in LDCs will subsequently lead to higher food prices for these staples in other developing and more developed regions. Notably, results from the IMPACT model suggest that many of these consequences can be abated by reductions in population growth in Africa by 2050. Under this scenario most increases in food consumption associated with rapid African population growth and their associated consequences effectively disappear.

Population composition and the demand for food

Analysis of the projected changes in the structure of sub-Saharan Africa's population further provides insight into the broader impacts of population growth on the demand for food. By 2050, for example, this demand will primarily be driven by the exceptional growth expected to occur within Africa's working-age population in ages 15-60. Proportionally, this age group will account for a larger share of population in sub-Saharan Africa than in other world regions. Apart from its larger relative increase in size, however, the working age population will be the primary beneficiaries of any income growth that will occur in sub-Saharan Africa between 2010 and 2050. Changes in Africa's childhood population will also have implications of the demand for food. Although fertility trends will decline between 2010 and 2050, children will still be born in larger numbers to women in sub-Saharan Africa than to women in other parts of the world. During this period, sub-Saharan Africa's Total Fertility Rate (TFR), on average, will still be the highest in the world and will account for a 60% increase in its childhood population below age 5.

Beyond these compositional changes are the possible effects of growth-induced changes in the size of female cohorts in the reproductive ages. Changes in population of females in the childbearing ages have implications for trends in the demand for food because food is consumed in larger quantities during pregnancy than in the pre-pregnancy period (Olson 2005). Population projections however indicate that despite declines in fertility between 2010 and 2050, the number of sub-Saharan African women in the child-bearing ages (i.e., age 15 to 49) will increase by about 2.1 percent per year in the next four decades under conditions of rapid growth. Consequently, by 2050, the cohort of women of reproductive age will increase by about 130 percent. Within geographic regions, the size of the female population in the ages will increase by more than 100% in Central (150%), East (150%), and West Africa (128%), suggesting that

reproductive-age related changes in food demand will be more notable in Africa's fastest growing regions.

Another consequence of changes in the size of Africa's female reproductive-age population is associated with the fact that, beyond pregnancy-related increases in food demand, women's nutritional needs continue to be higher in the post-pregnancy period than in the pre-pregnancy years (Olson 2005). More importantly, however, increases in the size of the female reproductive age population will result in substantial increases in the number of mothers living with young children. Progress towards food security will therefore require enhanced programmatic focus on the positive association between maternal nutritional status and the nutritional status of their children (Barker 1997; Andersson and Bergstrom 1997)**.** Broad changes in food demand associated with increases in the female reproductive age population further underscore the gendered dimensions of the challenge of achieving food security in Africa in the coming decades. As noted in recent studies, women still play a crucial role in food production processes in sub-Saharan countries (Gawaya 2008; Linares 2009). Consequently, enhanced efforts to achieve food security will serve the dual purpose of meeting women's nutritional demands and improving their capacity to make meaningful contributions to food production in sub-Saharan African countries.

2. Natural resource constraints

Addressing sub-Saharan Africa's future food demands will necessitate the efficient exploitation of natural resources to increase the production of basic food staples. For example, increasing agricultural production may require the expansion of crop cultivation to unexploited land areas. Water-use patterns will need to be effectively managed while forest resources will

need greater levels of protection. However, because natural resources are finite, and growing populations demand them in greater quantities, practical limits will be encountered in the expanded use of these resources in food production processes. Changes in age-structure will also have important implications for the supply of labor required for the expanded utilization of natural resources since Africa's agricultural production systems rely heavily on manual labor. In other words, without significant changes in other factors of production, the productivity of cultivation areas will be directly linked with trends in the future supply of labor. As cultivation areas expand in the context of rapid population growth however, competing demands will also be placed on fresh-water resources that will significantly challenge the capacity of Africa's water distribution systems. How these challenges are resolved will have important implications for the use of water resources in irrigation and rain-fed production systems.

Climate change will pose additional challenges to the ways in which natural resources are used in Africa's food production systems. Based on their analysis of climatic variability and harvests in the developing countries, Lobell et al. (2008) suggest that major adaptations of Africa's crop production systems are needed in order to mitigate the negative impacts of these changes on the availability of food staples. Climate change is also expected to decrease water supply in Africa (de Wit and Stankiewicz 2006) and accelerate processes of land degradation within its sub-regions (Meadows and Hoffman 2003). Specific elements of climate change will also negatively affect levels of food stocks required for achieving food security. Rising temperatures, for example, are expected to result in overall declines in agricultural productivity (Burke et al. 2009). Moreover, increases in carbon dioxide are likewise expected to decrease the region's yields for selected crops, including wheat (Lui et al. 2008), while carbon fertilization

resulting from climate change is unlikely to produce meaningful increases in food production (Collier, Conway, and Venables 2008).

