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2020 VISION

2020 Discussion Paper 41 • August 2005

Looking Ahead

Long-Term Prospects for Africa's Agricultural Development and Food Security

Mark W. Rosegrant, Sarah A. Cline,
Weibo Li, Timothy B. Sulser, and
Rowena A. Valmonte-Santos

"A 2020 Vision for Food, Agriculture, and the Environment" is an initiative of the International Food Policy Research Institute (IFPRI) to develop a shared vision and consensus for action on how to meet future world food needs while reducing poverty and protecting the environment.

2020 discussion papers present technical research results that encompass a wide range of subjects drawn from research on policy-relevant aspects of agriculture, poverty, nutrition, and the environment. They contain materials that IFPRI believes are of key interest to those involved in addressing emerging food and development problems.

This discussion paper was prepared for the IFPRI 2020 conference "Assuring Food and Nutrition Security in Africa by 2020: Prioritizing Actions, Strengthening Actors, and Facilitating Partnerships," Kampala, Uganda, April 1–3, 2004. Designed in close consultation with a distinguished Advisory Committee, the conference is the centerpiece of a longer-term consultative process on implementing action for African food and nutrition security. This process is cosponsored by the European Commission (EC); Canada Fund for Africa; Centre de coopération internationale en recherche agronomique pour le développement (CIRAD); Centre Technique de Coopération Agricole et Rurale (CTA); Deutsche Welthungerhilfe (German Agro Action); Development Cooperation Ireland; Federal Ministry for Economic Co-operation and Development, Germany, with Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and Internationale Weiterbildung und Entwicklung (InWEnt); Ministère des Affaires étrangères, France; Regional Land Management Unit (RELMA); The Rockefeller Foundation; Sasakawa Africa Association; United States Agency for International Development (USAID); World Food Programme (WFP); and World Vision International. The 2020 Vision Initiative also gratefully acknowledges support from the following donors: Canadian International Development Agency (CIDA); Danish International Development Agency (Danida); and Swedish International Development Cooperation Agency (Sida).

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August 2005

Suggested citation:
Rosegrant, Mark W., Sarah A. Cline, Weibo Li, Timothy B. Sulser, and Rowena A. Valmonte-Santos. 2005. *Looking Ahead: Long-term prospects for Africa's agricultural development and food security*. 2020 Discussion Paper No. 41. Washington, D.C.: International Food Policy Research Institute.

Publisher:
International Food Policy Research Institute
2033 K Street, NW
Washington, DC 20006-1002
Telephone: +1-202-862-5600
www.ifpri.org

Printed in the United States of America on recycled paper.

ISBN 0-89629-655-5

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Foreword

Sub-Saharan Africa is the only developing region in the world where food insecurity has worsened instead of improved in recent decades. In this discussion paper, Mark W. Rosegrant, Sarah A. Cline, Weibo Li, Timothy B. Sulser, and Rowena A. Valmonte-Santos show that this discouraging trend need not be a blueprint for the future. The research contained in this discussion paper was conducted in preparation for the IFPRI 2020 Africa conference "Assuring Food and Nutrition Security in Africa by 2020: Prioritizing Actions, Strengthening Actors, and Facilitating Partnerships," held in Kampala, Uganda, April 1–3, 2004.

The authors examine the implications of several different policy scenarios based on IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT). This model, developed at IFPRI in the early 1990s, has been continually updated to incorporate more food sectors and geographic regions. In this paper, the authors use IMPACT to assess the consequences of a wide range of policy and investment choices for Africa, including a business as usual scenario (continuation of current policy and investment trends through 2025), a pessimistic scenario (declining trends in key investments and in agricultural productivity), and a vision scenario (improving trends in investments and hence in agricultural productivity and human capital), as well as scenarios for more effective use of rainfall in agriculture, reduced marketing margins, and three different scenarios for trade liberalization. The wide variation in results reveals how much these choices will matter. For example, the number of malnourished children under five years old in Sub-Saharan Africa in 2025 is projected to be 38.3 million under business as usual, 55.1 million under the pessimistic scenario, and 9.4 million under the vision scenario. It is our hope that this research will clarify the steps needed to help stimulate the actions contributing to approaching the vision scenario.

Joachim von Braun
Director General, IFPRI

Acknowledgments

We would like to particularly acknowledge the strong support and insightful comments of Rajul Pandya-Lorch, head of IFPRI's 2020 Vision Initiative. We thank two anonymous reviewers who provided helpful comments. We also extend our warm appreciation to Mary-Jane Banks and Heidi Fritschel for their excellent editorial assistance.

Executive Summary

Food security in Africa has substantially worsened since 1970. Although the proportion of malnourished individuals in Sub-Saharan Africa has remained in the range of 33–35 percent since around 1970, the absolute number of malnourished people in Africa has increased substantially with population growth, from around 88 million in 1970 to an estimate of over 200 million in 1999–2001.

Yet this discouraging trend need not be a blueprint for the future. New research from IFPRI shows that policy choices and investments made now could substantially improve, or further worsen, the prospects for food security in Africa over the next two decades. This paper explores and evaluates the consequences of various policies related to food security in Africa based on projections for the year 2025, focusing on agricultural production. It uses IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) and IMPACT–WATER to consider how several different policy scenarios are likely to affect the supply of, demand for, and trade of crops. The results of these policy scenarios show that the number of malnourished children, one important indicator of food security, could rise as high as 41.9 million or fall as low as 9.4 million by 2025.

The *business as usual* scenario assumes a continuation of current trends and existing plans in food policy, management, and investment, including declining investments in the agricultural sector. Agricultural production grows only modestly to 2025. Although per capita kilocalorie consumption rises and the percentage of malnourished children under age five falls from 32.8 to 28.2 percent, the absolute number of malnourished children rises from 32.7 million in 1997 to 38.3 million in 2025.

The *pessimistic* scenario envisions a future in which trends in agricultural production and nutrition deteriorate by comparison with *business as usual*. African countries experience a decline in both domestic and international investments in education, health, clean water, and agricultural research. Agricultural productivity and yield growth decline compared with *business as usual*, whereas harvested area growth increases at the same slow rate as in *business as usual*. Malnutrition in Africa proliferates under this scenario. Per capita kilocalorie availability in Sub-Saharan Africa increases only slightly, and the total number of malnourished children under five years old in Sub-Saharan Africa escalates from 32.7 million to 55.1 million in 2025.

The *vision* scenario attempts to show what type of transformation would be necessary for Africa to reach the MDG target of cutting the proportion of people suffering from hunger in half by 2015. In this scenario national governments and international donors increase investments in education, HIV/AIDS prevention and treatment, water-harvesting technologies and agricultural extension, female schooling, and clean water access in Africa. Population growth slows, but gross domestic product and crop productivity increase significantly. Under this scenario available kilocalories per capita increase markedly in Sub-Saharan Africa, while the total number of malnourished children is reduced to 9.4

million in 2025. Most notably, the percentage of malnourished children under five years old meets—or comes close to meeting—the proposed MDG target of cutting the percentage of malnourished children in half by 2015 in all African regions.

IMPACT was also used to model other types of scenarios related to specific technologies, policies, and investments. Three scenarios show that improved water harvesting can result in increased effective rainfall for agricultural use in rainfed areas, with consequent increases in agricultural production and declines in cereal prices. A *reduced marketing margins* scenario showed the effects of improvements in rural infrastructure, marketing, and communications. This scenario leads to an increase in cereal production and demand in Africa, while reducing the percentage of malnourished children in Sub-Saharan Africa in 2025 to 25.2 percent, compared with the 26.8 percent projected under *business as usual*. This percentage difference is equivalent to 2.3 million fewer malnourished children under five years old in Sub-Saharan Africa in 2025. Finally, three scenarios were modeled to assess the effects of different levels of trade liberalization on Africa. These scenarios all raise commodity prices to varying degrees, but full trade liberalization also offers substantial net economic benefits to Africa.

Many of the challenges facing Africa's agricultural sector stem from a few root causes, including poor political and economic governance in many African countries, inadequate funding for the agricultural sector, poor water resources management, and neglect of research and development. The strategies for addressing these challenges should take into account local, natural, and human resources, as well as the political and economic agenda of each country. However, the various scenarios assessed here point to common policy priorities for addressing food and nutrition security in Africa. These priorities include (1) reform of agricultural policies, trade, and tariffs; (2) increased investment in rural infrastructure, education, and social capital; (3) better management of crops, land, water, and inputs; (4) increased agricultural research and extension; and (5) greater investments in women.

1. Africa's Food Security Challenge

In 2000 the world community adopted eight Millennium Development Goals that aimed to promote human development and reduce poverty, hunger, and disease, even in the poorest countries. Some developing regions and countries are making progress toward these goals, but in many categories measured, including food security, the situation in Africa is stagnant or worsening. More than 200 million Africans now suffer from malnutrition.

Policy choices and investments made now could substantially improve, or further worsen, the prospects for food security in Africa over the next two decades. This paper explores and evaluates the consequences of various policies related to food security in Africa based on projections for the year 2025, focusing on agricultural production. We use IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) to consider how several different policy scenarios are likely to affect the supply of, demand for, and trade of crops. We also draw on IFPRI's IMPACT–WATER model to examine additional projections concerning the future of water resources.

The paper begins by examining the current food security situation and the serious challenges for Africa in the coming decades. Chapters 2, 3, and 4 discuss and analyze possible futures for food and water resources in Africa, and the final chapter presents conclusions.

Food Security in Africa

While the definition of food security has evolved over time (see Heidhues et al. 2004 for a more detailed discussion), a food-secure household is generally described today as one that can reliably obtain food of adequate quality and quantity to support a healthy and active life for all members of the household. Food security is influenced by many factors, including poverty, consistent access to food, nutrition, food production, the availability of resources, and coping strategies. Food availability is crucial to food security, but it is not the only factor necessary for a household to be food secure. Even when production levels are sufficient to meet demand in a given region, households remain food insecure if they do not have the income or resources to purchase or produce the food they require. Consistent access to food is also important; smallholder farmers can often produce enough food for their households following the harvest, but they may struggle with food shortages at other times of the year (Benson 2004).

Food security in Africa has substantially worsened since 1970. Although recent data show that the proportion of malnourished individuals in Sub-Saharan Africa fell slightly from 35 percent in 1990–92 to 33 percent in 1999–2001, a longer-term perspective reveals that this share has remained within the 33–35 percent range since around 1970. Even more discouraging, the absolute number of malnourished people in Africa has increased substantially with population growth, from around 88 million in 1970 to an estimate of over 200 million in 1999–2001 (FAO 2003). This record is in stark contrast to that of other developing regions such as South and East Asia, which have made significant strides in combating malnutrition over the same time frame.

The aggregate numbers, however, conceal considerable variation across the African continent. During the 1990s the proportion of malnourished people declined in all African regions except Central Africa, where it increased from 35 percent in 1990–92 to 58 percent in 1999–2001, driven primarily by an increase of

44 percent in the Democratic Republic of Congo. Some progress has been made in the other Sub-Saharan regions, particularly in West Africa, where the rate of malnutrition fell from 21 percent in 1990–92 to 15 percent in 1999–2001. In Benin, Ghana, and Nigeria, in particular, both the percentage and the number of malnourished people have consistently declined over the past 20 years (InterAcademy Council 2004). Both East and southern Africa have made some progress in reducing the percentage of undernourished people; nevertheless, around 40 percent of the populations of both these regions are still malnourished. Not surprisingly, North Africa has a much lower proportion of malnourished people than the rest of the continent, at 4 percent in 1999–2001 (FAO 2003).

Another indicator of food insecurity is the proportion of undernourished children in a region. This indicator has also shown an increasing trend in Africa over the past 30 years, from around 27 percent in the 1970s to over 33 percent more recently (InterAcademy Council 2004). This trend is striking, because Africa is the only developing region where the number of malnourished children has been increasing. Again, there is variation across the continent, with some countries faring much worse than others. In some Sub-Saharan African countries, including Burundi, Eritrea, Ethiopia, Madagascar, and Niger, the prevalence of undernourishment in children under five years old is over 40 percent (FAO 2003). Even worse, many countries in Africa with high rates of childhood malnutrition have shown increasing trends (InterAcademy Council 2004).

Challenges Facing African Food Security

The challenges Africa faces in building food security include physical factors, such as climate, geography, and poor resource endowments; political factors, such as lack of sound governance, infrastructure, and public-private partnerships, and the need for political reform; and socioeconomic factors, such as HIV/AIDS, poverty, gender inequality and lack of empowerment of women, and low water availability. The most daunting of these challenges are discussed below.

Box 1—African regions within IMPACT

Sub-Saharan Africa (SSA)

- Central and western SSA: Benin, Cameroon, Central African Republic, Comoros, Congo Republic, Côte d'Ivoire, Democratic Republic of Congo, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Sao Tome and Principe, Senegal, Sierra Leone, and Togo
- Eastern SSA: Burundi, Kenya, Rwanda, Tanzania, and Uganda
- Nigeria
- Northern SSA: Burkina Faso, Chad, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Somalia, and Sudan
- Southern SSA: Angola, Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Reunion, Swaziland, Zambia, and Zimbabwe

West Asia and North Africa (WANA)

- Egypt
- Turkey[a]
- Other WANA: Algeria, Cyprus, Iran, Iraq, Jordon, Kuwait, Lebanon, Libya, Morocco, Saudi Arabia, Syria, Tunisia, United Arab Emirates, and Yemen

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[a] Results for Turkey (part of West Asia) are not presented in this paper except in cases where data aggregation precludes their exclusion from West Asia/North Africa. These instances are noted where relevant.

Lack of Sound Governance

Poor governance is a major issue in many African countries, and one that has serious repercussions for long-term food security. Problems such as corruption, collusion, and nepotism can significantly inhibit the capacity of governments to promote development efforts. Corruption is perceived to be significant in many African countries. Transparency International's Corruption Perception Index, for example, rates 8 countries in Africa[1] among the top 20 most corrupt countries worldwide (Transparency International 2003). Corruption and other governance problems are also often correlated with conflict, and governance-related conflicts are often linked with hunger and food security, both as a cause and as an effect (Messer and Cohen 2004). This tendency was substantiated by a study conducted by Estache and Kouassi (2002) that showed that high levels of inefficiency, including inaccessibility and unavailability of resources, are linked with weak governance and institutions.

Long-term peace and security—absent in many African countries—are crucial to development (Zhang 2004). Further, the political and legal frameworks that enable development through strong institutions, community participation and empowerment, social equity and justice, and government accountability are preconditions for the success of agricultural development strategies. Local and regional farmer organizations are a key component, for example, in facilitating communication and information exchange, and in encouraging the adoption of appropriate methods and technologies. Sound governance can inhibit conflict and allow the prioritization of appropriate development strategies, including support for a strong agricultural sector. All countries depend on sound governance for sustainable agricultural development, but different countries take different measures to ensure sound governance, according to their individual country conditions (see Paarlberg 2002 for further discussion of governance and food security).

HIV/AIDS

Africa has absorbed the brunt of the HIV/AIDS epidemic, particularly in Sub-Saharan Africa, where AIDS is the leading cause of adult mortality and morbidity. In 2003, an estimated 26.6 million people were living with HIV in Africa, and another 2.3 million people died of AIDS (UNAIDS 2003). In addition to its obvious health, economic, and social impacts, the disease has serious impacts on food security and nutrition. Since AIDS strikes the most productive age group (15- to 50-year-olds), when family members fall ill or die from the virus, households are less able to produce or buy food, assets are depleted for medical or funeral costs, and children are frequently left without adults to care for them. Those who are infected often die before they can pass on crucial farming knowledge and expertise to the next generation, a situation that has lasting effects on agricultural production. The Food and Agriculture Organization of the United Nations (FAO) estimates that by 2020 the epidemic will claim the lives of 20 percent or more of the population working in agriculture in many southern African countries. Moreover, more than two-thirds of the total population of the 25 most-affected countries resides in rural areas, affecting agricultural production as well as farm and domestic labor supplies (FAO 2000a, 2004a). And because women in Southern Africa are a major source of agricultural labor, food production can be reduced by up to 60 percent in HIV-infected households when women's time and energy are diverted to care for family members infected with HIV (Oxfam International and Save the Children 2002).

Households must often switch from the production of more nutritious, labor-intensive crops, such as maize, to less labor-intensive root crops that provide poor nutrition. Lack of resources also makes it more difficult for HIV-affected households to supplement their diet through the purchase of more nutritious and varied foods. The prevalence of stunting, for example, is greater among orphans in AIDS-affected households. In addition,

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[1] Including North and Sub-Saharan Africa.

malnutrition increases family members' susceptibility to HIV (for example, through transference from mother to baby), creating a vicious cycle that supports the progression of the virus (Haddad and Gillespie 2001). The effect of malnutrition is further exacerbated because HIV-infected individuals actually have greater nutritional requirements than the rest of the population; they require up to 50 percent more protein and 15 percent more calories (Haddad and Gillespie 2001).

Soil Infertility

Soil quality in Africa varies widely, ranging from very old, weathered, and leached rocks to soils inherently low in nutrients because of their clay and organic matter content (DFID 2002). In Sub-Saharan Africa soil quality is classified as degraded on about 72 percent of arable land and 31 percent of pastureland. In addition to natural nutrient deficiencies in the soil, soil fertility is declining by the year through "nutrient mining," whereby nutrients are removed over the harvest period and lost through leaching, erosion, or other means. Nutrient levels have declined over the past 30 years, resulting in low levels of minerals like nitrogen, phosphorus, and potassium.[2] Some studies have shown that depletion rates for these three nutrients are greater than 60 kilograms per hectare per year for many countries and sites (Smaling, Nandwa, and Janssen 1997; De Jager et al. 1998; van den Bosch et al. 1998; Wortmann and Kaizzi 1998; Nkonya et al. 2003). Arable land declined by 24.5 percent per capita in Africa between 1980 and 1993, which is 1.3 times the global average of 18 percent (UNU–INRA/World Bank 1999). This severe soil fertility depletion and erosion affects both marginal and high-quality rainfed lands. Expansion of agricultural lands into marginal areas also contributes to degradation of soil fertility.