As a result of the fixed nature of land, water, and other natural resource stocks, sub-Saharan population growth will inevitably reduce the per capita availability of these resources. With the possible doubling of the region's population by 2050, these constraints will require new strategies to sustainably manage the ways in which natural resources are used in food production processes. Other constraints to natural resource use, such as declining soil fertility and pollution, if not addressed, will further undermine the fundamental basis of food production processes. Incorporating new lands into agricultural production processes is unlikely to produce meaningful increases in crop yields if the physical properties of these lands are compromised by the withering influences of natural and man-made forces. Land traditionally used for food production in fragile ecological regions will need protection from drought and desertification processes that considerably threaten livelihoods and food security (Darkoh 1998). In general, therefore, limited resource stocks, their exploitation in response to population pressures, as well as their sustainable management have far-reaching implications for food security and human development in sub-Saharan Africa.

Water constraints

Like most developing regions, sub-Saharan Africa experienced increased population pressure on its water resources towards the end of the previous century (Falkenmark 1990; Seckler et al. 1998). Nevertheless, concerns about the decline of water stocks as result of climate change are now overshadowed by those associated with the increasing demand of water resulting from population growth (Ashton 2002; Vorosmarty et al. 2000). Even more concerning is the fact that

in the coming decades, Africa's population size is expected to double at the same time in which its water supplies will be declining. By 2025, for example, Africa's population will be 165% higher than it was in 1985. Yet, its sustainable water resources are expected to *decrease* by about 10% during this same period (Vorosmarty et al. 2000). Some scholars even suggest that sub-Saharan Africa will need to double the size of its available water sources in order to meet future demand (Seckler et al. 1998)

Population pressure of the demand for water has serious implications for human well-being especially in Africa's arid and semi arid regions where water resources are already scarce (Falkenmark and Widstran 1992). Indeed, a major challenge associated with future increases in the demand for water is the fact that Africa's population is unevenly distributed around its main water systems. In particular, many of its regions with high population densities are located in areas most vulnerable to fluctuations in rainfall and runoff from rivers (Vorosmarty et al. 2005). Yet, in contrast, the Congo River basin, which accounts for one third of Africa's water supply from runoff, is less densely settled and contains only about 10% of the continent's total population (Hinrichsen and Tacio 2002, UNEP 1999). In terms of water-use changes, population growth will have a greater impact on the demand for water for food production than for that associated with domestic consumption and these impacts will be most deleterious in sub-Saharan Africa countries (Mlote, Sullivan, and Meigh 2002). Decreasing water resources will further have negative consequences for food supplies since increases in risk of root-zone deficiency arising from water shortfalls adversely affects crop yields (Falkenmark 1990).

Changes in land areas used for food production

Population pressure on the demand for food will precipitate notable changes in the size of crop areas harvested between 2010 and 2050. Specifically, land areas used for irrigated and rainfed crop cultivation will require significant expansion to accommodate expected increases in the consumption of food. According to the IMPACT model, rapid population growth both at the global level and in Africa will lead to increases in the overall size of crop cultivation areas. However, cultivation area expansions associated with rapid population growth in Africa will be smaller than the respective land-use changes associated with global population growth. Results from the model also indicate that the crop cultivation areas most likely to increase with rapid population growth are those directly linked with the cultivation of food staples, such as millet and sorghum, which are native to sub-Saharan Africa. Lower population growth rates are however expected to result in significant reductions in the overall size of crop cultivation areas in the developing world.

Emerging from these findings are two questions essential for understanding what these land use changes imply for food security in sub-Saharan Africa. First, how will rapid population growth affect the dynamics of the expansion of crop cultivation areas in sub-Saharan Africa given the fact that region's land stocks are fixed? Second, are there ecological and social constraints to land use that will undermine Africa's capacity to translate increases in crop cultivation areas into increasing food supplies needed to meet its growing demand for food? Previous studies suggest that developing countries, including those in Africa, have yet to harness the full potentials of irrigation for food production purposes (Rosegrant et. al 2005). Consequently, it is also important to understand whether population-growth influences on the incorporation of land for food production differ for irrigation and rainfed crop production processes. In sum, projections from the IMPACT model raise a number of critical questions

related to whether or not land use changes induced by population pressure will result in meaningful increases in crop yields in sub-Saharan Africa.