Several studies point to possible causes of soil fertility depletion in Africa (Pender, Place, and Ehui 1999; UNU–IRA/World Bank 1999; Barrett et al. 2002). Some of the factors most commonly mentioned include the limited adoption of inorganic fertilizer or organic fertilizer replenishment strategies; the limited adoption of soil and water conservation measures; use of heavy machinery on soils with weak soil structure; the declining use and length of fallow periods; the expansion of agricultural production into marginal and fragile areas, such as cultivation on steep slopes or in arid areas without proper anti-erosion measures; the use of animal dung and crop residues as fuel rather than as soil amendments; and the removal of vegetation through overgrazing, logging, development, and domestic use. Soil fertility depletion can also be related to many socioeconomic, institutional, and policy-related factors. Rapid population growth, limited access to agriculture-related technical assistance, and lack of knowledge about profitable soil fertility management practices can lead to expansion into less-favored lands. Access to fertilizer can also be constrained by (1) market liberalization and trade policies that increase fertilizer prices relative to commodity prices; (2) limited access to markets and infrastructure; (3) limited development of output, input, and credit markets; and (4) poverty and cash constraints that limit farmers' ability to purchase fertilizer and other inputs and cause them to focus on the short term (Pender, Place, and Ehui 1999).

A number of approaches have been adopted to deal with soil infertility in Sub-Saharan Africa. These approaches include organic farming, high external input agriculture, low external input sustainable agriculture, and integrated soil fertility management (Pender and Mertz 2004; Martin 1999; Makokha et al. 2001; Kirchmann and Bergstrom 2001). Pender and Mertz (2004) argue that a pragmatic approach to the problem is needed, and no single approach will likely succeed because of the diverse contexts of Sub-Saharan Africa.

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[2] For an estimated 1 million square kilometers of cultivated land, the rates were 660 kilograms per hectare for nitrogen, 75 kilograms per hectare for phosphorus, and 450 kilograms per hectare for potassium. In contrast, farms in North America have actually increased the average nutrient level per hectare: up to 2,000 kilograms for nitrogen, 700 kilograms for phosphorus, and 1,000 kilograms for potassium over the same period (UNU–INRA/World Bank 1999).

Poverty

The history of poverty in Africa is punctuated by systematic marginalization by colonial powers, chronically poor resource endowments at both household and regional levels, and the vagaries of climate and geography, from massive droughts and floods to extreme remoteness. Instability due to continuing political, ethnic, and armed conflicts further entrenches parts of Africa in a cycle of chronic poverty and food insecurity. Poverty in Africa has also been affected historically by unfavorable trade policies and the external debt burdens held by many African nations. Lack of government investments in social services and infrastructure has hindered economic development, thus adding to mounting poverty levels.

Poverty has serious effects on food and nutrition security. It contributes to poor agricultural productivity, as many African farmers cannot afford to purchase inputs such as fertilizer, pesticides, and improved seeds, which would help to increase productivity. Additionally, poverty reduces the ability of poor consumers to purchase the food required to maintain a healthy and productive life. Per capita consumption of food has actually declined in recent years in some African regions.

According to a traditional measure of poverty (the number of people living on less than US$1 per day), 163.6 million people in Sub-Saharan Africa lived below the poverty line in 1981, and the number increased to 226.8 million in 1990 and 315.8 million in 2001. The poverty estimates also increased in percentage terms, with 41.6 percent below the poverty line in 1981, 44.6 percent in 1990, and 46.9 percent in 2001 (World Bank 2004b).

Although these traditional measures of poverty are commonly used, many in the development community have supported measures such as the Millennium Development Goals (MDGs) that use a complex set of conditions as a yardstick in assessing the entire living situation of poor people. Many African nations have fully committed to poverty reduction strategies (UNECA 2003) that model the MDGs established by the Millennium Declaration of the United Nations, although these country strategies are not quite as ambitious (World Bank 2003b). Though poverty is still a much more complicated problem than quantitative indicators can represent (UNDP 2003; World Bank 2001a, 2001b, 2003a), the MDG targets were established in an effort to address the reality of poverty (and the experience of the world's poor) more comprehensively than in the past (Table 1). The MDG indicators and targets provide a means of measuring trends and improvements in the areas of income, hunger, education, gender equality, health, the environment, and access to opportunities for development.

Poor Infrastructure

Infrastructure is one of the key inputs to more rapid agricultural development in Africa. Several studies have shown the aggregate-level links between poverty, growth, and rural capital-intensive infrastructure in Africa and other developing regions, including Lipton and Ravallion (1995), Jimenez (1995), and Van de Walle (1996). The impact of specific infrastructure components, such as rural roads, telephones, or electricity, on poverty alleviation and growth has been documented in Howe (1984); Binswanger, Khandker, and Rosenzweig (1993); Jacoby (1998)/ and Lebo and Schelling (2001).

Renkow, Hallstrom, and Karanja (2004) estimated the fixed transaction costs (those not dependent on commercialized volume) that hinder subsistence farmers' access to product markets in Kenya. They found out that high transaction costs are equivalent to a value-added tax of approximately 15 percent, illustrating the potential for raising producer welfare with effective infrastructure investments. Another study in Uganda by Smith et al. (2001) shows that the rehabilitation of roads increases labor opportunities in the service sector, possibly leading to poverty reduction. In addition, road, rail, and telecommunications are important determinants of bilateral trade flow. Limão and Venables (1999) found that improving destination infrastructure by one standard deviation reduces transport costs by an amount equivalent to a reduction of 6,500 kilometers at sea or 1,000 kilometers of overland travel. Results of their study demonstrated that most of Africa's poor trade performance can be accounted for by poor infrastructure. Moreover, lack of adequate infrastructure in much of Sub-Saharan Africa impedes more productive agriculture.

Torero and Chowdhury (2005) show that Sub-Saharan Africa has continued to lag significantly behind other regions in infrastructure investments, including paved roads, telephone lines, and electricity production. Less than half of the population in Sub-Saharan Africa has access to safe drinking water (Fishbein 2001), and the availability of clean water may affect child mortality rates (Galiani, Gertler, and Schargrodsky 2003) as well as the attainment of universal primary education for girls

Table 1—Millennium Development Goals and targets

Goals	Targets
1. Eradicate extreme poverty and hunger	1. Halve the proportion of people whose income is less than $1 a day 2. Halve the proportion of people who suffer from hunger
2. Achieve universal primary education	3. Ensure that children everywhere, boys and girls alike, will be able to complete a full course of primary schooling
3. Promote gender equality and empower women	4. Eliminate gender disparity in all levels of education
4. Reduce child mortality	5. Reduce by two-thirds the under-five-year-old mortality rate
5. Improve maternal health	6. Reduce by three-quarters the maternal mortality ratio
6. Combat HIV/AIDS, malaria, and other disease	7. Halt and reverse the spread of HIV/AIDS 8. Halt and reverse the incidence of malaria and other major diseases
7. Ensure environmental sustainability	9. Integrate the principles of sustainable development into country policies and reverse the loss of environmental resources 10. Halve the proportion of people without sustainable access to safe drinking water and basic sanitation 11. Achieve a significant improvement in the lives of at least 100 million slum dwellers
8. Develop a global partnership for development	12. Develop further an open, rule-based, predictable, nondiscriminatory trading and financial system 13. Address the special needs of the least developed countries 14. Address the special needs of landlocked countries and small island developing states 15. Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term 16. In cooperation with developing countries, develop and implement strategies for decent and productive work for youth 17. In cooperation with pharmaceutical companies, provide access to affordable, essential drugs in developing countries 18. In cooperation with the private sector, make available the benefits of new technologies, especially information and communications

Source: UNSD 2004b.

(Leipziger et al. 2003). The significant lags in infrastructure have normally been attributed to geography (diseases, internal distance, and sparsely populated areas are a big obstacle) and to the poor initial condition of infrastructure in Africa. Unlike Asia and Latin America, Sub-Saharan Africa inherited a highly dispersed and unevenly distributed infrastructure from its colonial past. There was little improvement of infrastructure, if any, during the colonial era, and "in some important respects, it can even be said that colonial policy reinforced the handicaps of SSA [Sub-Saharan Africa]" (Platteau 1996, 200). The limited infrastructure that was built during that era was driven by the objective of connecting natural resources to export markets. The rest of the continent was virtually ignored, and this skewed distribution of infrastructure was perpetuated even after independence. Ensuring adequate infrastructure is an essential challenge for agricultural development in Africa.

Limited Access to Developed-Country Markets and Difficulties with Economic Liberalization

Economic liberalization in Africa has had mixed results. The economic crisis of the 1980s induced most African countries to accept long-run structural adjustment programs representing a wide range of market liberalization and public sector reforms, including major agricultural sector reforms. Reforms focused on liberalizing input and output prices, eliminating regulatory controls on input and output markets, and restructuring public enterprises (including removing the regulatory functions of marketing boards) (Rosegrant et al. 2001). These reforms were implemented with the idea that introducing market forces to the agricultural sector would immediately lead to economic growth. Reforms to food crop markets were more comprehensive than reforms to export crop markets in central and western Africa, and actual reforms in southern and eastern Africa have been limited, with state trading and price bands remaining in effect in a number of countries, including Kenya, Malawi, and Zimbabwe (Kherallah et al. 2000).

State-owned enterprises in Africa continue to dominate fertilizer, seed, and agrochemical markets regardless of the penetration of some multinationals and private traders. Hence input market reforms are significantly less comprehensive throughout the region compared to the rest of the world. Most reform efforts have been partially reversed in the face of resistance by entrenched groups. These entrenched groups want to keep their access to rents and privileges, while most regional governments lack strong political legitimacy and are unwilling or unable to generate solid indigenous support for major reform efforts. Donor demands and prescriptions tend to dominate policymaking (Kherallah et al. 2000).

The global trade environment has also caused serious problems for African agriculture. Support policies and border protection of the wealthy countries of the Organization for Economic Cooperation and Development (OECD), valued at hundreds of billions of dollars each year, cause harm to agriculture in developing countries. Estimates utilizing general equilibrium models show that the increase in world prices from removal of OECD protection will lead to larger agricultural production in developing countries. Beghin, Roland-Holst, and Van der Mensbrugghe (2002) estimate that removal of OECD protection could boost rural value-added in low- and middle-income countries by US$60 billion per year. Other studies (Tokarick, Sutton, and Yang 2002; Tokarick 2003) arrive at lower numbers, estimating that OECD market access barriers and subsidy policies cost developing countries as a whole US$8 billion in overall welfare annually (0.13 percent of developing-country gross domestic product [GDP]). Diao, Diaz-Bonilla, and Robinson (2003) estimate that OECD subsidies and border protection reduce agricultural exports from the developing world by US$37.2 billion (25.3 percent) annually. Agricultural value-added among developing countries is reduced by US$23.0 billion annually, while national welfare of developing countries is repressed by US$9.4 billion. For specific countries and specific commodities, the effects can be critical, as in the case of cotton for the rural poor in a number of African countries. Using household survey data, Minot and Daniels (2002) find that a 20 percent drop in world cotton prices, as might be due to developed-country subsidies, would increase poverty in Benin, a country dependent on cotton exports, by 4 percentage points through direct and indirect effects on rural incomes. This increase is equivalent to a 10 percent rise in the population living under the poverty line.

In addition, GATT (General Agreement on Tariffs and Trade), TBT (Technical Barriers to Trade), SPS (Sanitary and Phyto-Sanitary Agreements), the HACCP (Hazard Analysis and Critical Control Points) system, and other trade policies make it difficult for Africa and most developing countries to comply and penetrate the international markets, particularly those of the developed world. Compliance with these trade policies entails economic costs for export producers from developing countries, increasing the likelihood that their products will only reach the domestic market and that economic growth from the international market will be restricted.

Limited Irrigation

Some experts argue that the full potential of irrigation in Africa has not yet been completely exhausted, claiming that of the 42.5 million hectares (ha) of potential irrigated land, only 30 percent (12.7 million ha) is being irrigated (InterAcademy Council 2004). FAO (1997) points out that this prospective irrigated area is not being exploited because more than 60 percent of the area is located in humid regions, with almost 25 percent in the Congo Basin alone. These areas have excessive rainfall, and as a result irrigation is only supplementary.

Unlike in Asia, investment costs in Africa are substantial, ranging from US$5,000 to US$25,000 per ha (InterAcademy Council 2004). Costs of water development have been increasing for medium- and large-scale irrigation, with the cost of full water control at US$8,300 per ha in Sub-Saharan Africa compared with US$6,800 per ha in North Africa in 1995 dollars (FAO 1995). As a result of the high indirect costs of social infrastructure, including roads, houses, electric grids, and public service utilities, the average irrigation cost in Sub-Saharan Africa has risen to US$18,300 per ha (Rosegrant, Cai, and Cline 2002).

Aside from the prohibitive irrigation costs, irrigation in Africa often generates low benefits because of (1) inherently difficult agroclimatic and agronomic conditions, (2) lack of appropriate crop varieties and low use of complementary inputs (such as fertilizer), (3) labor scarcity leading to high labor costs and labor bottlenecks at peak seasons, (4) insecure land tenure and water rights that reduce incentives to invest in and maintain irrigation facilities, (5) problems in coordinating technical and socioeconomic aspects of irrigation and irrigated farming, (6) poor operation and maintenance of irrigation systems, and (7) overvalued exchange rates as a disincentive to agricultural production (Rosegrant and Perez 1997).

The factors mentioned have made Africa a predominantly rainfed agricultural region. Of 1.101 billion ha of agricultural area in Africa, only 1.15 percent (12.68 million ha) was irrigated in 2000 (InterAcademy Council 2004). In 1995 the total cereal area relying on rainfall for water supply ranged from 78 percent in West Asia and North Africa (WANA) to 96 percent in Sub-Saharan Africa. Rosegrant et al. (2002) project rainfed area to remain relatively stable until 2025, with 77 percent of area remaining rainfed in WANA and 95 percent in Sub-Saharan Africa.

Low Agricultural Research Investment

Analysis of global public agricultural research expenditures showed a declining annual growth rate in both developed and developing countries from 1976 to 1996 (Table 2) (Pardey and Beintema 2001). The poorest performance is in Sub-Saharan Africa, where public agricultural investment grew at only 1.5 percent per year during this period (one-third the rate of developing countries as a whole), and actually declined in the first half of the 1990s. As a result of this slow growth, annual expenditures on agricultural research were only 25 percent higher in Sub-Saharan Africa in 1995 than in 1976, while they nearly tripled in other developing countries as a whole.

Another measure of agricultural research intensity is to estimate agricultural research expenditures as a percentage of agricultural GDP. Both developed and developing countries had an increasing percentage of public research expenditure as a share of agricultural GDP from 1976 to 1995. All

Table 2—Annual growth rate (%) of global public agricultural research expenditures, 1976-96

Region	1976–81	1981–86	1986–91	1991–96	1976–96
Developing countries	7.0	3.9	3.9	3.6	4.5
Sub-Saharan Africa	1.7	1.4	0.5	–0.2	1.5
China	7.8	8.9	2.8	5.5	5.2
Asia and Pacific, excluding China	8.2	5.1	7.5	4.4	6.5
Latin America and the Caribbean	9.5	0.5	0.4	2.9	2.5
Middle East and North Africa	7.4	4.0	4.2	3.5	4.8
Developed countries	2.5	1.9	2.2	0.2	1.9
Total	4.5	2.9	3.0	2.0	3.2

Source: Pardey and Beintema 2001.
Note: See Pardey and Beintema 2001 for further explanation on computation of estimates.

regions of the world showed an increasing share except for Sub-Saharan Africa, where public research expenditure as a share of agricultural GDP is declining, implying a reduction of government support to agricultural R&D. African governments have cut their support because of pressure to reduce spending in general. Declines may also be due to a shift in priorities, with governments questioning the value of research and extension given the lack of improvement in agricultural productivity in Africa. Donor assistance to agricultural research has likewise declined as a result of priorities shifting from agricultural production to environmental protection, health, education, water and sanitation, and other areas.

Moreover, in contrast to other developing regions of the world, the private sector in Africa is not increasing its research efforts as government spending declines. Beintema and Stads (2004) showed that private sector investment in agricultural R&D in developing countries during 2000 was insignificant. Private sector investment amounted to 50 percent of total agricultural R&D in developed countries in 1995, compared with only 5.5 percent in developing countries (Beintema and Stads 2004). In Africa the private sector plays an exceptionally small role in funding agricultural research, accounting for only 2 percent of total agricultural research spending. An increase in this contribution is highly unlikely because the potential profits from conducting research on important crops in Africa are not sufficiently high to attract the interest of either domestic or international private firms (NEPAD 2002).

The weakness in research in Africa extends to agricultural biotechnology. Advancement in genetic modifications or utilization of genetically modified organisms (GMOs) as a response to environmental stresses and food insecurity in the developing countries hold high potential to address economic and environmental issues. Atanassov et al. (2004) showed the current regulatory status, approvals, and testing of GMOs in 16 developing countries from Africa, Asia, and Latin America. Among the four participating African countries, South Africa has five commercial GM approvals for planting cotton, maize, and soybeans, while Egypt, Kenya, and Zimbabwe have no events at all. In addition, South Africa has approved 172 field trials for GMOs, while Kenya has approved 2. Egypt and Zimbabwe have approved no field trials of GMO crops.

2. Three Scenarios for the Future: Business as Usual, Pessimistic, and Vision

The future projections generated for this paper are based on results from IMPACT for food supply, demand, net trade, and malnutrition and from the associated IMPACT–WATER model for water resource projections (see Boxes 2 and 3 for more information on methodologies). While the baseline years for IMPACT and IMPACT–WATER are 1997 and 1995, respectively, projections in the analysis for both models extend to 2025. Results are presented for five regions of Sub-Saharan Africa and two regions of West Asia/North Africa, as outlined in Box 1 on page 2.[3] Consistent assumptions for model drivers are used here for the business as usual scenario to achieve comparable results for the two models (see Box 4 for summaries of the scenarios). In this section we focus on the results for the main staple commodities, including cereals and roots and tubers.

Box 2—IMPACT Methodology[a]

IMPACT is a representation of a competitive world agricultural market for 32 crop and livestock commodities, including all cereals, soybeans, roots and tubers, meats, milk, eggs, oils, oilcakes/meals, sugar/sweeteners, fruits/vegetables, and fish. It is specified as a set of 36 country or regional submodels, within each of which supply, demand, and prices for agricultural commodities are determined. The country and regional agricultural submodels are linked through trade, a specification that highlights the interdependence of countries and commodities in global agricultural markets. The model uses a system of supply and demand elasticities incorporated into a series of linear and nonlinear equations, to approximate the underlying production and demand functions. World agricultural commodity prices are determined annually at levels that clear international markets. Demand is a function of prices, income, and population growth. Growth in crop production in each country is determined by crop prices and the rate of productivity growth. The model is written in the General Algebraic Modeling System (GAMS) programming language. The solution of the system of equations is achieved using the Gauss–Seidel method algorithm. This procedure minimizes the sum of net trade at the international level and seeks a world market price for a commodity that satisfies market-clearing conditions.

IMPACT generates annual projections for crop area, yield, and production; crop demand for food, feed, and other uses; crop prices and trade; and livestock numbers, yield, production, demand, prices, and trade. The current baseline year is 1997 (using a three-year average of 1996–98) and the model incorporates FAOSTAT data (FAO various years) on commodity, income, and population; projections from the World Bank (World Bank 1998, 2000a, 2000b) and the UN (United Nations 1998); a system of supply and demand elasticities from literature reviews and expert estimates; and rates for malnutrition from UN-ACC/SCN (1996), WHO (1997), and calorie-malnutrition relationships developed by Smith and Haddad (2000). The version of the model used here projects results to the year 2025. Additional information about the model and its formulation can be found in Rosegrant, Meijer, and Cline (2002).

[a] The modeling results presented in this paper are not directly comparable with those in von Braun et al. (2005) because the two analyses use different versions of the IMPACT model. Please refer to the technical appendix of von Braun et al. for specific details of the model and scenario specifications used in that analysis.

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[3] The current version of IMPACT aggregates "Other WANA" as one region. In addition to the North African countries of Algeria, Libya, Morocco and Tunisia, this region also includes Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen. This leads to results that are significantly higher than for North Africa alone, which represents around 31 percent of Other WANA meat production, 32 percent of Other WANA root and tuber production, and 24 percent of Other WANA cereal production.

Box 3—IMPACT–WATER Methodology

The IMPACT–WATER integrated water-food modeling framework developed at IFPRI (Rosegrant and Cai 2000) is applied to assess the current situation and plausible future options of irrigation water supply and food security, primarily on a global scale. This model simulates the relationships among water availability and demand, food supply and demand, international food prices, and trade at regional and global levels. The world is divided into 69 spatial units, including single river basins in China, India and the United States, and aggregated river basins in other countries and regions. For each spatial unit, crop-wise water demand and supply are calculated and then incorporated into separate rainfed and irrigated crop area and yield functions. Eight food crops are considered: rice, wheat, maize, other coarse grains, soybeans, potatoes, sweet potatoes, and cassava/other roots and tubers. For more information on the IMPACT–WATER methodology, see Rosegrant, Cai, and Cline (2002).

Box 4—Scenario Names, Abbreviations, and Descriptions

Scenario name	Abbreviation	Description	Projection period
Business as usual	BAU	Current trends and existing plans for food policy, management, and investment continue over the projection period, including declining agricultural investments by international donors and national governments to 2025.	1997–2025
Pessimistic	PES	Trends in agricultural production and nutrition deteriorate by comparison with BAU, including declines in national and international investments affecting HIV/AIDS, agricultural research, education, and so on; declines in agricultural productivity, yield growth, and consequently GDP; and deterioration of social factors, such as female education levels, access to clean water, labor productivity, and life expectancy.	1997–2025
Vision	VIS	Current trends and existing plans for food policy, management, and investment improve considerably to 2025, enabling increased labor productivity through higher investment in HIV/AIDS prevention and treatment, higher levels of education, and strengthened agricultural research and extension.	1997–2025
High increase in effective rainfall use		BAU conditions, combined with increased effective rainfall (in rainfed areas only) incorporating the following three variables.	
(HIER)	HIER–1	Effective rainfall use in all basins and countries increases by 10 percent in 2025 over actual 1995 rainfall levels.	1995–2025
	HIER–2	HIER–1 plus low investments in irrigation.	1995–2025
	HIER–3	Effective 2025 rainfall use in Sub-Saharan African basins and countries only increases by 15 percent over actual rainfall levels in 1995.	1995–2025
Reduced marketing margins	RMM	BAU conditions, combined with improved rural infrastructure, marketing, and communications, which decreases marketing margins and increases productivity.	1997–2025
Trade liberalization		BAU conditions, combined with the following three trade liberalization variables.	
Full trade liberalization	FTL	Producer and consumer subsidy equivalent prices (PSEs and CSEs, respectively) between domestic and international prices are completely removed in all countries from 2005.	1997–2025
Africa protectionism	PRO	PSE and CSE values increase by 50 percent in all African countries in 2005, after which they are maintained at that level until 2025.	1997–2025
Africa trade liberalization	ATL	PSEs and CSEs respectively between domestic and international prices are completely removed in African countries only, and base line protection levels are maintained in all other countries and regions.	1997–2025

Business as Usual Scenario

The *business as usual* scenario (henceforth *BAU*) assumes a continuation of current trends and existing plans in food policy, management, and investment. Investments by international donors and national governments in the agricultural sector continue to decline throughout the projection period. This sluggish investment trend, combined with sporadic policy reform, leads to slow progress in meeting the major challenges facing African agriculture.

Under this scenario, per capita kilocalorie consumption in Sub-Saharan Africa is projected to increase from 2,231 kilocalories per capita per day in 1997 to 2,526 kilocalories in 2025, lagging behind the rest of the world (Table 3). Despite increasing kilocalorie consumption, the number of malnourished children under the age of five increases from 32.7 million in 1997 to 38.3 million in 2025, although this absolute increase represents a decline in percentage terms from 32.8 percent in 1997 to 28.2 percent in 2025 (Tables 4 and 5). Sub-Saharan Africa is the only region where absolute numbers of malnourished children increase under *BAU*, and, while increases occur in several Sub-Saharan African regions under this scenario, northern Sub-Saharan Africa experiences a particularly sharp increase, from 10.2 million malnourished children under five years old in 1997 to 13.8 million in 2025 (a 35 percent increase). Central and western Sub-Saharan Africa also show a fairly sharp increase in the numbers of malnourished children, at about 20 percent (from 6.9 million in 1997 to 8.3 million in 2025). The trend in malnutrition is more positive in West Asia/North Africa;[4] the percentage of malnourished children decreases under *BAU* from 13.2 percent in 1997 to 7.7 percent in 2025. It should be noted, however, that whereas the percentage of malnourished children declines slightly in all regions between 1997 and 2025, the projected figures do not come close to meeting the MDG target of halving the percentage of people suffering from hunger by 2015, and, equally, targets for 2025 fall far short of being met under this scenario.

As shown above, food security in Africa does not improve substantially to 2025 under *BAU*. A

Table 3—Projected per capita kilocalories available in Africa under the *business as usual* scenario, 1997, 2015, 2020, and 2025

	Available kilocalories per capita per day			
		Projected		
Region/Country	**Baseline 1997**	**2015**	**2020**	**2025**
Northern Sub-Saharan Africa	2,175	2,253	2,293	2,346
Central and western Sub-Saharan Africa	2,175	2,309	2,378	2,458
Southern Sub-Saharan Africa	2,022	2,162	2,225	2,305
Eastern Sub-Saharan Africa	1,999	2,110	2,167	2,233
Nigeria	2,759	3,073	3,203	3,356
All Sub-Saharan Africa	2,231	2,377	2,444	2,526
West Asia/North Africa[a]	3,059	3,175	3,209	3,238
Developing countries	2,668	2,935	3,001	3,058

Source: IFPRI IMPACT projections 2004.

[a] In this table, West Asia/North Africa includes Egypt, Other West Asia/North Africa, and Turkey.

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[4] The child malnutrition figures for West Asia/North Africa include data for Turkey as well as Egypt and Other WANA. As a result, the number of malnourished children is higher than would be the case for North Africa alone.

Table 4—Projected number of malnourished children in Africa under the *business as usual* scenario, 1997, 2015, 2020, and 2025

Region/Country	Number of malnourished children under five years old (millions)			
	Baseline 1997	Projected		
		2015	2020	2025
Northern Sub-Saharan Africa	10.2	14.6	13.8	13.8
Central and western Sub-Saharan Africa	6.9	8.5	8.6	8.3
Southern Sub-Saharan Africa	4.0	4.4	4.3	4.2
Eastern Sub-Saharan Africa	4.6	5.8	5.2	5.0
Nigeria	6.9	7.9	7.4	7.1
All Sub-Saharan Africa	32.7	41.3	39.3	38.3
West Asia/North Africa[a]	5.9	4.7	4.1	3.6
Developing countries	166.3	135.4	132.2	124.1

Source: IFPRI IMPACT projections 2004.

[a] In this table, West Asia/North Africa includes Egypt, Other West Asia/North Africa, and Turkey.

Table 5—Projected percentage of malnourished children in Africa under the *business as usual* scenario, 1997, 2015, 2020, and 2025

Region/Country	% of malnourished children under five years old			
	Baseline 1997	Projected		
		2015	2020	2025
Northern Sub-Saharan Africa	40.0	37.9	37.1	36.3
Central and western Sub-Saharan Africa	27.8	25.3	24.3	23.2
Southern Sub-Saharan Africa	26.9	23.9	22.6	21.6
Eastern Sub-Saharan Africa	27.6	25.8	24.9	24.2
Nigeria	39.1	35.2	33.6	32.3
All Sub-Saharan Africa	32.8	30.4	29.2	28.2
West Asia/North Africa[a]	13.2	9.6	8.6	7.7
Developing countries	31.4	26.0	24.7	23.5

Source: IFPRI IMPACT projections 2004.

[a] In this table, West Asia/North Africa includes Egypt, Other West Asia/North Africa, and Turkey.

Table 6—Projected crop production growth rates in Africa under the *business as usual* scenario, 1997-2025

	Production growth rates (% per year)				
Region/Country	**Wheat**	**Maize**	**Other course grains**	**Rice**	**All roots and tubers**
Nigeria	3.3	2.1	2.6	2.9	2.7
Northern Sub-Saharan Africa	2.6	2.1	2.7	2.9	2.7
Central and western Sub-Saharan Africa	3.0	3.0	3.4	3.4	2.9
Southern Sub-Saharan Africa	2.8	2.4	3.4	2.8	2.4
Eastern Sub-Saharan Africa	3.7	2.4	3.0	2.6	2.8
All Sub-Saharan Africa	2.9	2.4	2.8	3.0	2.7
Egypt	1.6	1.6	0.7	1.5	2.3
Other West Asia/North Africa	1.9	2.0	1.2	1.7	2.2
All Africa	1.9	2.3	2.4	2.5	2.7

Source: IFPRI IMPACT projections 2004.

Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

contributing factor to ongoing food insecurity under this scenario is the expected modest growth in agricultural production by historical standards to 2025. Between 1997 and 2025, *BAU* projects annual African cereal production growth of 1.9 percent for wheat, 2.3 percent for maize, 2.4 percent for other coarse grains, 2.5 percent for rice, and 2.7 percent for roots and tubers (Table 6). The projected 2.7 percent cereal production growth in Sub-Saharan Africa is slightly less than the 3.6 percent actual annual increase in production achieved during 1982–97; projected annual root and tuber production growth rates of 2.7 percent per year also represent a decline from actual 1982–97 rates, which averaged 4.3 percent per year.

Under *BAU*, crop production in Africa continues to expand onto unused land. Area under cereal and root and tuber cultivation increases in Sub-Saharan Africa over the projection period at rates ranging from 27 percent in Nigeria to 40 percent in central and western Sub-Saharan Africa, although this expansion is slow by historic equivalents (Table 7). Area increases in North Africa are smaller, at 14.3 percent for Egypt and 12.9 percent for Other WANA.

African cereal yield growth averages 1.4 percent per year under *BAU* between 1997 and 2025. North African cereal yields grow at a lower rate than in Sub-Saharan Africa, at 1.0 percent per year in Egypt and 1.3 percent per year in Other WANA. Cereal yield growth across Sub-Saharan Africa is higher, however, averaging 1.7 percent per year over the projection period, essentially doubling the actual yield growth achieved during 1967–97 (Table 8). A number of considerations and assumptions underlie these mildly optimistic growth rates. Sub-Saharan African yields are very low by other developing country standards, indicating that significant growth should be possible if countries in the region move toward appropriate technologies, policies, and programs. According to Boserupian theories of induced technological innovation, growing population pressure can be expected to lead to higher yield growth rates as low-input agriculture increasingly ceases to be a viable option (Boserup 1981). Under BAU, total

Table 7—Projected cereal, root, and tuber area in Africa under the *business as usual* scenario, 1997 and 2025

	Cereals (million hectares)		Roots and tubers (million hectares)	
Region/Country	**Baseline 1997**	**Projected 2025**	**Baseline 1997**	**Projected 2025**
Northern Sub-Saharan Africa	29.2	37.9	0.9	1.1
Central and western Sub-Saharan Africa	10.2	14.3	6.0	8.3
Southern Sub-Saharan Africa	9.0	12.2	2.5	3.0
Eastern Sub-Saharan Africa	6.8	9.1	2.6	3.4
Nigeria	18.1	23.2	5.8	7.1
All Sub-Saharan Africa	73.1	96.7	17.8	22.9
Egypt	2.6	3.0	0.1	0.1
Other West Asia/North Africa	26.6	30.1	0.5	0.5
All Africa	102.4	129.9	18.3	23.5

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table 8—Projected crop yield growth rates in Africa under the *business as usual* scenario, 1997-2025

	Crop yield growth rates, 1997–2025 (% per year)			
Region/Country	**All cereals**	**Maize**	**Rice**	**Cassava and others**
Northern Sub-Saharan Africa	1.7	1.3	1.9	2.0
Central and western Sub-Saharan Africa	1.9	1.9	1.9	1.6
Southern Sub-Saharan Africa	1.5	1.3	2.1	1.7
Eastern Sub-Saharan Africa	1.6	1.5	1.7	1.9
Nigeria	1.6	1.5	2.0	1.8
All Sub-Saharan Africa	1.7	1.5	1.9	1.7
Egypt	1.0	1.1	1.3	1.0
Other West Asia/North Africa	1.3	1.2	1.5	2.3
All Africa	1.4	1.4	1.5	1.7

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

cereal and root and tuber harvested area in Sub-Saharan Africa declines from 0.16 hectares per capita in 1997 to 0.11 hectares per capita in 2025. Of course, higher population densities do not guarantee rapid innovation. Even as populations throughout Sub-Saharan Africa are losing their ability to practice shifting cultivation because of high population densities, they also continue to practice other elements of extensive cultivation, including low levels of technological and capital inputs, traditional land tenure and land husbandry practices, and traditional methods of resource acquisition (Cleaver and Schreiber 1994). Moreover, harvested area grows at a slow rate in most regions in the coming decades under *BAU*. Considering that a high proportion of land suitable for agricultural use is already being harvested—together with other factors, such as urbanization, slow growth in irrigation investment, and soil degradation—additional growth of harvested area will be hindered in the future. Declining real cereal prices under this scenario also influence harvested area expansion, ultimately making it unprofitable.

The slow rate of area expansion causes production growth to come primarily from yield improvements, which are also slow under this scenario. Investments in agricultural research and rural infrastructure continue to decline into the future, compounding the decline in yield growth in many regions around the world. Many of the successes achieved in rice and wheat yields during the Green Revolution make future yield gains for these crops more difficult because many of the gains in recent decades—such as increasing crop-planting density through changes to plant architecture, raising the weight of usable food product as a fraction of total plant weight, introducing strains with greater fertilizer responsiveness, and improving management practices—are not readily repeatable. Under *BAU*, new investments in water harvesting and crop breeding for rainfed environments continue to be slow, leading to little improvement in rainfed yields.

While crucially important, an improved policy framework that allows the market to operate freely will not launch African agriculture on a strong and sustainable yield growth path without proactive measures at the national and international levels to ensure more widespread diffusion of technological solutions and more intensive input application across the region. National governments must continue to pursue nondistortionary measures that stimulate fertilizer use above the 1997 application rates of only 8 kilograms per hectare of arable and permanent cropland (Byerlee and Heisey 1996). While the removal of fertilizer subsidies during the 1980s and 1990s was necessary to stimulate private sector participation in the market, the benefits have not yet been realized because of a variety of factors, including trade barriers, political indifference, foreign exchange shortages, low crop prices, and a lack of institutional and physical infrastructure (World Bank 2000a). National governments must encourage fertilizer use in high-potential areas, put in place proper measures to ensure environmental sustainability, and address the high cost of fertilizers by lowering transport costs and raising scale-economies of international purchasing and shipment (Byerlee and Heisey 1996; Bumb and Baanante 1996). Given that the total supply potential for the region is only 8.4 million metric tons (with demand of 3.5 million metric tons in 1994/95), Sub-Saharan Africa will have to import large quantities of fertilizer over the foreseeable future, thus necessitating stable and timely supplies of foreign exchange (Bumb and Baanante 1996).

A number of researchers (Versteeg, Adegbola, and Koudokpon 1993; Janssen 1993) have pointed to the suitability of labor-intensive techniques such as legume rotations, animal manures, and alley cropping as potential short-term fertilizer substitutes in cases of labor surplus (Byerlee and Heisey 1996). Such organic solutions are inadequate on their own because of the high level of crop nutrients required by much of Sub-Saharan Africa's degraded soil base, but organic and synthetic solutions have additive properties that could enhance overall nutrient replacement and provide trade-offs between capital and labor (Vanlauwe, Aihou, and Houngnandan 2001). Some potential strategies include the use of leguminous short-term and tree fallows to increase nitrogen concentrations and maximize potassium recycling (Sanchez et al. 2001). Becker and Johnson (1998) highlight the effectiveness of site-specific, multipurpose cover legumes as short-duration fallows capable of sustaining rice yields under intensified cropping, with use of these fallows in one study area increasing rice yields by 29 percent above control levels.

These alternative nutrient-replenishing practices are generally site specific and highly knowledge intensive, requirements that are problematic for smallholders lacking significant management capacity. Further research into how best to empower farmers to carry out proper cropping systems management is clearly required, and much of this research will have to be publicly funded and performed by researchers at the national level, since private sector research capacity in Sub-Saharan Africa is minimal. Areas in need of attention include the development of nutrient management systems for specific soils, low-cost soil rehabilitation techniques, methods for incorporating perennial crops in farming landscapes, and innovative incentive structures to encourage long-term conservation of forest and grazing land (Scherr 1999).

Dynamic crop management programs involving extensive on-farm research have not traditionally been a national priority in Sub-Saharan Africa, with most governments preferring to place resources behind relatively less complex and costly research into improved germplasm, particularly high-yielding maize varieties (Byerlee and Heisey 1996; Dowswell, Paliwal, and Cantrell 1996). By the late 1990s, improved maize varieties were being grown on approximately 40 percent of maize area in Sub-Saharan Africa, but the lagging development of sustainable management practices has kept yields well below the developing world average (Byerlee and Eicher 1997). Accumulated farming experience simply cannot provide farmers with the knowledge base necessary to effectively apply fertilizer, plant high-yielding varieties with appropriate density, and weed early once soil fertility is restored. As maize production systems become increasingly science based, it will be up to a variety of publicly and internationally funded information disseminators to enhance farmer knowledge, technical skills, and managerial capacity (Dowswell, Paliwal, and Cantrell 1996). IMPACT's *BAU* projections assume that modest investments in maize productivity will be forthcoming, with annual maize yield growth rates in Sub-Saharan Africa rising from a rate of 0.6 percent between 1982 and 1997 to a rate of 1.5 percent between 1997 and 2025 (Table 8).