Projected trends in the expansion of crop cultivation areas

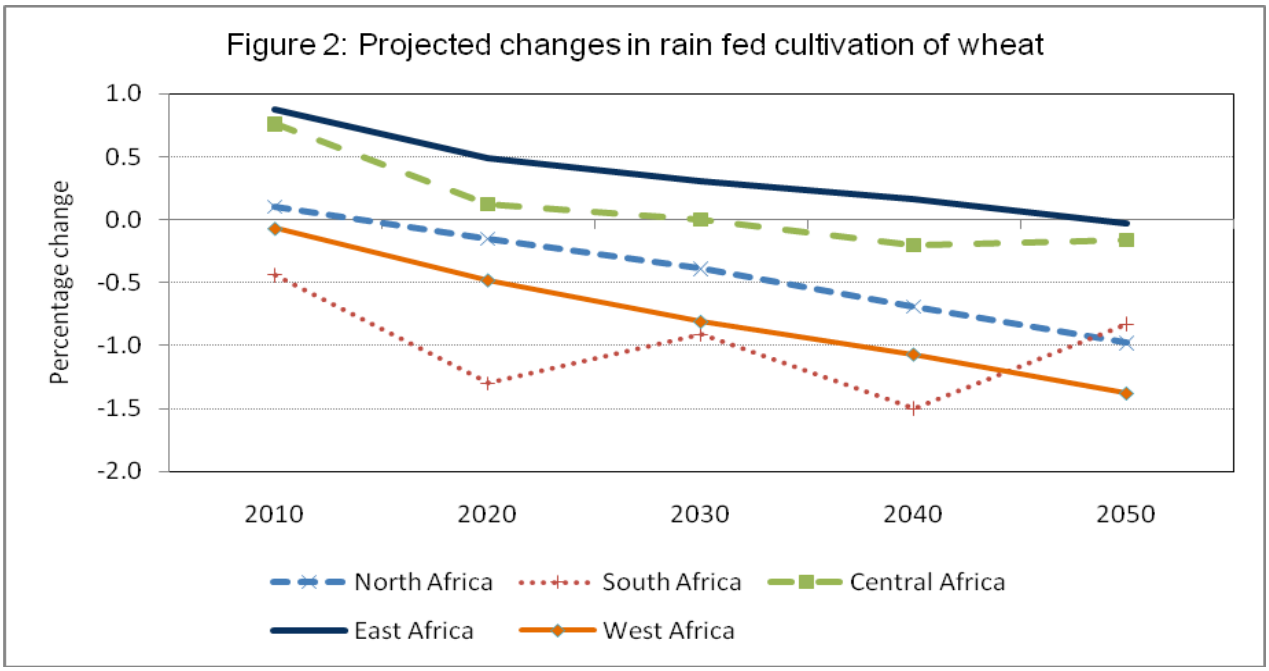
In terms of the dynamics of the expansion of crop-cultivation areas, evidence from the CASE database suggests that irrigated areas are unlikely to expand at rates that correspond with the needs of sub-Saharan Africa's growing population (IFPRI 2010). With regard to rice cultivation, for example, rates of expansion of irrigation areas are expected to systematically decline in sub-Saharan Africa over the next four decades. In other words, because stocks of land are fixed, systematically smaller proportions of land will be incorporated into irrigated rice cultivation areas as population size increases. These declining rates of expansion are generally robust to whether or not the negative impacts of climate change on natural resources are mitigated.

Irrigated-land expansion trends will however vary across Africa's geographic regions. In Central Africa, where population size is projected to increase by more than 110% between 2010 and 2050, growth rates of irrigated areas used for rice cultivation are expected to decline by 46% percent, regardless of the whether income growth rates are high, low, or moderate (IFPRI 2010). The growth of irrigated areas under rice cultivation will likewise decline in East, West, North, and Southern Africa, despite considerable increases in population size expected to occur in these regions. In addition, the largest declines in rates of expansion of irrigation rice areas are expected to occur in North and Southern Africa.

Constraints to the expansion of irrigated areas are however not restricted to rice cultivation processes. For example, the expansion of irrigated areas used for wheat cultivation is also expected to proceed at lower rates across all Africa's geographic regions between 2010 and

2050. In terms of magnitude, these declines will exceed 40% in the three regions with the fastest growing populations in Africa: West Africa (96%), East Africa (55 %) and Central Africa (44%). Similar declines will also be observed in expansion of irrigated areas used for the cultivation of cassava, maize, and groundnuts across Africa over the course of the next four decades.