In addition to paying greater attention to cropping systems, future research efforts must diversify from a focus on maize to explore opportunities for alternative crops such as cassava and rice that have particular problems associated with African agroecological conditions. Technological diffusion has proven a major problem in Sub-Saharan Africa, with Goldman and Block (1993) identifying a number of commodities for which there exist underutilized high-yielding varieties, including cassava (with potential yield increases of 50 percent on half of currently planted area), sweet potato, and rice (for both irrigated and mangrove environments) (cited in Spencer 1994). Significant increases in rice production will depend crucially on further irrigation development, although past experiences with irrigated rice production have not been positive, and exploitable water supplies are limited. The *BAU* scenario projects strong rice yield growth of 1.5 percent annually between 1997 and 2025 in Africa, and a 1.9 percent growth in Sub-Saharan Africa, representing a modest increase above the growth achieved between 1982 and 1997. At this rate of increase, African rice yields are projected to reach 1.54 metric tons per hectare by 2025, significantly lower than the projected developing world average of 3.38 metric tons per hectare. Under *BAU*, cassava yields also increase at a fairly rapid annual rate of 1.7 percent in Sub-Saharan Africa over the projection period, following actual annual growth of 1.2 percent during 1982–97. At this rate of increase, cassava yields reach 12.87 metric tons per hectare by 2025 under *BAU*, slightly lower than the projected yield of 16.44 metric tons per hectare in Latin America.

The experience with maize in Sub-Saharan Africa shows that small farmers will make use of improved seeds and complementary inputs, provided the technology, infrastructure, and overall macroeconomic environment are appropriate. In order to address the region-specific conditions, improved technology packages need to place a premium on efficient input use and maximizing returns to labor and cash during early adoption. Above all, effective research must be embedded within an overall framework for agricultural development that emphasizes smallholder commercialization, private sector initiative at all levels, decentralized public participation, trade, and poverty alleviation (World Bank 2000b). Alston et al. (2000) calculated the mean rate of return to local research in Sub-Saharan Africa at a very respectable 34.3 percent, despite the finding that lack of staff continuity and breeding strategies in many national programs have been responsible for the widespread perception that local research efforts have not been successful (Alston et al. 2000; Byerlee and Heisey 1996). These results indicate that local research and extension services have the capability to perform the tasks required of them, but need to be stronger and better funded if they are to provide consistent and expanded services.

Projections under *BAU* indicate burdensome, yet manageable, agricultural import needs for Africa in 2025. Net cereal imports are projected to increase from 56.2 million metric tons in 1997 to 110.0 million metric tons in 2025 (Table 9). Central and western Sub-Saharan Africa remains the major net cereal-importing subregion in Sub-Saharan Africa, with net imports increasing from 4.6 million metric tons in 1997 to 9.7 million metric tons in 2025. Nigeria has the largest projected percentage increase in net imports under *BAU*, from 2.0 million metric tons in 1997 to 6.1 million metric tons in 2025. Wheat remains the dominant African cereal import, with net imports rising from 31.8 million metric tons in 1997 to 55.9 million metric tons in 2025. Maize has the sharpest increase in net imports, however, from 10.4 million metric tons to 20.1 million metric tons.

The development challenges facing Africa are clearly the most daunting of those facing any developing region. Concerted investment in agricultural and human development will be necessary to overcome these challenges over the next two decades. However, pervasive poverty, mismanagement, and corruption in the region—particularly in Sub-Saharan Africa—have limited the scope for internally generated investment, while donor fatigue and the perceived failures of much of the multilateral lending and bilateral aid in the past may limit the availability of external funds.

Fulfillment of the projected outcomes under *BAU* would require total investment expenditures in

Table 9—Projected net cereal trade in Africa under the *business as usual* scenario, 1997 and 2025

	Net cereal trade (million metric tons)							
	Wheat		Maize		Other coarse grains		Rice	
Region/Country	Baseline 1997	Projected 2025	Baseline 1997	Projected 2025	Baseline 1997	Projected 2025	Baseline 1997	Projected 2025
Northern Sub-Saharan Africa	–1.7	–4.7	–0.1	–0.5	–0.1	0.4	–0.4	–1.1
Central and western Sub-Saharan Africa	–1.9	–4.9	–0.2	0.4	–0.2	0.1	–2.3	–5.3
Southern Sub-Saharan Africa	–1.2	–2.4	–0.8	–1.6	–0.1	0.3	–0.3	–0.7
Eastern Sub-Saharan Africa	–0.5	–1.1	–0.6	–1.8	–0.1	0.3	–0.2	–0.6
Nigeria	–1.3	–2.9	0.0	–1.6	–0.0	0.4	–0.7	–2.0
All Sub-Saharan Africa	–6.6	–16.1	–1.6	–5.2	–0.4	1.6	–3.8	–9.8
Egypt	–6.9	–8.7	–2.9	–3.5	0.0	–0.8	0.3	–0.5
Other West Asia/North Africa	–18.4	–31.2	–5.9	–11.4	–7.0	–18.8	–3.1	–5.7
All Africa	–31.8	–55.9	–10.4	–20.1	–7.4	–18.0	–6.6	–16.0

Source: IFPRI IMPACT projections 2004.

Note: The total for “All Africa” is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the “Other West Asia/North Africa” region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Africa of US$170.5 billion between 1997 and 2025 (Table 10). Rural roads account for projected spending of US$61.4 billion, while education accounts for US$38 billion, provision of access to clean water for US$31.6 billion, irrigation[5] for US$20.2 billion, and agricultural research for US$19.4 billion.

Pessimistic Scenario

Even with the relatively strong agricultural productivity growth projected under *BAU*, the food security implications for Africa are disappointing. Alternatively, Africa's future could be even bleaker with agricultural stagnation, drastically deepening poverty, and worsening social indicators. Many countries in the region have struggled with the transition to private sector input and output markets, and uncertain input availability and producer prices remain major factors limiting the ability of smallholders to plan investments with long time horizons (Byerlee and Eicher 1997).

While *BAU* projects that area expansion will slow over the next two decades, even these projections may be optimistic given the extent of the ongoing degradation of the existing land base. Severe soil fertility depletion and erosion affect both marginal and high-quality rainfed lands, frequently characterized by inappropriate nutrient replacement or conservationist practices, pest problems, overdependence on maize monoculture, and high water variability. A variety of studies indicate that productivity losses from soil degradation since World War II have amounted to 25 percent, with African farm survey data showing declines in grain yields from 2–4 metric tons per hectare to 1 metric ton per hectare on originally fertile land, and estimates of cumulative crop yield reductions from ero-

Table 10—Projected total investments by sector in Africa under the *business as usual* scenario, 1997-2025

	Total investments (billion US$)					
Region/Country	Irrigation	Rural roads	Education	Clean water	National agricultural research	Total investments
Northern Sub-Saharan Africa	1.0	4.3	1.9	5.4	0.9	13.5
Central and western Sub-Saharan Africa	1.2	23.5	3.3	6.2	1.8	36.0
Southern Sub-Saharan Africa	6.6	13.4	6.3	3.4	2.7	32.4
Eastern Sub-Saharan Africa	0.4	7.2	2.7	3.6	3.8	17.7
Nigeria	8.0	6.2	3.9	3.9	1.0	23.0
All Sub-Saharan Africa	17.3	54.6	18.0	22.5	10.2	122.6
Egypt	0.0	0.5	2.2	1.7	3.4	7.9
Other West Asia/North Africa	2.9	6.3	17.7	7.5	5.7	40.1
All Africa	20.2	61.4	38.0	31.6	19.4	170.5

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

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[5] This irrigation investment calculation only includes the crop area for the commodities included in the IMPACT model. Additional irrigated area planted with other crops is not included.

sion averaging 6.2 percent across all Sub-Saharan African countries (Oldeman 1998 and Sanchez et al. 1997 as cited in Scherr 1999; Scherr and Yadav 1996). Bojo (1996) estimates economic loss from soil degradation as ranging from under 1 percent of agricultural GDP in Madagascar, Mali, and South Africa to 2–5 percent of agricultural GDP in Ethiopia and Ghana, to over 8 percent in Zimbabwe (Scherr 1999). Soil degradation may indeed remain a serious problem during the IMPACT projection period, particularly on marginal lands with rapidly growing populations in parts of the Sahel, mountainous East Africa, and the dry belt stretching from the coast of Angola to southern Mozambique (Cleaver and Schreiber 1994). For instance, Lal (1995) predicts that water erosion alone will reduce crop productivity in Sub-Saharan Africa by 14.5 percent between 1997 and 2020 (Scherr 1999).

Given these worrisome trends and projections, an alternative, pessimistic scenario may represent a more plausible future for Africa. The *pessimistic* scenario (henceforth *PES*) envisions a future in which trends in agricultural production and nutrition deteriorate by comparison with *BAU*. African countries experience a decline in investments, both nationally and from international donors. Education investments decline, and higher numbers of households remain without access to clean water in 2025. HIV/AIDS continues to affect a large proportion of the population in many African countries because of a continued lack of adequate investment in treatment and prevention, especially from the international community. This leads to a decline in labor productivity, which is one of the factors that influences yield growth. Agricultural productivity declines compared with *BAU*, while harvested area growth increases at the same slow rate as in *BAU*. This puts an increased burden on yield growth to make up for the shortfall; however, yield growth under *PES* declines compared with *BAU*. Soil fertility deterioration and increased erosion affect agricultural land in many African countries, leading to decreased yields.

Within IMPACT, the *PES* scenario is quantified by subtracting 0.50 percent from crop yield growth rates and 0.50 percent from livestock growth (number of head) beginning in 2005 (see Table 11). Additionally, because of the importance of agricultural production to African economies, *BAU* GDP growth rate assumptions are cut by 25 percent under *PES*. Lastly, a variety of social indicators are also projected to worsen, with female access to secondary schooling and access to clean water falling by 15 percent and the female-to-male life expectancy ratio falling by 1.5 percent compared with *BAU* levels. Population growth is also expected to increase in Africa under *PES*, so the UN medium variant population growth projections used for *BAU* are replaced with the high variant for *PES*.

Table 11—Assumptions for *pessimistic* and *vision* scenarios

Variable	***Pessimistic* scenario**	***Vision* scenario**
Crop yield growth	0.50 percent lower than *BAU* levels	50 percent higher than *BAU* levels
Livestock numbers growth	0.50 percent lower than *BAU* levels	50 percent higher than *BAU* levels
Population	High UN variant	Low UN variant
GDP growth	25 percent lower than *BAU* levels	6.5 percent for Nigeria; 8 percent for the rest of Africa
Female access to secondary schooling	15 percent lower than *BAU* levels	Reaches 90 percent
Clean water access	15 percent lower than *BAU* levels	Reaches 95 percent
Female-to-male life expectancy ratio	1.5 percent lower than *BAU* levels	2 percent higher than *BAU* levels

Source: IFPRI IMPACT 2004.

Malnutrition in Africa proliferates under *PES*. Daily per capita kilocalorie availability in Sub-Saharan Africa increases only slightly under this scenario, from 2,231 kilocalories in 1997 to 2,333 kilocalories in 2025, cutting improvements made under *BAU* by almost 300 kilocalories (Table 12). The total number of malnourished children under five years old in Sub-Saharan Africa escalates from 33 million to 55 million in 2025, 17 million more children than projected under *BAU* (Table 13). As with *BAU*, northern Sub-Saharan Africa has the largest number of malnourished children of all Sub-Saharan regions under *PES*, with an increase from 10.2 million in 1997 to 19.6 million in 2025. With

Table 12—Projected per capita kilocalories available in Africa under the *pessimistic* scenario, 1997, 2015, 2020, and 2025

	Available kilocalories per capita per day			
		Projected		
Region/Country	Baseline 1997	2015	2020	2025
Northern Sub-Saharan Africa	2,175	2,154	2,165	2,187
Central and western Sub-Saharan Africa	2,175	2,220	2,261	2,308
Southern Sub-Saharan Africa	2,022	2,069	2,105	2,152
Eastern Sub-Saharan Africa	1,999	1,985	2,007	2,037
Nigeria	2,759	2,822	2,889	2,976
All Sub-Saharan Africa	2,231	2,257	2,290	2,333
West Asia/North Africa[a]	3,059	3,078	3,096	3,116

Source: IFPRI IMPACT projections 2004.

[a] In this table, West Asia/North Africa includes Egypt, Other West Asia/North Africa, and Turkey.

Table 13—Projected number of malnourished children in Africa under the *pessimistic* scenario, 1997, 2015, 2020, and 2025

	Number of malnourished children under five years old (millions)			
		Projected		
Region/Country	Baseline 1997	2015	2020	2025
Northern Sub-Saharan Africa	10.2	16.7	17.8	19.6
Central and western Sub-Saharan Africa	6.9	10.0	10.2	11.0
Southern Sub-Saharan Africa	4.0	5.4	5.5	5.9
Eastern Sub-Saharan Africa	4.6	7.2	7.4	8.0
Nigeria	6.9	10.4	10.3	10.6
All Sub-Saharan Africa	32.7	49.7	51.2	55.1
West Asia/North Africa[a]	5.9	8.3	8.0	8.1

Source: IFPRI IMPACT projections 2004.

[a] In this table, West Asia/North Africa includes Egypt, Other West Asia/North Africa, and Turkey.

increases in malnourished children of between 3 and 4 million each, Nigeria, central and western Sub-Saharan Africa, and eastern Sub-Saharan Africa experience lower levels of growth in the number of malnourished children than other subregions under this scenario. Southern Sub-Saharan Africa is projected to have the lowest increase in malnourishment, from 4 million malnourished children in 1997 to 5.9 million in 2025. The number of malnourished children also increases in West Asia/North Africa under *PES*, from 5.9 million children in 1997 to 8.1 million children in 2025.

Malnourished children in Sub-Saharan Africa also increase in percentage terms under the *PES* scenario, from 32.8 percent in 1997 to 33.2 percent in 2025 (Table 14). The percentage of malnourished children declines slightly in Nigeria, central and western Sub-Saharan Africa, and southern Sub-Saharan Africa, but increases in northern Sub-Saharan Africa by 0.3 percent and in eastern Sub-Saharan Africa by 1.4 percent. While the percentage of malnourished children in West Asia/North Africa does shift slightly over the projection period, the 2025 percentage increase remains unchanged from the 1997 level, at 13.2 percent. It is important to note that the number of malnourished children in the region could increase still further if African countries were unable to increase food imports to the high levels needed under this scenario because of budgetary and foreign exchange constraints.

One of the factors influencing the decline in food security under *PES* is poor agricultural performance compared with *BAU*. Conditions under *PES* adversely affect overall agricultural production, reducing cereal output in 2025 to 212 million metric tons—9 percent below the *BAU* level—as cereal production growth declines to 1.9 percent annually (Table 15). Root and tuber production only reaches 294 million metric tons under *PES*, 7.5 percent below the *BAU* level. Slowing area and yield growth also contributes to the shortfall in agricultural production, although both cereal and root and tuber area growth remain slightly positive in Africa at 0.9 percent annually (Table 16). These rates of area growth represent declines from the actual 1.2 percent annual cereal area growth and 2.2 percent annual root and tuber area growth achieved during 1967–2000, and reflect rising land scarcity and degradation under *PES*. Cereal yield growth falls to 1.3 percent annually in Sub-Saharan Africa under *PES* (Table 17). Cereal yield growth in North Africa falls slightly over the projection period under this

Table 14—Projected percentage of malnourished children in Africa under the *pessimistic* scenario, 1997, 2015, 2020, and 2025

Region/Country	% of malnourished children under five years old			
	Baseline 1997	Projected 2015	Projected 2020	Projected 2025
Northern Sub-Saharan Africa	40.0	40.5	39.6	40.3
Central and western Sub-Saharan Africa	27.8	28.1	27.1	27.5
Southern Sub-Saharan Africa	26.9	27.0	25.9	26.4
Eastern Sub-Saharan Africa	27.6	29.0	28.1	29.0
Nigeria	39.1	39.4	38.3	38.6
All Sub-Saharan Africa	32.8	33.5	32.6	33.2
West Asia/North Africa[a]	13.2	13.4	12.8	13.2

Source: IFPRI IMPACT projections 2004.

[a] In this table, West Asia/North Africa includes Egypt, Other West Asia/North Africa, and Turkey.

Table 15—Projected crop production growth rates in Africa under the *pessimistic* scenario, 1997-2025

Region/Country	Crop production growth rates (% per year)					
	Wheat	Maize	Other course grains	Rice	All Cereals	All roots and tubers
Northern Sub-Saharan Africa	2.3	–4.1	2.4	2.5	2.5	2.4
Central and western Sub-Saharan Africa	2.7	0.4	3.1	3.0	2.6	2.6
Southern Sub-Saharan Africa	2.4	–2.2	3.1	2.4	3.2	2.1
Eastern Sub-Saharan Africa	3.4	–5.7	2.7	2.2	2.6	2.6
Nigeria	3.0	–0.8	2.3	2.5	2.7	2.4
All Sub-Saharan Africa	2.5	–1.9	2.5	2.6	2.7	2.5
Egypt	1.3	–0.8	0.4	1.2	1.5	2.0
Other West Asia/North Africa	1.6	–2.1	0.9	1.3	1.7	1.9
All Africa	1.6	–1.3	2.1	2.1	2.3	2.4

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table 16—Projected growth rates in cereal, root, and tuber area in Africa under the *pessimistic* scenario, 1997-2025

Region/Country	Cereal and roots and tubers area growth (% per year)	
	All cereals	All roots and tubers
Northern Sub-Saharan Africa	1.0	0.7
Central and western Sub-Saharan Africa	1.2	1.2
Southern Sub-Saharan Africa	1.1	0.7
Eastern Sub-Saharan Africa	1.1	0.9
Nigeria	0.9	0.7
All Sub-Saharan Africa	1.0	0.9
Egypt	0.5	0.5
Other West Asia/North Africa	0.5	0.3
All Africa	0.9	0.9

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table 17—Projected cereal yield growth rates in Africa under the *pessimistic* scenario, 1997-2025

Region/Country	Cereal yield growth (% per year) Wheat	Maize	Other course grains	Rice	All Cereals
Northern Sub-Saharan Africa	1.0	1.0	1.4	1.6	1.3
Central and western Sub-Saharan Africa	1.0	1.5	1.6	1.7	1.6
Southern Sub-Saharan Africa	0.1	1.0	1.8	1.4	1.1
Eastern Sub-Saharan Africa	1.5	1.1	1.3	1.6	1.2
Nigeria	1.5	1.1	1.3	1.6	1.3
All Sub-Saharan Africa	1.1	1.1	1.4	1.6	1.3
Egypt	0.5	0.8	0.7	0.9	0.7
Other West Asia/North Africa	1.1	0.8	0.4	1.2	0.9

Source: IFPRI IMPACT projections 2004.