Constraints to the expansion of land used in rainfed production systems are of greater significance for food security in sub-Saharan Africa since about 90% of the region's food produce is harvested from rainfed systems (Rosegrant et al. 2005). Estimates from the CASE database however point to broadly similar trends in the dynamics of expansion of rainfed cultivated areas as are expected to occur in the region's irrigated food production systems (IFPRI 2010). For example, rainfed land areas used for the cultivation of wheat will expand at slower rates in all African sub-regions between 2010 and 2050 (Figure 2). In East, West and North Africa, these rates of expansion will fall at systematically higher rates in every ten-year period between 2010 and 2050.



Instructively, the expansion of rainfed lands used for the production of major food staples, such as wheat, rice, maize, and cassava, will decline in West and Central Africa, despite the fact that these two regions have some of the highest annual rainfall totals in Africa (Nicholson 2000). Likewise, in North Africa, land used for the rainfed cultivation of food staples such as wheat, rice, and maize will also increase at systematically decreasing rates between 2010 and 2050. The main exception to these overall trends will be observed in the rainfed cultivation of cassava in North Africa. According to the CASE estimates, North African land used for this purpose will systematically increase at faster rates between 2010 and 2050**.** The specific determinants of these increases are unclear. However, since cassava consumption is now concentrated in West and Central Africa, these trends suggest that North Africa will increasingly turn to cassava consumption will slower growth in its major food staple, wheat.

Instructively, these trends do not by themselves suggest that Africa's irrigated food production systems will be less productive over the next four decades. Instead, they suggest that given constraints to the expansion of crop cultivation areas, improved technologies should be developed to increase per capita food production in cultivated areas if food security is to be achieved.

Constraints to the productivity of land

Prospects for translating increases in land areas under cultivation into increasing crop yields are however likely to be compromised by the limited availability of stocks of viable land in regions with high rates of population growth. Countries highly susceptible to drought, desertification, and land degradation have very limited capacity to expand crop cultivation into productive land areas regardless of their future course of population growth. Ecological

constraints are thus likely to significantly limit the extent to which expansions in the size of crop cultivation areas will result in increases in crop yields. Between 2010 and 2050, for example, some of Africa's fastest population growth rates will be found in Mali, Niger, Chad, and Burkina Fasso (UN 2009), all of which are located in the environmentally vulnerable Sahel region where crop yields are usually very low. Similarly, by 2050, Somalia and Tanzania are respectively expected to have the third and seventh fastest growing populations of the world. However, both countries experienced more than ten droughts between 1970 and 2004 (Haile 2005).

Other scholars suggest that the theoretical carry capacity of Africa's land has been exceeded resulting in declines in soil fertility and fallow periods (Drechsel, Kunz, and Vries 2001; King 2004). In addition, more than 70% of the region's arable land is currently undergoing some form of degradation while processes of nutrient mining further continue to affect soil fertility levels by decreasing the phosphorous, nitrogen, and potassium content of African soils (Rosegrant et al 2004). In general, therefore, if population growth leads to expansions in land areas used for agricultural cultivation, significant challenges will be faced in translating these expansions into increases in crop yield. At current levels of technology, however, such expansions are likely to lead to less than proportionate increases in overall crop yields in sub-Saharan African countries.

3. The supply of food

In practical terms, real success in improving food security in sub-Saharan Africa hinges on the extent to which its growing food demands are matched by corresponding increases food supply. Many constraints to natural resource use in food production processes can be overcome with improved agricultural technologies. In recent years farmers in developing countries have found ways to increase crop yields by successfully adopting such technologies. Hybrid food

strains, selective breeding, the expanded use of fertilizers, pesticides, and synthetic nitrogen have all demonstrated promise in terms of their ability to increase food supplies (Huang, Pray, and Rozelle 2002; Otsuka and Kijima 2010). Nevertheless, sub-Saharan Africa's capacity to produce similar increases in yields is strikingly lower than that of other developing regions. In recent decades, for example, improved agricultural technologies increased crop yields by between 60 and 80% in Latin America, Asia, and the Middle East while the respective increase in sub-Saharan Africa was only by about 28% (Sanchez 2002).