Table 18—Projected net cereal trade in Africa under the *pessimistic* scenario, 1997 and 2025

	Net cereal trade (million metric tons)							
	Wheat		Maize		Other coarse grains		Rice	
Region/Country	Baseline 1997	Projected 2025	Baseline 1997	Projected 2025	Baseline 1997	Projected 2025	Baseline 1997	Projected 2025
Northern Sub-Saharan Africa	–1.7	–4.5	–0.1	–1.2	–0.1	–3.0	–0.4	–1.2
Central and western Sub-Saharan Africa	–1.9	–4.3	–0.2	–4.7	–0.2	0.2	–2.3	–4.7
Southern Sub-Saharan Africa	–1.2	–2.1	–0.8	–0.7	–0.1	0.2	–0.3	–0.7
Eastern Sub-Saharan Africa	–0.5	–1.0	–0.6	–0.7	–0.1	0.0	–0.2	–0.7
Nigeria	–1.3	–2.8	0.0	–2.1	0.0	–2.0	–0.7	–2.1
All Sub-Saharan Africa	–6.6	–14.7	–1.6	–9.4	–0.4	–4.6	–3.8	–9.4
Egypt	–6.9	–12.0	–2.9	–1.3	0.0	–0.9	0.3	–1.3
Other West Asia/North Africa	–18.4	–41.1	–5.9	–6.5	–7.0	–19.6	–3.1	–6.5
All Africa	–31.8	–67.9	–10.4	–17.2	–7.4	–25.1	–6.6	–17.2

Source: IFPRI IMPACT projections 2004.
Note: The total for “All Africa” is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the “Other West Asia/North Africa” region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

scenario, with an annual growth rate of 0.7 percent in Egypt and 0.9 percent in Other WANA. This decline in food production, which increased imports cannot offset, contributes to the increased malnutrition across the region, and the reduction in the already slow income growth that occurs in African countries leads to inadequate levels of food for many households. In terms of trade, Africa's net cereal imports of 110 million metric tons in 2025 under *BAU* increase to 127.4 million metric tons under *PES*, reaching a level that may not be sustainable over an extended period given foreign exchange constraints (Table 18).

With its present day levels of food insecurity and heavy dependence on food aid, Africa can ill afford further declines in per capita income. The continent simply does not possess the necessary foreign exchange to satisfy its food needs through imports. While the assumptions underlying *PES* do include a substantial increase in net imports of agricultural commodities (especially cereals) to help mitigate the projected production gap, the region would still experience a significant increase in child malnourishment even at these high and potentially economically unsustainable import levels.

Investment expenditures fall sharply in Africa under *PES*, declining 33 percent to US$114.9 billion (Table 19). Rural road investment in Africa declines 31 percent from *BAU* levels to US$42.6 billion, education investment declines 17 percent to US$31.7 billion, investment in clean water provision declines 19 percent to US$25.7 billion, agricultural research investment declines 23 percent to US$14.9 billion, and irrigation investment is discontinued. Investment expenditures decline in all regions under *PES*, with investments in Sub-Saharan Africa decreasing 35 percent compared with *BAU* levels, and investments in Other WANA decreasing by 29 percent. Egypt's investments only decrease 10 percent, however, as a result of a greater initial level of development. Several regions in Sub-Saharan Africa fare particularly badly, with Nigerian investments declining by 47 percent and investments in southern Sub-Saharan Africa declining by 40 percent.

Table 19—Projected total investments by sector in Africa under the *pessimistic* scenario, 1997–2025

	Total investments (billion US$)					
Region/Country	**Irrigation**	**Rural roads**	**Education**	**Clean water**	**National agricultural research**	**Total investments**
Northern Sub-Saharan Africa	0	2.9	1.7	4.7	0.7	10.0
Central and western Sub-Saharan Africa	0	15.5	3.1	4.4	1.3	24.2
Southern Sub-Saharan Africa	0	9.2	5.8	2.3	2.2	19.5
Eastern Sub-Saharan Africa	0	4.9	2.5	3.1	2.9	13.4
Nigeria	0	4.3	3.6	3.5	0.8	12.3
All Sub-Saharan Africa	0	36.8	16.8	17.8	7.8	79.2
Egypt	0	0.4	2.3	1.6	2.8	7.1
Other West Asia/North Africa	0	5.4	12.7	6.3	4.3	28.6
All Africa	0	42.6	31.7	25.7	14.9	114.9

Source: IFPRI IMPACT projections 2004.

Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Budget constraints and declining international interest in agriculture result in further declines in public investment in crop breeding for rainfed agriculture in African countries, especially for staple crops such as wheat, maize, rice, other coarse grains, potatoes, cassava, yams, and sweet potatoes. The investment gap for these commodities is not filled by private agricultural research, however, because such research focuses mainly on developed-country commodities and commercial crops in developing countries. Declining funding for research leads to diminishing productivity growth in rainfed crop areas, especially in marginal areas.

Vision **Scenario**

The previous analysis prompts the question, "What type of transformation, in terms of economic and agricultural growth, education, and health, would be necessary for Africa to battle childhood malnutrition as effectively as the rest of the developing world?" The third scenario in our analysis, the vision scenario (henceforth *VIS*), attempts to answer this question by providing a sense of the magnitude of the region's challenges and the necessity of concerted attention by national governments and international organizations. *VIS* models the interventions necessary to cut child malnutrition in Africa sufficiently to reach the MDG target of cutting the proportion of people suffering from hunger in half by 2015. It provides a glimpse into a positive vision of substantial improvements in African agriculture, nutrition, and food security. National governments and international donors increase investments in African countries to help overcome many of the existing challenges facing agriculture today. Labor productivity increases through greater investments in education and investments in HIV/AIDS prevention and treatment. Improvements are also seen in productivity in rainfed areas, emphasizing water-harvesting technologies and extension assistance to farmers as means of implementing these technologies.

A dramatic decrease in childhood malnutrition would be achieved if total GDP growth in Egypt, Other WANA, and the five Sub-Saharan Africa subregions (Nigeria, northern, central and western, eastern, and southern) increased from *BAU* levels of 3.2–4.0 percent per year over the projection period to an annual growth rate of 6.5 percent for Nigeria and 8 percent for all other African regions. Population growth is also assumed to grow at a lower rate under *VIS*, using the UN low variant population growth for the African region. Crop productivity, as expressed by annual yield growth, is assumed to increase 50 percent over the *BAU* levels for cereals, roots and tubers, and soybeans so as to achieve the results projected under *VIS*. Substantial crop yield growth at this level would require an estimated 8 to 10 percent annual growth in fertilizer use across the region, a level commensurate with the 9 percent annual growth achieved in Asia between 1959/60 and 1994/95 (Bumb and Baanante 1996).[6] Yield growth rates of this level would be necessary to satisfy rising cereal demand across the continent without increasing the level of cereal imports. If yield growth rates were lower, higher cereal imports could meet the deficit between regional demand and supply, although it is difficult to see how the region could achieve 8 percent GDP growth without tremendous growth in agricultural productivity (see Table 11).

A variety of additional variables concerning access to clean water and the status and education of women have proven crucial determinants of childhood well-being and would have to improve drastically to significantly improve malnutrition figures (Smith and Haddad 2000). Under *VIS*, the rate of female access to secondary schooling is assumed to reach 90 percent, clean water access is expected to reach 95 percent, and the female-to-male life expectancy ratio is expected to increase by 2 percent across the region by 2025. Achievement of the impressive advances in quality-of-life indicators represented by *VIS* would require a tremendous level of commitment and investment at all levels, and a major effort to focus on the status, education, and health of women.

Under this scenario, available kilocalories per capita increase in Sub-Saharan Africa from 2,231

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[6] Cleaver and Schreiber (1994), however, estimate that fertilizer use would have to rise 15 percent annually to achieve 3.5 percent annual yield growth.

per day in 1997 to 3,455 per day in 2025 (Table 20). The number of malnourished children under five years old in Sub-Saharan Africa decreases substantially by 2025, with most regions falling below 2 million children (Table 21). The total number of malnourished children in Sub-Saharan Africa is reduced from 32.7 million in 1997 to 9.4 million in 2025. Northern Sub-Saharan Africa is home to the largest number of malnourished children, although great strides are made in this region as well, with a reduction from 10.2 million children in 1997 to 3.9 million in 2025. Childhood

Table 20—Projected per capita kilocalories available in Africa under the *vision* scenario, 1997, 2015, 2020, and 2025

Region/Country	Available kilocalories per capita per day			
	Baseline 1997	Projected		
		2015	2020	2025
Northern Sub-Saharan Africa	2,175	2,714	2,907	3,123
Central and western Sub-Saharan Africa	2,175	2,849	3,091	3,351
Southern Sub-Saharan Africa	2,022	2,979	3,334	3,734
Eastern Sub-Saharan Africa	1,999	2,636	2,859	3,096
Nigeria	2,759	3,544	3,860	4,221
All Sub-Saharan Africa	2,231	2,926	3,178	3,455
West Asia/North Africa[a]	3,059	3,500	3,622	3,739

Source: IFPRI IMPACT projections 2004.

[a] In this table, West Asia/North Africa includes Egypt, Other West Asia/North Africa, and Turkey.

Table 21—Projected number of malnourished children in Africa under the *vision* scenario, 1997, 2015, 2020, and 2025

Region/Country	Number of malnourished children under five years old (millions)			
	Baseline 1997	Projected		
		2015	2020	2025
Northern Sub-Saharan Africa	10.2	7.2	5.7	3.9
Central and western Sub-Saharan Africa	6.9	3.8	2.9	1.7
Southern Sub-Saharan Africa	4.0	2.0	1.4	0.7
Eastern Sub-Saharan Africa	4.6	2.7	2.0	1.2
Nigeria	6.9	4.3	3.1	1.8
All Sub-Saharan Africa	32.7	20.0	15.1	9.4
West Asia/North Africa[a]	5.9	1.7	0.5	0.0

Source: IFPRI IMPACT projections 2004.

[a] In this table, West Asia/North Africa includes Egypt, Other West Asia/North Africa, and Turkey.

malnourishment is completely eliminated in West Asia/North Africa under *PES*, declining from 5.9 million in 1997.

Most notably, the percentage of malnourished children under five years old meets—or comes very close to meeting—the proposed MDG target of cutting the percentage of malnourished children in half by 2015 in all African regions (Table 22). The percentage of malnourished children in all of Sub-Saharan Africa declines by 25 percent over the projection period, falling to 7.5 percent in 2025. The regions with the largest percentage of malnourished children remaining in 2025 under *VIS* are northern Sub-Saharan Africa and Nigeria, with 10.3 and 9.3 percent, respectively. These two regions still experience the largest decline in the percentage of malnourished children, however, with a drop of around 30 percent.

A substantial increase in crop production is required to reach the malnutrition goals for Africa conceived under *VIS*. Annual cereal production growth rates are projected to be 3 percent per year for all of Africa, and 3.5 percent per year in Sub-Saharan Africa alone between 1997 and 2025 under *VIS* (Table 23). Cereal production growth in Egypt is the lowest of all regions, at 2.1 percent, while the highest growth is projected in central and western Africa at 4.2 percent. Rice yields are projected to have the largest percentage growth over the period, with a 3.4 percent annual growth in Africa and a 4 percent growth rate in Sub-Saharan Africa alone.

While both area and yield increases contribute to the increase in production, yield growth rates are higher over the time frame. Harvested area of cereals, roots, and tubers for Africa as a whole expands from 121 to 153 million hectares, a gain of 32 million hectares over the projection period. Although this is a significant total increase, the annual area growth is only 0.8 percent per year (Table 24). Yield growth increases substantially under *VIS*. Growth between 1997 and 2025 across Sub-Saharan Africa is 2.5 percent for all cereals, compared with the *BAU* level of 1.7 percent. Root and tuber yields increase at an even greater rate over the period, at 2.7 percent in Sub-Saharan Africa, 3.0 percent in northern Sub-Saharan Africa, and 2.9 percent in Other WANA (Table 25).

Projected net cereal imports, at 101 million metric tons by 2025, are significantly lower under *VIS* than under either *BAU* or *PES*, and represent

Table 22—Projected percentage of malnourished children in Africa under the *vision* scenario, 1997, 2015, 2020, and 2025

Region/Country	% of malnourished children under five years old Baseline 1997	Projected 2015	2020	2025
Northern Sub-Saharan Africa	40.0	21.2	15.8	10.3
Central and western Sub-Saharan Africa	27.8	13.9	9.9	5.9
Southern Sub-Saharan Africa	26.9	12.4	8.2	4.0
Eastern Sub-Saharan Africa	27.6	13.8	9.9	6.0
Nigeria	39.1	20.5	14.9	9.3
All Sub-Saharan Africa	32.8	16.9	12.2	7.5
West Asia/North Africa[a]	13.2	3.8	1.2	0.0

Source: IFPRI IMPACT projections 2004.

[a] In this table, West Asia/North Africa includes Egypt, Other West Asia/North Africa, and Turkey.

Table 23—Projected cereal production growth rates in Africa under the *vision* scenario, 1997-2025

Region/Country	Cereal production growth (% per year) Wheat	Maize	Other course grains	Rice	All Cereals
Northern Sub-Saharan Africa	3.3	2.8	3.6	3.9	3.5
Central and western Sub-Saharan Africa	3.8	3.9	4.4	4.5	4.2
Southern Sub-Saharan Africa	3.0	3.1	4.4	3.7	3.4
Eastern Sub-Saharan Africa	4.7	3.2	3.8	3.7	3.5
Nigeria	4.3	2.9	3.4	3.9	3.3
All Sub-Saharan Africa	3.6	3.2	3.7	4.0	3.5
Egypt	2.0	2.2	1.2	2.3	2.1
Other West Asia/North Africa	2.6	2.6	2.5	2.5	2.4
All Africa	2.6	3.0	3.2	2.6	3.0

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table 24—Sum of 1997 harvested cereal, root, and tuber area in Africa and projected 2025 cereal, root, and tuber area in Africa under the *vision* scenario

Region/Country	Baseline 1997 (million hectares)	Projected 2025 (million hectares)
Northern Sub-Saharan Africa	30.0	38.9
Central and western Sub-Saharan Africa	16.1	22.5
Southern Sub-Saharan Africa	11.4	15.1
Eastern Sub-Saharan Africa	9.4	12.5
Nigeria	23.9	30.0
All Sub-Saharan Africa	90.9	119.1
Egypt	2.8	3.2
Other West Asia/North Africa	27.1	30.5
All Africa	120.8	152.8

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table 25—Projected crop yield growth in Africa under the *vision* scenario, 1997–2025

	Crop yield growth (% per year)					
Region/Country	**Wheat**	**Maize**	**Other course grains**	**Rice**	**All Cereals**	**All roots and tubers**
Northern Sub-Saharan Africa	2.0	2.0	2.7	2.9	2.5	3.0
Central and western Sub-Saharan Africa	2.1	2.8	3.0	3.2	2.9	2.5
Southern Sub-Saharan Africa	0.7	2.0	3.2	2.7	2.2	2.5
Eastern Sub-Saharan Africa	2.8	2.2	2.5	3.0	2.4	2.8
Nigeria	2.8	2.2	2.5	2.9	2.4	2.9
All Sub-Saharan Africa	2.1	2.3	2.6	2.9	2.5	2.7
Egypt	1.2	1.7	1.6	1.9	1.6	2.8
Other West Asia/North Africa	2.2	1.7	1.1	2.3	1.9	2.9
All Africa	2.1	2.1	2.3	2.5	2.2	2.7

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

an increase of 80 percent over 1997 net import levels. In percentage terms, the greatest increase occurs in Sub-Saharan Africa, where total cereal imports increase from 12 million metric tons in 1997 to 45 million in 2025 under *VIS*. The increase in imports is very low in North Africa, at only 1 percent in Egypt and 36 percent in Other WANA. Of the four cereals, wheat imports are the largest, reaching 52 million metric tons Africa-wide by 2025 (Table 26).

The obstacles to achieving the results modeled under *VIS* are daunting. This scenario requires a 78 percent increase in projected investments for Africa over *BAU* levels for a total of US$303.2 billion (Table 27). The total percentage increase in investments is even higher for Sub-Saharan Africa alone, at 94 percent more than *BAU* levels from 1997 to 2025. Under *VIS*, rural road investment rises 56 percent above *BAU* levels to US$95.4 billion, education investment jumps 117 percent to US$82.3 billion, clean water investment increases 55 percent to US$49.1 billion, irrigation investment jumps 141 percent to US$48.7 billion, and agricultural research investment increases 44 percent to US$27.8 billion.

Greater investment in agricultural research helps to improve crop yields. Investments in both conventional breeding and in the tools of biotechnology, such as marker-assisted selection and cell and tissue culture techniques, ultimately lead to improved cereal yield growth in rainfed environments. This growth comes both from incremental increases in the yield potential and from improved stress resistance, including improved drought tolerance. Participatory plant breeding assists in tailoring new crop varieties for rainfed environments and remote areas to lead to additional yield increases. Better policies and increased rural infrastructure investment help to exploit remaining yield gaps by linking rural farmers to markets and reducing the risks of rainfed farming.