Beyond the necessity of increasing food supplies is the urgent need to improve the efficiency of food distribution systems to ensure that larger proportions of crop yields eventually reach local markets. Furthermore, with high rates of population growth, the expansion of food stocks will only improve prospects for food security if it results in meaningful increases in the per capita availability of food. In short, for food security to be achieved, high population growth rates need to be offset by corresponding increases in the supply of food; otherwise, the per capita availability of food calories will decline. Trends in crop yields and caloric availability are, therefore, essential for understanding whether the demand and supply for food will be reconciled, in the context of high population growth, in sub-Saharan Africa.

Crop yields

Global estimates from the IMPACT model indicate that crop yields will increase more slowly in LDCs in response to rapid population growth in Africa than to population growth in other world regions (Tokgoz and Rosegrant, unpublished). One implication of this disparity is that constraints to increasing food supplies as population size increases are likely to be greater in African than non-African countries. This comparison, however, discounts the fact that stocks of a

wide variety of food staples are expected to significantly increase, in some cases faster than population growth, between 2010 and 2050. For selected food crops, yield increases are therefore likely to keep pace with population growth in Africa even if population growth rates remain very high. However, larger increases in overall food supplies will still be required in order to meet the growing food demands of its rapidly increasing population.

Estimates from the CASE maps underscore the fact that the supply of major food staples will increase between 2010 and 2050. In fact, the increasing trend in yields for these staples is expected to persist, regardless of whether or not the impacts of climate change are mitigated. The degree to which crop yields are able to keep pace with demographic changes in sub-Saharan Africa will however vary, depending on both the expected course of population and income growth in the next four decades. For example, evidence from the CASE maps suggest that because incomes affect food purchases, and thus access to food, more favorable outcomes are likely to be observed if population growth proceeds at rates lower than current levels (IFPRI 2010).

Using information from the CASE database, Figure 3 compares projected changes in both population size and crop yields associated with the scenario of low population growth and high income growth. Across all Africa's geographic regions, yields, in millions of tons per hectare, will increase faster for the four major staple food products than population size. Arguably, the most favorably food security outcomes in Figure 3 are those associated with estimates for Southern Africa, where the size of the population is expected to decline between 2010 and 2050 under low population growth assumptions. During this period, total yields for rice and wheat are expected to double while maize yields are expected to increase by more than 60%. Additionally,

in the two regions with the fastest population growth rates, Eastern and Central Africa, rice and wheat yields will either match or exceed expected changes in population size.

Figure 3:
Changes in population size under low growth rate assumptions and total crop yeild between 2010 and 2050

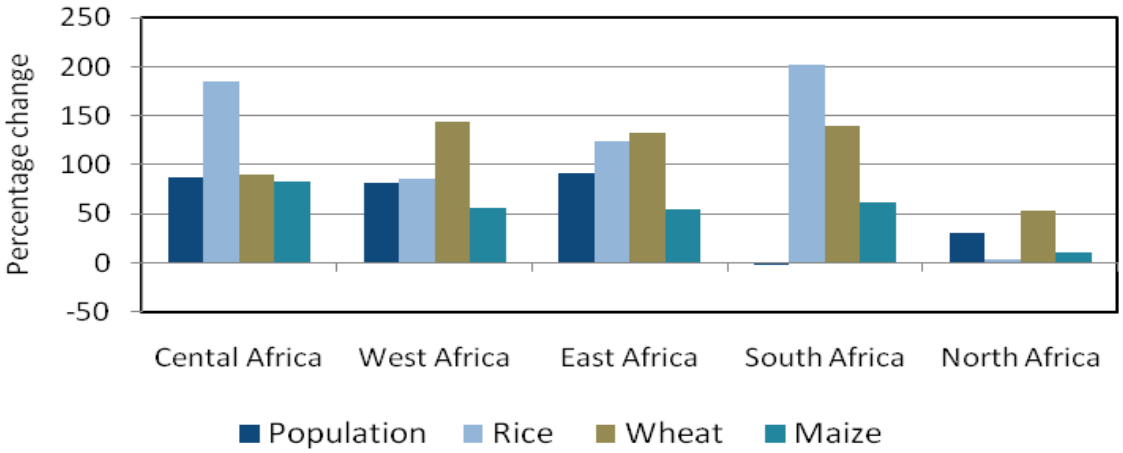
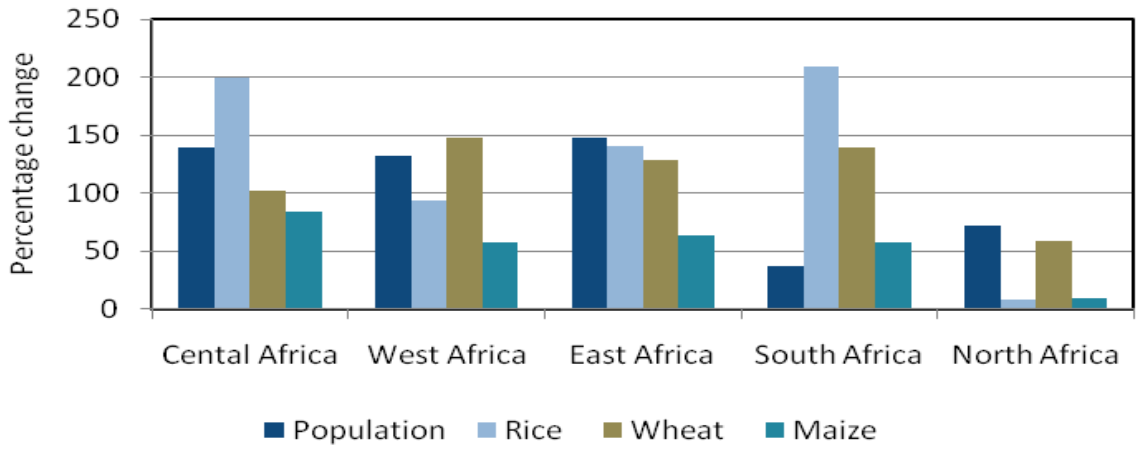