Table 26—Projected net cereal trade in Africa under the *vision* scenario, 1997 and 2025

Region/Country	Wheat Baseline 1997	Wheat Projected 2025	Maize Baseline 1997	Maize Projected 2025	Other coarse grains Baseline 1997	Other coarse grains Projected 2025	Rice Baseline 1997	Rice Projected 2025
	Net cereal trade (million metric tons)							
Northern Sub-Saharan Africa	–1.7	–9.7	–0.1	–0.1	–0.1	4.3	–0.4	–2.2
Central and western Sub-Saharan Africa	–1.9	–7.4	–0.2	–6.2	–0.2	1.0	–2.3	–6.2
Southern Sub-Saharan Africa	–1.2	–4.2	–0.8	–0.8	–0.1	0.6	–0.3	–0.8
Eastern Sub-Saharan Africa	–0.5	–2.2	–0.6	–1.2	–0.1	0.4	–0.2	–1.2
Nigeria	–1.3	–3.7	0.0	–2.8	–0.0	2.7	–0.7	–2.8
All Sub-Saharan Africa	–6.6	–27.2	–1.6	–13.3	–0.4	9.0	–3.8	–13.3
Egypt	–6.9	–7.3	–2.9	–0.7	0.0	–0.9	0.3	–0.7
Other West Asia/North Africa	–18.4	–17.5	–5.9	–5.5	–7.0	–18.4	–3.1	–5.5
All Africa	–31.8	–52.0	–10.4	–19.4	–7.4	–10.3	–6.6	–19.4

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table 27—Projected total investments by sector in Africa under the *vision* scenario, 1997–2025

Region/Country	Irrigation	Rural roads	Education	Clean water	National agricultural research	Total investments
	Total investments (billion US$)					
Northern Sub-Saharan Africa	3.4	6.8	17.4	12.1	1.3	40.9
Central and western Sub-Saharan Africa	2.0	37.6	9.6	8.7	2.8	60.7
Southern Sub-Saharan Africa	12.5	20.9	9.5	4.6	4.0	51.4
Eastern Sub-Saharan Africa	1.0	11.5	10.2	6.5	5.5	34.7
Nigeria	19.8	9.6	12.8	7.0	1.5	50.7
All Sub-Saharan Africa	38.6	86.4	59.5	38.5	15.0	238.1
Egypt	0.6	0.7	2.6	2.1	4.7	10.6
Other West Asia/North Africa	9.4	8.3	20.2	8.4	8.1	54.5
All Africa	48.7	95.4	82.3	49.1	27.8	303.2

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

3. Scenarios for Water Resources

Under business as usual, parts of Africa are likely to experience very high water stress. Three water-related scenarios show that there are steps that policymakers and farmers can take to promote the more effective use of water, with consequent benefits for food production and food prices.

Water Resources under the *Business as Usual* Scenario

Sub-Saharan Africa will experience the highest percentage growth in water consumption of all the IMPACT regions over the period 1995–2025. Under *BAU*, total water withdrawals for the region as a whole are projected to increase from 128 km^3 in 1995 to 214 km^3 in 2025, a 67 percent increase (Table 28). The greatest increases in water withdrawals occur in central and western Sub-Saharan Africa, at 125 percent, and Nigeria, at 113 percent. Northern Sub-Saharan Africa has a lower increase than the rest of the region under *BAU*, at 31 percent. Water withdrawals in Egypt and Other WANA also grow at a slower rate than in Sub-Saharan Africa, at 21 and 20 percent, respectively.

The "criticality ratio," or ratio of water withdrawal to total renewable water (TRW), is an indicator of water scarcity at the basin level. A higher criticality ratio indicates a more intensive use of

Table 28—Projected water withdrawal and the share of total renewable water in Africa under the *business as usual* scenario, 1997 and 2025

	Total water withdrawal (km^3)			Ratio of withdrawal to TRW (km^3)	
Region/Country	**Baseline 1997**	**Projected 2025**	**% increase**	**Baseline 1997**	**Projected 2025**
Northern Sub-Saharan Africa	52.2	68.3	31	0.06	0.08
Central and western Sub-Saharan Africa	11.0	24.7	125	0.00	0.01
Southern Sub-Saharan Africa	44.4	78.3	76	0.04	0.07
Eastern Sub-Saharan Africa	9.9	19.6	98	0.03	0.06
Nigeria	10.9	23.2	113	0.04	0.08
All Sub-Saharan Africa	128.4	214.1	67	0.02	0.04
Egypt	54.3	65.6	21	0.89	1.08
Other West Asia/North Africa	143.2	171.5	20	1.16	1.39
All Africa	325.9	451.2	38	–	–

Source: Rosegrant, Cai, and Cline 2002.

Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT-WATER model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

river basin water, and lower water quality for downstream users. Areas with criticality ratios equal to or greater than 0.4 are considered to be under "high water stress," and those with ratios equal to or greater than 0.8 are considered to be under "very high water stress." As shown by the criticality ratios, Sub-Saharan Africa is not purely water scarce. In Sub-Saharan Africa the criticality ratio was 0.02 in 1995 and is projected to increase to 0.04 in 2025 under *BAU*. The situation is similar throughout all regions in Sub-Saharan Africa, with the highest ratios in the region reaching only 0.08 in Nigeria and northern Sub-Saharan Africa (Table 28). North Africa's level of water stress is quite different, however. These areas are considered to be under very high water stress, with criticality ratios of 0.89 in Egypt and 1.16 in Other WANA in 1995. The situation is projected to worsen by 2025 under *BAU*, with both regions expected to have a criticality ratio greater than 1 by 2025.

In 1995, irrigation accounted for 88 percent of consumptive water use in Africa (Table 29). This proportion varies significantly across the continent, however, with irrigation accounting for at least 90 percent in North Africa and northern Sub-Saharan Africa but only for around 50–60 percent in Nigeria, central and western Sub-Saharan Africa, and eastern Sub-Saharan Africa. While this ratio declines in all regions under *BAU*, the greatest decline in the share of water consumed for irrigation occurs in eastern Sub-Saharan Africa, from 57 percent in 1995 to 38 percent in 2025 (Table 29). Non-irrigation water use (primarily related to household and industrial uses) increases considerably by 2025, however, from 21 km^3 to over 47 km^3 in 2025 under *BAU*, leading to a decline in the share of irrigation to 79 percent across Africa (Table 30).

However, this appearance of plentiful water at the basin level is misleading, largely because of the lack of investment in water resources development. In fact, developed water at the irrigation system is scarce and becoming increasingly more so. This scarcity can be observed through the irrigation water supply reliability index (IWSR). The IWSR is

Table 29—Projected water consumption in Africa under the *business as usual* scenario, 1995 and 2025

	Total water consumption (km^3)		**Irrigation water consumption (km^3)**		**Ratio of irrigated to total water consumption**	
Region/Country	**Baseline 1995**	**Projected 2025**	**Baseline 1995**	**Projected 2025**	**Baseline 1995**	**Projected 2025**
Northern Sub-Saharan Africa	3.08	37.5	27.7	29.7	0.90	0.79
Central and western Sub-Saharan Africa	5.4	11.3	2.6	3.6	0.48	0.32
Southern Sub-Saharan Africa	16.0	24.2	14.0	19.6	0.88	0.81
Eastern Sub-Saharan Africa	4.6	8.5	2.6	3.2	0.57	0.38
Nigeria	5.6	11.8	3.5	6.7	0.63	0.57
All Sub-Saharan Africa	62.4	93.3	50.4	62.8	0.81	0.67
Egypt	27.9	31.9	25.4	27.2	0.91	0.85
Other West Asia/North Africa	84.4	95.9	78.1	84.2	0.93	0.88
All Africa	174.7	221.1	153.9	174.2	0.88	0.79

Source: Rosegrant, Cai, and Cline 2002.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT-WATER model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table 30—Projected non-irrigation water consumption in Africa under the *business as usual* scenario, 1995 and 2025

Region/Country	Domestic (km^3) Baseline 1995	Domestic (km^3) Projected 2025	Industry (km^3) Baseline 1995	Industry (km^3) Projected 2025	Total non-irrigation (km^3) Baseline 1995	Total non-irrigation (km^3) Projected 2025
Northern Sub-Saharan Africa	2.4	5.9	0.2	0.5	3.1	7.8
Central and western Sub-Saharan Africa	2.4	6.4	0.2	0.6	2.8	7.7
Southern Sub-Saharan Africa	1.5	3.4	0.2	0.5	2.0	4.6
Eastern Sub-Saharan Africa	1.6	4.3	0.1	0.2	2.0	5.3
Nigeria	1.7	3.8	0.2	0.7	2.1	5.1
All Sub-Saharan Africa	9.6	23.8	0.9	2.5	12.0	30.5
Egypt	1.6	2.9	0.7	1.5	2.5	4.7
Other West Asia/North Africa	3.4	6.3	2.0	3.5	6.2	11.7
All Africa	14.6	33.0	3.6	7.5	20.7	46.9

Source: Rosegrant, Cai, and Cline 2002.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT-WATER model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table 31—Projected irrigation and non-irrigation water supply reliability in Africa under the *business as usual* scenario, 1995 and 2025

Region/Country	Irrigation Water Supply Reliability (IWSR) Baseline 1995	Irrigation Water Supply Reliability (IWSR) Projected 2025	Non-irrigation Water Supply Reliability (NIWSR) Baseline 1995	Non-irrigation Water Supply Reliability (NIWSR) Projected 2025
Northern Sub-Saharan Africa	0.74	0.70	0.97	0.95
Central and western Sub-Saharan Africa	0.96	0.88	1.00	1.00
Southern Sub-Saharan Africa	0.72	0.72	1.00	1.00
Eastern Sub-Saharan Africa	0.80	0.74	0.99	0.98
Nigeria	0.59	0.72	0.94	0.95
All Sub-Saharan Africa	0.73	0.72	0.98	0.97
Egypt	0.73	0.71	1.00	1.00
Other West Asia/North Africa	0.79	0.75	1.00	1.00

Source: Rosegrant, Cai, and Cline 2002.

the proportion of potential demand (the demand for irrigation water in the absence of any water supply constraints) realized in actual consumptive use (the realized water demand, given the limitations of water supply for irrigation) and is defined as the ratio of water supply available for irrigation to potential demand for irrigation water. Sub-Saharan Africa had the lowest irrigation reliability of any major region in 1995, at 0.73, indicating that less than three-quarters of potential irrigation demand in existing systems is being met (Table 31). Nigeria had an extremely low reliability in 1995, at 0.59, but under *BAU*, the index increases to 0.72 in 2025. Northern Sub-Saharan Africa's index falls from 0.74 to 0.7 over the projection period; central and western Sub-Saharan Africa experiences an even larger decline, from 0.96 to 0.88; and the index also falls in eastern Sub-Saharan Africa, from 0.8 to 0.74. In southern Sub-Saharan Africa an average of 0.72 is maintained, but with extreme decreases in reliability in low rainfall years. IWSR values also decline in North Africa—from 0.73 to 0.71 in Egypt, and from 0.79 to 0.75 in Other WANA (Table 31).

Irrigated and Rainfed Production

Irrigated area in Africa is small relative to the rest of the world, at only 12.8 million hectares for cereals in 1995, which under *BAU* increases to 15.4 million hectares in 2025 (Table 32 and Appendix Table A.1). This is equal to 12.5 percent of the total African cereal area in 1995 and 11.4 percent in 2025. Irrigated cereal area in Sub-Saharan Africa is especially small, comprising only 4.5 percent of the total cereal area in 1995 and 4.8 percent in 2025. A slightly larger percentage of cereal area is irrigated in North Africa, with 31.9 percent of total area irrigated in 1995 and 32.1 percent in 2025.

While Sub-Saharan Africa and Africa as a whole have a larger percentage of rainfed area than many other regions around the world, North Africa is more on par with the global average. In 1995, 69 percent of global cereal area planted was rainfed, including 40 percent of rice, 66 percent of wheat, 82 percent of maize, and 86 percent of other grains. Worldwide rainfed cereal yield is about 2.2 metric tons per hectare, which is about 65 percent of the irrigated yield. Rainfed cereal production accounts for 58 percent of worldwide cereal production, and irrigated production accounts for 42 percent of world production.

The proportion of cereals produced using irrigated agriculture is also relatively low in Africa, although this differs considerably between North Africa and Sub-Saharan Africa. Overall, 34 percent of African cereal production was irrigated in 1995, with only 10.6 percent in Sub-Saharan Africa and 62 percent in North Africa (Appendix Table A.2). By 2025 under *BAU*, irrigation accounts for 11.4 percent of total cereal production in Sub-Saharan Africa, and 64 percent of cereal production in North Africa. While irrigated production is higher across North Africa, irriga-

Table 32—Cereal area, production, and yield in all Africa under the *business as usual* scenario, 1995 and 2025

	Baseline 1995			Projected 2025		
Indicator	**Irrigated**	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**
Cereal area (million hectares)	12.8	90.1	102.9	15.4	119.9	135.3
Cereal production (million metric tons)	40.8	79.8	120.6	67.0	150.8	217.8
Cereal yield (metric tons per hectare)	3.19	0.89	1.17	2.43	1.26	1.48

Source: Rosegrant, Cai, and Cline 2002.

tion is especially crucial to Egyptian agriculture because nearly all cereal production is irrigated.

Cereal yields are also extremely low in Sub-Saharan Africa. In 1995, the total cereal yield for all of Sub-Saharan Africa area was only 0.91 metric tons per hectare. Under *BAU* it is projected to increase to 1.34 metric tons per hectare in 2025. The irrigated cereal yield in Sub-Saharan Africa was 2.16 metric tons per hectare, and under *BAU* it is projected to increase to 3.23 metric tons per hectare in 2025. Given the prevalence of irrigation in Egypt, as already mentioned, Egyptian irrigated yields are much higher than in the rest of Africa, at 5.48 in 1995, rising to 8.36 by 2025 under *BAU* (Appendix Table A.3).

In 1995, 51 percent of all harvested root and tuber area in Africa was irrigated. The proportion was similar in both Sub-Saharan Africa (51 percent), and North Africa (45 percent). The ratios in Africa and Sub-Saharan Africa are expected to decrease slightly by 2025, with 49 percent of harvested area irrigated in both regions (Table 33 and Appendix Table A.4). Irrigated root and tuber area increases slightly in North Africa under BAU over the projection period, with 51 percent of the harvested area irrigated in 2025. In 1995, 55 percent of all root and tuber production in Africa and Sub-Saharan Africa and 58 percent of all root and tuber production in North Africa was irrigated. The 2025 projected equivalents under *BAU* are 52 percent in Africa, 51 percent in Sub-Saharan Africa, and 59 percent in North Africa (Appendix Table A.5).

In 1995, African root and tuber yield was 8.0 metric tons per hectare; it is projected to increase to 12.4 metric tons per hectare by 2025 under *BAU*. The regional average yields are slightly higher for irrigated as opposed to rainfed areas. North African yields are significantly higher than in Sub-Saharan Africa in both 1995 and 2025, primarily because of the high irrigated yields. Root and tuber yields are projected to increase from 21.3 metric tons per hectare in Egypt and 25.7 metric tons per hectare in the Other WANA in 1995, to 28.2 metric tons per hectare and 47.2 metric tons per hectare, respectively, in 2025 (Appendix Table A.6).

Water Harvesting

Rainfed agriculture will retain an important role in the growth of food production in the future. However, appropriate investments and policy reforms will be required to enhance the contribution of rainfed agriculture. Water harvesting is one technique that has the potential in some regions to improve rainfed crop yields and provide farmers with improved water availability and increased soil fertility in some local and regional ecosystems, as well as environmental benefits through reduced soil erosion. Water harvesting involves concentrating and collecting the rainwater from a larger

Table 33—Roots and tubers area, production, and yield in Africa under the *business as usual* scenario, 1995 and 2025

	Baseline 1995			Projected 2025		
Indicator	**Irrigate**	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Totals**
Roots and tubers area (million hectares)	8.8	8.5	17.3	10.7	11.2	21.8
Roots and tubers production (million metric tons)	75.4	62.2	137.7	139.5	130.0	269.5
Roots and tubers yield (metric tons per hectare)	8.6	7.3	8.0	13.1	11.6	12.4

Source: Rosegrant, Cai, and Cline 2002.

catchment area onto a smaller cultivated area. The runoff can either be diverted directly and spread on the fields, or collected in some way to be used at a later time.

While many water-harvesting case studies and experiments have shown increases in yield and water use efficiency, it is not clear if the widespread use of these technologies is feasible. Construction and maintenance costs for water-harvesting systems—particularly the labor costs—are particularly important in determining if a technique will be widely adopted at the individual farm level. The initial high labor costs of building the water-harvesting structure often provide disincentives for adoption. The initial labor costs for construction generally occur in the dry season when labor is cheaper but scarce because of worker migration; maintenance costs, on the other hand, often occur in the rainy season when labor costs are higher because of competition with conventional agriculture. The impacts of HIV/AIDS on agricultural labor in Africa would likely cause additional problems in terms of sourcing adequate labor to initiate water-harvesting projects, and some projects may require inputs that are too expensive for some farmers to supply. In addition, many farmers in arid or semi-arid areas do not have the capacity to move large amounts of earth—a necessary aspect of some of the larger water-harvesting systems.

Given the high costs of implementation and higher short-term risk from the necessity of additional inputs, cash, and labor, broader farmer acceptance of water-harvesting techniques has been limited, despite localized successes. Moreover, water-harvesting initiatives frequently suffer from lack of hydrological data, insufficient attention to important social and economic considerations during the planning stages, and the absence of a long-term government strategy for ensuring the sustainability of interventions. Involving farmers more heavily in the planning stages and using farmers to maintain and collect data, as well as providing appropriate educational and extension support, could help expand the contribution of water harvesting.

Scenarios for High Increase in Effective Rainfall Use

In addition to direct investment in *blue water*—meaning water derived from increased withdrawal capacity and efficient irrigation and municipal and industrial use—an alternative approach would be to invest in increasing the availability of *green water*—that which is available for evapotranspiration in rainfed areas. As a substitute to resolving the water shortage problem, effective rainfall available for crop growth can be increased through rainfall-harvesting technology. IMPACT simulates three scenarios on the basis that improved water harvesting results in effective rainfall use in rainfed areas, which gradually increases over time as a percentage of actual rainfall. Effective rainfall is defined here as the rainfall infiltration that is available for crop evapotranspiration.

Although improved water harvesting is often considered in connection with traditional agriculture, it also has potential in highly developed agriculture. Advanced tillage practices can also increase the share of rainfall that goes to infiltration and evapotranspiration. Contour plowing, which is typically a soil-preserving technique, also acts to capture, and allow infiltration of, a higher proportion of the precipitation. Precision leveling can also lead to greater relative infiltration and hence a higher percentage of effective rainfall.

For the *high increase in effective rainfall use* scenario (henceforth *HIER*), it is assumed that effective rainfall increases evenly over the projection period compared with *BAU*, and that by 2025, effective rainfall use (in rainfed areas only) is 10 percent higher than base year levels in those basins/countries where water shortages for crop growth exist. The analysis considers three scenarios:

1. *HIER–1: BAU* combined with *HIER*, whereby effective 2025 rainfall use in all basins/countries is 10 percent higher than actual base-year rainfall;
2. *HIER–2: BAU* and *HIER* combined with low investments in irrigation; and
3. *HIER–3: BAU* combined with a 15 percent increase in effective rainfall use in 2025 in Sub-Saharan African countries only.

Under *HIER–1*, global rainfed cereal production is 1,492 million metric tons in 2021–25, nearly 5 percent higher than the 1,424 million metric tons under *BAU*. The total production effect is somewhat less, however, because the boost in rainfed production through higher effective rainfall also tends to reduce cereal prices. Lower prices then act to dampen the total production effect by reducing production in irrigated areas. Hence the overall outcome is that high rainfall harvesting results in a combination of higher production with lower cereal prices, which is an important improvement. The price of wheat declines by 10 percent relative to *BAU* because of the production benefits of high rainfall harvesting; price effects are similar for rice and maize.

Under *HIER–2*, improved rainfall harvesting partly compensates for lower irrigation investment by cutting price increases resulting from the low investments by about half.

HIER–3 explores whether rainfall harvest improvements can make a significant difference if they occur on a limited regional basis only. The 15 percent increase in rainfall harvesting in Sub-Saharan Africa alone causes the cereal import burden to be cut by half, reducing average imports from 17.4 million metric tons per year to 8.7 million metric tons per year in 2021–25.

Other Water-Related Measures

In addition to water harvesting, the use of improved farming techniques has been suggested to help conserve soil and make more effective use of rainfall. Conservation tillage measures such as minimum-till and no-till farming have been tested in some developing countries. Precision agriculture,[7] which has been used in the United States, has also been suggested for use in developing countries. Along with research on integrated nutrient management, applied research to adapt conservation tillage technologies for use in unfavorable rainfed systems in developing countries could have a large, positive impact on local food security and standards of living.

Increased investment in rural infrastructure and policies is also important to close the gap between potential yields in rainfed areas and actual yields achieved by farmers. Important policies include higher priority for rainfed areas in agricultural extension services, and access to markets, credit, and input supplies. The successful development of rainfed areas is likely to be more complex than in high-potential irrigated areas because of the inherent comparative lack of access to infrastructure and markets and more difficult and variable agroclimatic environments. Progress may also be slower than in the early Green Revolution because new approaches will need to be developed and tested on a small scale for the specific environments involved before they can be disseminated more widely. Investment in rainfed areas, policy reform, and transfer of technology such as water harvesting will therefore require stronger partnerships between agricultural researchers and other agents of change, including local organizations, farmers, community leaders, nongovernmental organizations (NGOs), national policymakers, and donors.

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[7] Precision agriculture methods focus on information technology using site-specific soil, crop, and other environmental data to determine specific inputs required for certain sections of a field (Rosegrant, Cai, and Cline 2002).

4. SCENARIOS FOR MARKETING MARGINS AND TRADE

Producers and consumers of agricultural products in Africa can benefit from changes that give farmers better access to markets, both domestic and international. Scenarios for reduced marketing margins and increased trade liberalization show potential increases in agricultural productivity as well as broad economic benefits.

Reduction in Marketing Margins

As the earlier discussion of projection results under *VIS* showed, increases in crop productivity can have significant effects on production levels. Another method for increasing productivity is to improve rural infrastructure, marketing, and communications, thus decreasing marketing margins. This could be especially important in developing countries where rural infrastructure is lacking. A reduction in high domestic marketing margins can allow producers and consumers to gain from increased productivity. In this scenario (henceforth *reduced marketing margins*, or *RMM*), we estimate the effects of a 50 percent reduction in the marketing margins in Sub-Saharan Africa and a 40 percent reduction in North Africa. As with the *HIER* scenarios, all other parameters are the same as under *BAU*.

Table 34—Cereal demand and production in Africa under the *business as usual* and *reduced marketing margins* scenarios, 1997 and 2025

	Cereal demand (million metric tons)			Cereal production (million metric tons)		
		Projected 2025			Projected 2025	
Region/Country	**Baseline 1997**	***Business as usual* scenario *(BAU)***	***Reduced marketing margins* scenario *(RMM)***	**Baseline 1997**	***Business as usual* scenario *(BAU)***	***Reduced marketing margins* scenario *(RMM)***
Northern Sub-Saharan Africa	22.7	48.3	51.2	20.5	42.3	46.0
Central and western Sub-Saharan Africa	13.9	32.3	34.8	9.4	22.7	24.8
Southern Sub-Saharan Africa	12.3	24.6	26.7	9.8	20.0	22.5
Eastern Sub-Saharan Africa	10.8	21.9	23.6	9.0	18.7	20.8
Nigeria	22.8	47.6	51.2	20.6	41.4	45.1
All Sub-Saharan Africa	82.5	174.6	187.5	69.3	145.1	159.2
Egypt	23.7	37.8	39.2	15.9	24.3	26.0
Other West Asia/North Africa	73.5	129.7	135.1	38.9	62.7	65.6
All Africa	179.7	342.2	361.8	124.1	232.2	250.8

Source: IFPRI IMPACT projections 2004.

Note: The total for “All Africa” is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the “Other West Asia/North Africa” region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

The decreased marketing margins cause an increase in cereal production and demand in Africa. In the region as a whole, cereal demand under *RMM* increases 5.7 percent over *BAU* levels, while cereal production increases 8.0 percent. The effect is greater in the Sub-Saharan region alone, where cereal demand increases 7.3 percent and cereal production 9.7 percent over *BAU* levels (Table 34). Cereal production and demand also increase in Egypt, by 6.8 percent and 3.6 percent, respectively, while production in Other WANA increases by 4.6 percent and demand by 4.2 percent.

The impact is even stronger for meat commodities, with an increase of 9.3 percent in African meat demand and 9.8 percent in meat production. As in the case of cereals, the effects on meat commodities are even greater in Sub-Saharan Africa, where meat demand increases by 12.6 percent and meat production by 11.5 percent over *BAU* levels (Table 35). North Africa also experiences an increase in meat production and demand under *RMM*, with a 7.8 percent increase in production and a 5.7 percent increase in demand over *BAU* levels.

These projected increases in production and demand also have an effect on the number of malnourished children in Africa. The proposed reduction in marketing margins under *RMM* reduces the percentage of malnourished children in Sub-Saharan Africa in 2025 to 25.2 percent compared with the 28.2 percent projected under *BAU*. Although the difference in percentage terms may not seem exceptional, it translates as 4.1 million fewer malnourished children under five years old in Sub-Saharan Africa in 2025. In West

Table 35—Projected meat demand and production in Africa under the *business as usual* and *reduced marketing margins* scenarios, 1997 and 2025

	Meat demand (million metric tons)			**Meat production (million metric tons)**		
		Projected 2025			**Projected 2025**	
Region/Country	**Baseline 1997**	***Business as usual* scenario *(BAU)***	***Reduced marketing margins* scenario *(RMM)***	**Baseline 1997**	***Business as usual* scenario *(BAU)***	***Reduced marketing margins* scenario *(RMM)***
Northern Sub-Saharan Africa	1.6	3.9	4.3	1.6	3.8	4.3
Central and western Sub-Saharan Africa	1.0	2.5	2.8	0.8	2.3	2.5
Southern Sub-Saharan Africa	0.9	2.0	2.3	0.9	2.1	2.3
Eastern Sub-Saharan Africa	0.9	2.2	2.4	0.9	2.1	2.4
Nigeria	1.1	2.7	3.1	1.1	2.4	2.7
All Sub-Saharan Africa	5.5	13.3	15.0	5.4	12.7	14.1
Egypt	1.0	2.4	2.6	0.9	1.9	2.1
Other West Asia/North Africa	4.9	9.9	10.5	4.3	8.6	9.3
All Africa	11.4	25.6	28.0	10.6	23.2	25.5

Source: IFPRI IMPACT projections 2004.

Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Asia/North Africa,[8] the percentage falls only slightly, from 4.4 percent under *BAU* to 3.8 percent under *RMM* (Table 36).

Trade Liberalization

Three scenarios were modeled using IMPACT to assess the effects of different levels of trade liberalization on Africa:

1. *FTL: full trade liberalization*, whereby producer and consumer subsidy equivalent prices (PSEs and CSEs, respectively) between domestic and international prices (price wedges) are completely removed in all countries, with the reductions beginning in 2005;
2. *Africa protectionism, or PRO:* an increase of 0.50 in PSE and CSE values in all African countries in 2005, and maintenance of those levels from 2005 to 2025; and
3. *Africa trade liberalization, or ATL:* removal of all price wedges for all African countries (including all Sub-Saharan African regions, Egypt, and Other WANA), while retaining baseline protection levels in all other countries and regions.

Caution is still warranted when interpreting the results projected under these scenarios because IMPACT is a partial equilibrium model and thus does not account for the cross-sectoral linkages that would undoubtedly accompany widespread trade liberalization. A general equilibrium model would best assess these linkages (see, for example, Diao, Roe, and Somwaru 2001). Nevertheless, the direction and relative magnitude of the changes that result from the implementation of these scenarios are instructive in assessing the importance of the agricultural trade liberalization agenda.

Table 36—Projected number and percentage of malnourished children in Africa under the *business as usual* and *reduced marketing margins* scenarios, 1997 and 2025

Region/Country	Number of malnourished children under five years old (millions)			% of malnourished children under five years old		
		Projected 2025			Projected 2025	
	Baseline 1997	*Business as usual scenario (BAU)*	*Reduced marketing margins scenario (RMM)*	Baseline 1997	*Business as usual scenario (BAU)*	*Reduced marketing margins scenario (RMM)*
Northern Sub-Saharan Africa	10.2	13.8	12.6	40.0	36.3	33.3
Central and western Sub-Saharan Africa	6.9	8.3	7.3	27.8	23.2	20.4
Southern Sub-Saharan Africa	4.0	4.2	3.4	26.9	21.6	17.8
Eastern Sub-Saharan Africa	4.6	5.0	4.5	27.6	24.2	21.8
Nigeria	6.9	7.1	6.3	39.1	32.3	28.7
All Sub-Saharan Africa	32.7	38.3	34.2	32.8	28.2	25.2
West Asia/North Africa[a]	5.9	3.6	1.8	13.2	7.7	3.8

Source: IFPRI IMPACT projections 2004.

[a] In this table, West Asia/North Africa includes Egypt, Other West Asia/North Africa, and Turkey.

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[8] Here, West Asia/North Africa includes Egypt, Other WANA, and Turkey.

Impacts on Commodity Prices

Under *FTL*, removing trade barriers in all countries could have a significant effect on cereal prices in 2025, with increases projected in the range of 9–32 percent above projected *BAU* levels (Table 37). Of the cereal commodities, rice prices have the largest projected increase, at 14 percent, followed closely by maize, wheat, and other coarse grains. However, meat, and especially milk, prices escalate even more sharply in response to *FTL* because meat and milk prices are more distorted under *BAU* than are cereal prices. The smallest increase in meat prices is 12 percent for pork and poultry, while beef, sheep, and goat meat rise by 19 percent. Milk prices increase at a steep 32 percent under *FTL*. The removal of the price distortions consequently has a greater impact on livestock producers and consumers than on cereal producers and consumers.[9]

As is to be expected, world prices react more strongly under *FTL* than they do under *ATL*. Under *ATL*, cereal prices rise between 1 and 3 percent above *BAU* levels, while meat and milk prices increase between 1 and 4 percent. The effects are similar—though slightly higher—under *PRO*, whereby meat and milk prices increase 2–3 percent above *BAU* levels, and cereal prices increase 5–8 percent above *BAU* levels (Table 37).

Economic Benefits of Trade Liberalization

Although trade and prices are highly important indicators for evaluating the results of the various

Table 37—Projected world prices under the *business as usual* and *trade liberalization* scenarios, 1997 and 2025

	World prices (US$ per metric ton)				
Commodity	**Baseline 1997**	***Business as usual* scenario (*BAU*)**	***Full trade liberalization* scenario (*FTL*)**	***Africa protectionism* scenario (*PRO*)**	***Africa trade liberalization* scenario (*ATL*)**
Beef	1,808	1,707	2,030	1,771	1,765
Pork	2,304	2,165	2,421	2,215	2,189
Poultry	735	712	799	730	720
Sheep and goats	2,918	2,732	3,245	2,816	2,832
Milk	318	278	366	287	281
Wheat	133	117	128	123	119
Rice	285	232	264	245	238
Maize	103	102	112	107	103
Other coarse grains	97	86	94	93	87

Source: IFPRI IMPACT projections 2004.

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[9] It should be noted that the net effect on consumers of an increase in prices due to full trade liberalization depends on the level of distortions they face under the current trading regime. Although international cereal and livestock prices increase under FTL, consumers living under particularly heavily taxed systems will pay lower prices overall.

trade liberalization scenarios, it is most important to know what the net economic benefits would be. In the partial equilibrium approach utilized here, the net economic benefits due to full trade liberalization are estimated as the net benefits to producers (change in producer surplus) plus the net benefits to consumers (change in consumer surplus) plus the tax savings due to removals of subsidies under trade liberalization compared with the baseline results in 2025. It is projected that the net benefits in Africa under *FTL* for IMPACT commodities included in the model would total US$5.4 billion in 2025 (Table 38). The largest gain occurs in Sub-Saharan Africa, at US$4.60 billion, and the smallest gain occurs in Other WANA, at US$0.29 billion. Among the Sub-Saharan countries in 2025, northern Sub-Saharan Africa gains most under *FTL*, at US$2.22 billion, while eastern Sub-Saharan Africa has the lowest gain under *FTL*, at US$0.25 billion. The highest benefits to Sub-Saharan Africa—85 percent of the total benefits—are gained broadly through meat, milk, and cereal commodities (Table 38). They arise, in part, because African farmers face less competition from subsidized exports from developed countries under *FTL*; further, the removal of the costly subsidies and taxes that many African governments impose on food production and consumption is also a significant factor.[10]

Table 38—Projected benefits in Africa of global trade liberalization for IMPACT commodities under the *full trade liberalization* scenario, 2025

Region/Country	Projected benefits in 2025 (billion US$)
Northern Sub-Saharan Africa	2.22
Central and western Sub-Saharan Africa	0.72
Southern Sub-Saharan Africa	0.69
Eastern Sub-Saharan Africa	0.25
Nigeria	0.72
All Sub-Saharan Africa	4.60
Egypt	0.51
Other West Asia/North Africa	0.29
All Africa	5.40

Source: IFPRI IMPACT projections 2004.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT model includes some West Asian countries in the "Other West Asia /North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

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[10] The world price and global net benefits estimated here are similar in magnitude to those estimated by Diao, Roe, and Somwaru (2001) using a general equilibrium model for full agricultural trade liberalization, including a few additional commodities such as sugar and fruits and vegetables. Diao, Roe, and Somwaru estimated static welfare net benefits of US$31.1 billion and an increase in the index of world agricultural prices of 11.6 percent. However, our results find a considerably larger share of benefits accrue to developing countries, at 59 percent compared with the 8 percent reported by Diao, Roe, and Somwaru.

5. CONCLUSIONS

Many of the challenges facing Africa's agricultural sector, as discussed in this paper, stem from a few root causes. One of the major factors leading to failures in the agricultural sector is poor political and economic governance in many African countries (including ineffective institutions). Inadequate funding for the agricultural sector, including the weak role played by the private sector, has also hindered agricultural development. Water resources management has been at issue in many African countries, with poor infrastructure and lack of attention paid to climatic conditions, such as major droughts (Cooper 2004). In addition, the neglect of research and development and its funding has hindered the growth of the agricultural sector (Badiane 2004).

The strategies for addressing these challenges should take into account local, natural, and human resources, as well as the political and economic agenda of each country. However, the various scenarios assessed in this paper point to common policy priorities for addressing food and nutrition security in Africa. The following priority areas are discussed below in greater detail: (1) reform of agricultural policies, trade, and tariffs; (2) investment in rural infrastructure, education, and social capital; (3) crop, land, water, and input management; (4) agricultural research and extension; and (5) investment in women.

Reform of Agricultural Policies, Trade, and Tariffs

Africa's high export prices limit farmers' access to the international markets (Gladwin et al. 2001). In addition, domestic subsidies, protective tariffs, and other trade barriers imposed by wealthy nations harm farmers in Africa and other poor developing countries. The agricultural subsidies provided to farmers in developed countries reduce the likelihood of export opportunities for developing country farmers because consumers favor the artificially cheaper products produced by developed countries. Subsidized imported products also often displace the locally produced products in developing countries. Additional considerations need to be taken at the domestic level to take advantage of reforms in trade policies. Reforms in government bureaucracies and in the management of airports, ports, and customs agencies must be undertaken to experience the full benefits of trade reforms.

Reforms in agricultural and trade policy in North Africa started in the mid-1980s and sought to liberalize output and input prices, increase private sector involvement in agricultural production and trade, and privatize state trading enterprises. Some North African countries, such as Algeria, Egypt, Morocco, and Tunisia, sought to undertake sweeping macroeconomic and sectoral reforms affecting wages, interest and exchange rates, commodity prices, and domestic and international trade. They relied on international financial institutions to conduct stabilization and structural adjustment programs and sought to actively position themselves in the framework of the Euro–Mediterranean partnership with its special trading arrangements. On the other hand, Libya retained a prominent role for the state and sought to reform the public sector without necessarily affecting private sector intervention. Efforts were undertaken to have the private sector play a more important role in an economy dominated by a more efficient and productive public sector (DeRosa 1997). Nevertheless, progress has been generally slow in trade liberalization in the region.

Moreover, the high tariffs imposed by developed nations on agricultural products from developing nations reduce the ability of the developing countries to export their products and compete in the world market. A recent study conducted by the Institute of Economic Affairs in Britain estimates that EU agricultural policies have reduced African exports of milk products by more than 90 percent, livestock by nearly 70 percent, meat by almost 60 percent, and nongrain crops by 50 percent. These results indicate that EU agricultural policies have reduced Africa's total potential agricultural exports by half during the late 1990s to early 2000s. Without these agricultural policies, the current US$10.9 billion food-related exports annually from Sub-Saharan Africa could actually grow to nearly US$22 billion. In Sub-Saharan Africa, every US$1 in agricultural income produces an additional US$1.42 increase in GDP. Thus, without these EU policies, GDP in Sub-Saharan Africa could actually grow to nearly US$26.4 billion per year—enough to increase the annual income of every person in these countries by nearly 13 percent (Hassett and Shapiro 2003). If the agricultural policies of Canada, Japan, and the United States were included in the analysis, results would indicate major advances in poverty and food security in African countries.