Figure 4:
Changes in population size under high growth rate assumptions and total crop yeild between 2010 and 2050



Significantly, Figure 4 indicates that yields for major food staples will still increase under assumptions associated with high population growth and low income growth. In this context, relatively larger increases in population size will pose significant challenges to achieving food

security in most African regions since population growth will outpace crop yields. In North Africa, for example, population size will increase by 72 % between 2010 and 2050 while yields for all three food staples will increase by less than 60%. Additionally, although population size, as well as rice, and wheat yields increase by at least 100% in East Africa, its percentage change in population size will exceed that for yields for all three food staples. In some regions, however, slightly higher yields will be observed for crops such as rice, if population growth rates are higher (Figure 4) than lower (Figure 3). Yet, at least in West and Central Africa, increasing rice yields will be unmatched by increasing population size if population growth rates are higher (Figure 4). Additionally, these estimates suggest that all African regions, with exception of East Africa, will have at least one major crop for which yields will increase more than population size under high growth rate assumptions. This underscores the fact that a limited availability of food choices will also possibly characterize African societies in which population growth rates exceed the growth in crop yields. These societies are thus likely to be exposed to a range of nutrition-related consequences such as low dietary quality and poor nutrient intake that are associated with contexts in which food choices are limited.

In sum, increases in the supply of major food staples will lag behind population growth if African countries have higher rather than lower population growth rates. Although the preceding analysis focuses on selected major food staples, similar disparities also emerge when population growth is compared with changes in yield associated with other food products. Soybean yields, for example, are expected to increase at rates well below population growth in South, Central, and West Africa while cassava yields are expected to increase slower than population size in West, East, and Northern Africa (IFPRI 2010).

What do these trends therefore suggest about future trends in the availability of food stocks needed for achieving food security in Africa? In general, they point to three important implications. First, they suggest that at current levels of technology, low population growth rates provide the best option for achieving parity between food supplies and population size over the next four decades. Secondly, they underscore the fact that while crop yields will increase with rapid population growth, stocks of key food staples such as rice, wheat, and maize are likely to increase at disproportionately lower rates. Thirdly, these trends imply that under contexts of rapid population growth the consequences of limited crop yields will be unevenly distributed across African geographic regions. Shortfalls in crop yields will require significant improvements in food production processes in order to keep pace with population growth. Without these improvements, rapid population growth will outstrip Africa's food production capacity and adversely affect its prospects for improving human development.

Caloric Availability

Paradoxically, many African societies experienced widespread hunger and malnutrition in recent decades despite modest increases in food production across the region. Clearly, local access to food remains a major challenge to prospects for achieving food security. One of its determinants is the per capita availability of food calories. According to the IMPACT model, significant declines in per capita calorie availability will be observed in the LDCs between 2010 and 2050 if population growth rates remain very high. In sub-Saharan Africa, evidence already suggests that similar decrease will occur as a result of differential increases in overall food calories and population size. For example, between 2000 and 2050 food calorie trends in sub-Saharan Africa are expected to remain virtually unchanged (Hubert et. al. 2011). However, the

region's population will grow by about 1.8% annually during this period under medium variant assumptions (UN 2010).