Investment in Rural Infrastructure, Education, and Social Capital

As was shown under *VIS* and *RMM*, significant increases in investment in rural infrastructure would help increase food production and consumption, decrease malnutrition, and increase food security. Complementary infrastructure built by the villages, national governments, or NGOs is crucial to remove any limitations on the participation of the private sector and increase the costs of input and output marketing. Critical investments include rural transportation; rural water infrastructure; village production infrastructure, such as threshing and drying floors, and basic village storage facilities; electricity for agroprocessing; and telecommunications infrastructure (Reardon et al. 1995; Cleaver and Donovan 1995; Friis-Hansen 2000). Significant increases in investment in the exchange of information through the use of modern information and communication technologies (ICT) would enhance both market efficiency and the research capacity of the national agriculture research systems (NARSs) and thus improve the agricultural productivity of African countries. Use of ICT including Internet connections would provide NARSs with information access and facilitate networking with other national, regional, and global agencies (NEPAD 2002).

The model results also show that increased investments in education are essential to hasten improvements in food security. In agricultural areas, education works directly to enhance the ability of farmers to adopt more advanced technologies and crop-management techniques, thereby achieving higher rates of return on land (Rosegrant and Cline 2003). More broadly, education encourages movement into more remunerative nonfarm employment, helping to increase household incomes. Success in reducing poverty is usually enhanced by increasing the proportion of educational resources going to primary education and to the poorest groups or regions (Lipton, Yaqub, and Darbellay 1998; Gaiha 1994; World Bank 1990; Singh and Hazell 1993).

Improving rural associations is envisioned to provide better support to farmers and, at the same time, become a vehicle for defining and implementing rural development with farmer participation. In Africa, rural associations give assistance to farmers in terms of farm inputs and crops; credit to members (savings societies); joint production of food crops, particularly for women's groups; management of pastures; and processing of agricultural commodities. Donors are also inclined to support farmers' groups. Farmer-managed savings and loan cooperatives in countries like Benin, Burundi, Cameroon, Côte d'Ivoire, and Rwanda have been supported by donors and national governments and were found to be successful. However, despite the open and more liberal environment for farmers' associations, and the willingness of donors to support these groups, the volume of credit, farm inputs, and crops handled by formal and informal farmers' groups remains extremely small. There is a need to better educate farmers about this type of assistance. Improving the communication sector would contribute significantly to the development of farmers' awareness of such benefits (Cleaver and Donovan 1995).

The presence of NGOs strengthens the dynamic partnership in fighting rural poverty because of their flexibility; innovation; and strong social, economic, and political support for the poor. In Africa, NGOs have not worked closely with the public sector. One of the goals of the New Partnership for Africa's Development (NEPAD) is to bridge the gap between these two groups and improve the NGO/NARS relationship for the benefit of the rural poor (NEPAD 2002). Governments and policymakers should focus on policy reforms that promote investor security, thereby attracting them to the country or the region in question. Policy sectors needing to be revisited include agribusiness development, agricultural marketing and credit, and support for the telecommunications sector (NEPAD 2002).

Crop, Land, Water, and Input Management

The analysis in this paper indicates that sustainable productivity growth is one of the keys to food security improvements. Farmers are the primary managers of land, water, and pastures. They need to manage problems arising from deteriorating natural resources. Thus, agricultural input and crop technologies should focus on land and natural resources conservation, while at the same time increasing agricultural productivity.

As described in detail above, soil fertility improvement is essential for sustained productivity use. It may be appropriate to subsidize fertilizers in the short run in some countries; however, fertilizer subsidies must be supplemented by government investments in infrastructure, institutions, and policies that permanently reduce farm level prices (for example, reducing transportation costs and increasing efficiency in the input and output markets, Gladwin et al. 2001). But reliance on chemical fertilizers alone is not enough. An integrated approach to soil fertility management is recommended to replenish and improve the soil quality in Africa. Approaches to soil fertility management must allow farmers to make decisions on the basis of a combination of their own knowledge and research-based options. African governments should also implement policies to encourage efficiency improvements in farmers' use of local resources in marginalized areas. Farmers should depart from the high use of external inputs as the dominant method for increasing agricultural productivity, as this is not generally economically viable. The "low external input sustainable agriculture" (LEISA) technologies, such as integrated pest management, participatory conservation and use of plant genetic resources, and integrated soil fertility management, provide a sound complementary approach (Friis-Hansen 2000).

Uncertain land tenure undermines farmers' incentives to make agricultural investments like many of the water-harvesting methods mentioned earlier. Agricultural policy must take into account the importance of farmer stability in attracting agricultural investments (Reardon et al. 1995). African governments must take serious action in recognizing traditional land tenure systems, providing collective land ownership titles to groups, setting up judicial processes when dealing with disputes, and improving administrative capacity in land-titling matters. Studies have shown that in countries like Côte d'Ivoire, Ethiopia, Kenya, Malawi, Nigeria, Rwanda, South Africa, and Tanzania, traditional land-tenure relationships are breaking down under the force of government legislation. This breakdown is accelerated by land titling, the disappearance of customary mechanisms of dispute resolution, immigration of people from other ethnic groups, pastoral–farmer conflicts, and civil war. There are also cases where traditional land tenure is robust and has evolved toward individual ownership and rights of inheritance. These occur where governments protect the customary tenure through legislation (Cleaver and Donovan 1995).

As was shown in the discussion of water resources, water scarcity has a substantial impact on agricultural production. One strategy to address African water scarcity is supply management, which involves the location, development, and exploitation of new sources of water for irrigation and household and industrial uses. In addition, demand management addresses the incentives and mechanisms that promote water conservation and efficient water use (Rosegrant and Perez 1997). Changing the institutional and legal environment in which water is supplied and used empowers water users to make their own decisions regarding the use of water resources and, at the same time, provides a structure that presents the real scarcity value of water, including environmental externalities (Rosegrant and Perez 1997). Water subsidies should not be encouraged, since this leads to overuse of water resources. Subsidies distort the incentives of users to preserve the resource or to use it in a cost-effective manner. Overuse of water also compounds land degradation problems, such as those in Egypt where the low price of water resulted in area expansion for rice cultivation, in effect increasing waterlogging (UNEP–GEO 2000).

It is essential that investment in irrigation systems enhances water use efficiency. Groundwater development offers a major opportunity for promoting agricultural production and improving livelihoods. The exploitation of aquifers should not, however, undermine their sustainability; excessive use of groundwater can lead to a declining groundwater table. The capital required to develop groundwater irrigation is low, while its productivity is generally higher than surface irrigation. In addition, farmers exercise more care in utilizing this kind of irrigation because of the costs involved in lifting water. Furthermore, groundwater is a reliable irrigation source in times of drought (Inocencio, Sally, and Merrey 2003).

Technology development in Africa involves investment in efficient irrigation systems, particularly because of the recurrence of droughts. Irrigation investments in Mauritania, Niger, and Nigeria have proven productive. The current policy framework in northern Africa fails to address measures to sustainably manage scarce water and agricultural land. Although some countries apply the concepts of integrated water and land management, the institutional capacity and popular participation necessary to avoid conflicts and adverse socioeconomic impacts need to be revisited and strengthened (UNEP–GEO 2000).

Agricultural Research and Extension

Dramatic increases are needed in agricultural research investments if any plan for food and nutrition security in Africa is to be successful. Drastic changes must also take place in the way research and extension are carried out in Africa. In terms of soil fertility, there is a need to generate knowledge about fertilizer use and to diffuse that knowledge to the farm population. Expanded research efforts are needed to better understand semi-arid soils and to solve the very specific problems caused by lack of knowledge of local responses to the application of fertilizers. Expansion of extension efforts is necessary in most semi-arid African countries to help farmers learn new production practices and more economic resource use (Gladwin et al. 2001).

Lack of farmer knowledge about fertilizer use impedes agricultural growth in Africa (Gladwin et al. 2001). Decisions about how much fertilizer to use and where and how to apply it have become a very complicated issue. Likewise, crop diversification, especially into high-value crops, has been slow to develop because of limited technological opportunities available at the farm level. This is also related to the provision of credit to small-scale farmers (Friis-Hansen 2000). Policy reform must include improving extension agent training and ensuring that feedback is solicited from farmers. Extension workers are also crucial in furthering the acceptance of the LEISA technologies discussed earlier. Moreover, extension workers should engage their client farmers in critical thinking about their agricultural endeavors and management of their farming enterprises (Friis-Hansen 2000).

A key area for improvement in research is crop breeding and biotechnology. An example of a successful breeding technique is a hybrid between Asian and African species called "New Rice for Africa," which was bred to fit the rainfed upland rice environment in West Africa. This new variety produces over 50 percent more grain than current varieties when grown in traditional rainfed systems without fertilizer, matures 30–50 days earlier than current varieties, and is far more tolerant to disease and drought compared with current varieties (Rosegrant et al. 2002). As results under *VIS* showed, increases in yields such as those that could be achieved through crop breeding and biotechnology can lead to greater agricultural production and reduced malnutrition.

The tools of biotechnology are also necessary for crops in developing countries, particularly for those grown in high-stress environments, even if these countries stop short of true transgenic breeding. Such biotechnologies could include marker-assisted selection and cell and tissue culture techniques. However, molecular biotechnology has been applied only to a small number of traits of interest to commercial farmers, mainly developed by a few life science companies operating at the global level. It is also recognized that the private sector will not invest sufficiently to make the needed adaptations in these developing countries and regions. Thus public–private partnerships will be important for future development of these technologies. Moreover, coordination of public research and extension systems with agricultural faculties in universities should be strengthened. Further, stronger networks need to be established for exchanging technical information within Africa and outside the region.

Investment in Women

The improvements in the status of women modeled under *VIS*—resulting in lower levels of malnutrition than any of the other scenarios—show that the status of women can influence food security and nutrition in Africa (and worldwide for that matter). Women provide 70 to 80 percent of household food production in Sub-Saharan Africa (Brown et al. 2001). And while farm plots run by women have been found to have 20–40 percent lower yields than those run by men, it has been shown that when women receive the same levels of education, experience, and farm inputs as men, they can increase the yields of some crops by 22 percent (IFPRI 2000). In addition, the level of education among women is essential to household poverty reduction. A study focusing on Egypt (IFPRI 2000) found that when mothers' education levels were raised to at least the completion of primary school, the incidence of poverty was reduced by 33.7 percent. The education of women has powerful effects on nearly every dimension of development, from lowering fertility rates, to raising productivity, to improving environmental management (World Bank 1996).

Nevertheless, the role of women is often taken for granted, especially in developing countries. Despite the significant responsibility women take on in the household, gender discrimination is still prevalent in Africa. This hinders women's effectiveness in providing a healthy and secure environment for their families. If women are to be fully effective in contributing to food and nutrition security, discrimination against them must be eliminated and the value of their role promoted (Quisumbing, Meinzen-Dick, and Smith 2004). Eliminating gender discrimination requires policy reform in support of an equal playing field for both men and women in Africa.

The Women's Budget Initiative in South Africa, which began in 1990, is an example of a program that is making steps toward raising the profile of gender issues in Africa. This collaboration between the parliamentary Joint Standing Committee on Finance and several NGOs in South Africa is assessing the public budgetary allocations between men and women. Under the initiative, budget allocations for education, service provision, public-sector employment, provision for child care, and employment benefits are being tracked. In Sub-Saharan Africa, there have been successful attempts to close the gap in equality between men and women in the areas of land, water, livestock, education, technology, social capital, and health (Quisumbing, Meinzen-Dick, and Smith 2004).

In summary, the IMPACT results indicate that if the results modeled under *VIS* are to be realized, far higher investments in agricultural productivity, water resource use, and human well being will be necessary. *VIS* represents a self-reinforcing virtuous cycle of higher growth and higher investment, which has been beyond Africa's reach to date. Unfortunately, despite signs in some countries that political leaders recognize the costs of lack of long-term investment, the results indicated under *PES* could easily become the more plausible future reality unless many of the recommendations set out above are addressed. The unsatisfactory prospects for Sub-Saharan Africa under *BAU* show that more aggressive policy action on multiple fronts is imperative to food security in the region. Similarly, results confirmed under *VIS* show that massive increases in investment will be necessary to achieve serious inroads against child malnutrition.

Appendix

Table A.1—Projected irrigated, rainfed, and total cereal area in Africa under the *business as usual* scenario, 1995 and 2025

	Cereal area (million hectares)					
	Baseline 1995			Projected 2025		
Region/Country	**Irrigated**	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**
Northern Sub-Saharan Africa	1.1	29.8	30.1	1.4	41.6	43.0
Central and western Sub-Saharan Africa	0.2	9.6	9.8	0.4	15.0	15.4
Southern Sub-Saharan Africa	0.6	8.1	8.7	1.0	10.7	11.7
Eastern Sub-Saharan Africa	0.1	6.5	6.6	0.2	8.6	8.8
Nigeria	1.3	16.6	17.9	1.9	21.9	23.8
All Sub-Saharan Africa	3.3	69.8	73.0	4.9	97.7	102.6
Egypt	2.6	0.0	2.6	2.5	0.0	2.5
Other West Asia/North Africa	6.9	20.3	27.2	8.0	22.2	30.2
All Africa	12.8	90.1	102.8	15.4	119.9	135.3

Source: Rosegrant, Cai, and Cline 2002.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT–WATER model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table A.2—Projected irrigated, rainfed, and total cereal production in Africa under the *business as usual* scenario, 1995 and 2025

	Cereal production (million metric tons)					
	Baseline 1995			Projected 2025		
Region/Country	**Irrigated**	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**
Northern Sub-Saharan Africa	1.6	18.8	20.4	3.1	43.2	46.3
Central and western Sub-Saharan Africa	0.4	8.7	9.1	1.1	19.3	20.4
Southern Sub-Saharan Africa	1.1	7.7	8.8	2.4	14.7	17.1
Eastern Sub-Saharan Africa	0.3	9.2	9.5	0.5	16.1	16.7
Nigeria	3.7	14.9	18.5	8.7	28.7	37.3
All Sub-Saharan Africa	7.0	59.2	66.2	15.7	122.0	137.7
Egypt	14.3	0.0	14.3	20.8	0.0	20.8
Other West Asia/North Africa	19.4	20.6	40.0	30.6	28.7	59.3
All Africa	40.8	79.8	120.6	67.0	150.8	217.8

Source: Rosegrant, Cai, and Cline 2002.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT–WATER model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table A.3—Projected irrigated, rainfed, and total cereal yields in Africa under the *business as usual* scenario, 1995 and 2025

	Cereal yields (metric tons per hectare)					
	Baseline 1995			Projected 2025		
Region/Country	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
Northern Sub-Saharan Africa	1.51	0.65	0.68	2.17	1.04	1.08
Central and western Sub-Saharan Africa	1.99	0.91	0.93	2.93	1.29	1.33
Southern Sub-Saharan Africa	1.91	0.95	1.01	2.49	1.37	1.47
Eastern Sub-Saharan Africa	2.07	1.42	1.43	2.49	1.89	1.90
Nigeria	2.84	0.90	1.04	4.54	1.31	1.57
All Sub-Saharan Africa	2.16	0.85	0.91	3.23	1.25	1.34
Egypt	5.48	0.00	5.48	8.36	0.00	8.36
Other West Asia/North Africa	2.81	1.02	1.47	1.51	1.29	1.39
All Africa	3.19	0.89	1.17	2.43	1.26	1.48

Source: Rosegrant, Cai, and Cline 2002.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT–WATER model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table A.4—Projected irrigated, rainfed, and total roots and tubers area in Africa under the *business as usual* scenario, 1995 and 2025

	Roots and tubers area (million hectares)					
	Baseline 1995			Projected 2025		
Region/Country	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
Northern Sub-Saharan Africa	0.85	0.00	0.85	0.83	0.00	0.83
Central and western Sub-Saharan Africa	0.14	5.71	5.85	0.13	7.60	7.73
Southern Sub-Saharan Africa	2.08	0.23	2.30	2.58	0.28	2.86
Eastern Sub-Saharan Africa	0.17	2.26	2.42	0.16	2.97	3.13
Nigeria	5.28	0.00	5.28	6.64	0.00	6.64
All Sub-Saharan Africa	8.52	8.20	16.72	10.34	10.85	21.19
Egypt	0.12	0.00	0.12	0.13	0.00	0.13
Other West Asia/North Africa	0.13	0.30	0.43	0.19	0.31	0.50
All Africa	8.76	8.50	17.27	10.66	11.16	21.82

Source: Rosegrant, Cai, and Cline 2002.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT–WATER model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table A.5—Projected irrigated, rainfed, and total roots and tubers production in Africa under the *business as usual* scenario, 1995 and 2025

Region/Country	Roots and tubers production (million metric tons)					
	Baseline 1995			Projected 2025		
	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
Northern Sub-Saharan Africa	3.3	0.0	3.3	4.2	0.0	4.2
Central and western Sub-Saharan Africa	1.6	42.1	43.6	2.1	87.8	89.9
Southern Sub-Saharan Africa	10.4	1.5	11.9	18.3	2.9	21.2
Eastern Sub-Saharan Africa	1.5	14.4	15.9	2.1	30.4	32.5
Nigeria	53.0	0.0	53.0	100.3	0.0	100.3
All Sub-Saharan Africa	69.7	58.0	127.7	126.9	121.1	248.0
Egypt	2.5	0.0	2.5	3.6	0.0	3.6
Other West Asia/North Africa	3.3	4.2	7.5	9.0	8.9	17.8
All Africa	75.4	62.2	137.7	139.5	130.0	269.5

Source: Rosegrant, Cai, and Cline 2002.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT–WATER model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

Table A.6—Projected irrigated, rainfed, and total roots and tubers yield in Africa under the *business as usual* scenario, 1995 and 2025

Region/Country	Roots and tubers yield (million tons per hectare)					
	Baseline 1995			Projected 2025		
	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
Northern Sub-Saharan Africa	3.9	0.0	3.9	5.0	0.0	5.0
Central and western Sub-Saharan Africa	11.5	7.4	7.5	16.2	11.6	11.6
Southern Sub-Saharan Africa	5.0	6.6	5.2	7.1	10.4	7.4
Eastern Sub-Saharan Africa	8.8	6.4	6.6	12.9	10.2	10.4
Nigeria	10.0	0.0	10.0	15.1	0.0	15.1
All Sub-Saharan Africa	8.2	7.1	7.6	12.3	11.2	11.7
Egypt	21.3	0.0	21.3	28.2	0.0	28.2
Other West Asia/North Africa	25.7	14.0	17.4	47.2	28.6	35.7
All Africa	8.6	7.3	8.0	13.1	11.6	12.4

Source: Rosegrant, Cai, and Cline 2002.
Note: The total for "All Africa" is slightly higher than the actual total for all the individual countries because the IMPACT–WATER model includes some West Asian countries in the "Other West Asia/North Africa" region (Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, and Yemen).

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