Apart from the negative effects of this discrepancy on the availability of food, income trends are also important for understanding how the relationship between population growth and food calories will unfold over the next four decades. Here again, information from the CASE database indicates that food security in sub-Saharan Africa is more likely to be achieved under a scenario of low population and high income growth. In this context, available food calories per capita per day are expected to increase in all Africa's sub-regions, but more so in Central, West, and East Africa. In these regions, available food calories per capita will increase by about 40% or more between 2010 and 2050. Conversely, data from the CASE system indicates that per capita calorie trends will generally decline if rapid population growth is accompanied by limited growth in sub-Saharan African incomes, although these declines will be less acute in the Eastern African region.

Under conditions of rapid growth, declines in per capita caloric availability are likely to be mediated by demographic mechanisms that have important implications for levels of agricultural productivity. For example, increasing population densities associated with high population growth rates can reduce land holdings, as well as diet quality, and jeopardize prospects for achieving food security (Conelly and Chaiken 2000). Estimates suggest that in about 70% of all African countries, population pressure has reduced lengths of fallow between cultivation periods and depleted soil nutrients which can negatively affect the production of food calories (Drechsel, Kunzm and Vries 2001). Projected population estimates however suggest that the significance of these mechanisms is likely to increase over the next 40 years, as the region's population density

per square kilometers increases by 75%, 100%, and 128% under low, medium, and high growth rate assumptions respectively.

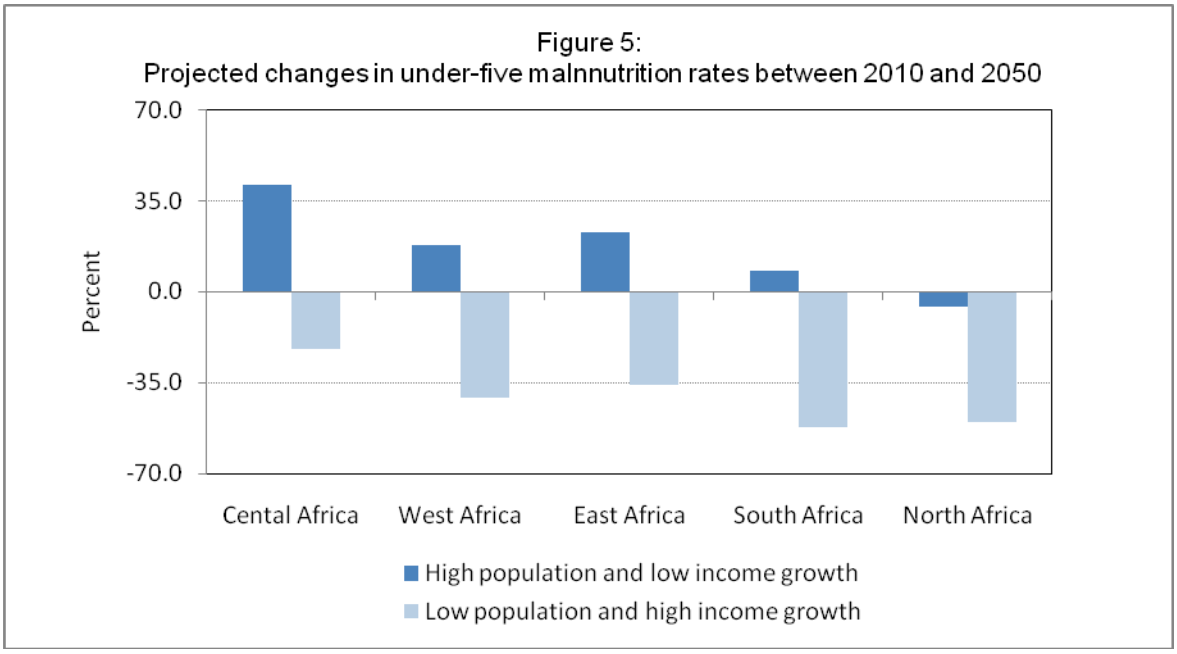
4. Implications for malnutrition

As a result of its influence on the demand, supply, and availability of food, population growth will be among the most critical determinants of malnutrition in sub-Saharan Africa over the next four decades. Corresponding trends in incomes are also important intervening influences that will determine how population growth rates will affect the prevalence of malnutrition. In general, however, the demographic influences on malnutrition operate on two related dimensions. First, rapid growth resulting from modest mortality declines in recent decades, and Africa's prevailing high fertility regimes, will continue to increase the size of its populations exposed to the risks of malnutrition and hunger.

For example, rapid growth among children will substantially increase in the size of sub-Saharan Africa's child population exposed to the risks of malnutrition between 2010 and 2050. However, potential exposure to these risks can only be realized if global social and economic relationships continue as they are. As noted earlier, the population of children below age five is expected to increase by 60% according to high variant growth assumptions. As such, without systematic efforts to improve nutritional outcomes among these children, increasingly larger numbers of children will become malnourished over the next four decades even if current rates of malnutrition remain unchanged. At the population level, high growth rates are further associated with increases in the proportion of populations exposed to the risks of hunger. Based on high growth rate assumptions, the IMPACT model predicts increases in the share of African populations exposed to hunger between 2010 and 2050 as high as 120 % in Senegal. Conversely,

the model suggests that substantial reductions in the proportion of Africans exposed to hunger will occur if population growth rates are lower than they currently are. These projected decreases range from an estimated 65% decline in Sierra Leone to a 2.3% decline in Zimbabwe.

A second dimension of the demographic influences on malnutrition will operate through the influence of population growth on proximate factors such as the size of the number of people living in poverty, pressures on natural resources, and reductions in caloric availability. Rapid population growth, in the context of high levels of poverty, will have the most adverse implications for food security in sub-Saharan Africa. For large segments of Africa's population, rising poverty will undermine effective demand for food, as a result of its constraining effect on their ability to make food purchases. Under conditions of rapid population and low income growth, the largest increases in under-five malnutrition will occur in one of Africa's fastest growing sub-regions, Central Africa, where rates of malnutrition could increase by 41% between 2010 and 2050 (IFPRI 2010). West, East, and South Africa may also experience malnutrition increases of 18%, 23%, and 8% respectively if rapid population growth is accompanied by low growth in incomes (Figure 5). Instructively, in North Africa, where population growth and poverty rates are low, malnutrition trends are expected to decline by 6.4 percent, even under high growth rate assumptions. Yet, under assumptions of low population and high income growth, the North African declines may be stronger, about 50%, while malnutrition trends may decline by double digits in each of the other four African geographic regions.



D. Conclusions

Future demographic changes and the ways in which they affect food security therefore have important implications for human development in sub-Saharan Africa. Based on the evidence reviewed in this chapter it seems clear that the demographic influences on food security are generally multidimensional. Evidence presented in this analysis suggests that Africa's high population growth rates have important implications for trends in the demand for food, constrain the use of natural resources, and negatively affect caloric availability. In the long run, these impacts may have adverse implications for the dynamics of hunger and malnutrition in sub-Saharan Africa since they may be concentrated among Africa's most vulnerable populations.

Projected changes in the demographic composition offer important clues concerning the segments of sub-Saharan Africa's population that will be increasingly susceptible to food insecurity under conditions of high population growth. In large part, these vulnerable groups are

the same groups likely to see significant changes in their patterns of food demand. Thus, they include the rural poor, women in the reproductive ages, and large cohorts of children born under Africa's high fertility regimes. Furthermore, Africa's elderly population, which will constitute the fastest growing age-group in its population during this period (UN 2010), will also be vulnerable to these risks since they are largely economic dependants.

Significantly, however, the possible impacts of these projected demographic changes are expected to operate within larger socioeconomic contexts. For example, if we assume economic stagnation or decline, rapid population growth concentrated among economically vulnerable segments of African society may increase the number of people living in poverty and increase food insecurity. In this context, food insecurity will not so much reflect the limited availability of food as it will the economic limitations to the access of food. Beyond these limitations, however, is the fact that rapid population growth in sub-Saharan African will very likely to be accompanied by overall decreases in caloric availability. Left unchecked, the combination of rising poverty and high population growth rates may produce the least favorable food security outcomes in Africa over the next four decades.

Prospects for food security can however be improved by targeted policies that seek to increase livelihoods and mitigate the causes and consequences of rapid population growth. Such policies could include the provision of enhanced poverty safety nets in rural areas that will both improve livelihoods and in the long run contribute towards fertility reduction. Renewed efforts are also needed to increase the adoption of improved technologies to more effectively utilize natural resources for food production processes. Conceptually, the benefits associated with these interventions are clear. However, sub-Saharan Africa still needs to maximize the use of these technologies in order to increase crop yields in ways that match its population growth trends.

Progress in this regard will positively affect caloric availability as food supplies increase. The combination of poverty reduction, population growth reduction, and technological expansion, therefore, offers the most favorable policy option for improving food security in Africa over the next four decades.

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