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STRATEGIES FOR SUSTAINABLE GLOBAL AND REGIONAL FOOD SECURITY

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INTRODUCTION

Over the past three decades, the world has made remarkable progress in increasing food production and reducing food insecurity. But progress slowed considerably during the 1990s, and achieving the Millennium Development Goal of cutting the number of hungry people by half by 2015 will be especially challenging. Agricultural growth and development will continue to have an important role in accelerating the sluggish progress in eliminating hunger given the rural center of gravity of poverty and food insecurity and the strong linkages to employment creation, income generation, and nutritional well-being.

This paper reviews key developments currently underway on the global agricultural front. It then looks ahead to 2020 with baseline and alternative scenarios for food supply and demand based on projections from IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT).[3] The paper then identifies some major risks to and uncertainties in agriculture that could have considerable implications for the people depending on agriculture for their food security and livelihoods. It concludes by outlining the role broad-based agricultural and rural development can play in accelerating progress toward sustainable food security for all.

FOOD INSECURITY: PAST, PRESENT, AND FUTURE

Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO 1996). As of 1999 (the last year for which data are available), there were 799 million food insecure people in the developing countries. Food insecurity can also be found in the countries in transition from centrally planned to market-oriented economies and in the industrialized countries. However, the problems are more severe and affect a far greater proportion of the population in developing nations (FAO 2002). The world has made progress – albeit too slowly and very unevenly – in reducing hunger. Since 1970, the number of food insecure people in developing countries has declined by about 17 percent, from 959 million, and the food insecure percentage of the population has dropped

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[3] For details on projections of future world food supplies, demand, trade, prices, and child malnutrition generated by IMPACT in June 2001, as well as a description of the model, see Rosegrant *et al*. (2001).

dramatically, from 37 to 17 percent (FAO 2000a, 2002). Food availability has increased by 26 percent over the past three decades to reach 2,667 calories per person per day, or more than enough for everyone to meet their minimum requirements if supplies were distributed according to need (Rosegrant *et al*. 2001). Adoption of modern varieties in developing countries led to gains in per capita production of cereals, the most important source of calories, and to lower real cereal prices, to the benefit of poor consumers (Kerr and Kolavalli 1999). The International Food Policy Research Institute (IFPRI) projects that food availability will increase in all regions during the period 1997-2020 (Rosegrant *et al*. 2001).

South Asia and Sub-Saharan Africa are home to over three-fifths of all food insecure people. Due to the high rate of population growth, the number of food insecure South Asians rose 18 percent between 1970 and 1999, even as the food insecure portion of the population fell from 37 to 24 percent. The number of food insecure Africans more than doubled, from 88 million to 195 million, as a result of widespread poverty, population growth, declining food production per capita, disease, environmental degradation, and violent conflict (FAO 2000a, 2002b).

Progress against hunger slowed dramatically during the 1990s. Whereas the number of people living in food insecurity fell by an annual average of 7 million over the period 1970-90, during the subsequent decade, the rate of decline slowed to 2.5 million people per year. If China, Indonesia, Viet Nam, Thailand, Nigeria, Ghana, and Peru are excluded from consideration, then the number of food insecure people in the rest of the developing world actually *increased* by over 80 million from 1991 to 1999.

The Food and Agriculture Organization of the United Nations (FAO) projects that in 2015, the food insecure population of the developing world will only decline to 610 million people. This is far short of the achieving the goal of the 1996 World Food Summit, reducing the number of people living in hunger by 50 percent – to 400 million people or fewer – by no later than 2015 (FAO 1996; Bruinsma 2003).

Child Malnutrition

Malnutrition among children under the age of five is of particular concern, as it is a factor in more than 5 million developing-country child deaths annually. Those who survive face impaired physical and mental development. This scourge compromises future health, productivity, and food security, and undermines both economic growth and equity (WHO 2001; Flores and Gillespie 2001).

Between 1970 and 1997, the number of malnourished preschoolers in the developing world declined by 19 percent, to 166 million, while the percentage of children under five afflicted by malnutrition dropped from 46 percent to 31 percent. South Asia and Sub-Saharan Africa are home to over 70 percent of the malnourished preschoolers in the developing world (Rosegrant *et al*. 2001). Birth weights of less than 2.5 kilograms are a major factor leading to child malnutrition, and usually result from poor maternal nutrition. In effect, malnutrition is passed from one generation to the next (ACC/SCN and IFPRI 2000).

With business as usual, IFPRI projects that by 2020, the number of malnourished children under five in developing countries will decline by just 21

percent from 1997, to 132 million. In Sub-Saharan Africa, the number of malnourished children is expected to *rise* by 18 percent (Rosegrant *et al*. 2001).

"Hidden Hunger"

Deficiencies of micronutrients – vitamins, minerals, and trace elements – are pervasive. Two billion people suffer anemia, due mainly to iron deficient diets, including 56 percent of pregnant developing country women and 76 percent of pregnant South Asian women. Anemic women have a 23 percent greater risk of maternal mortality. Their babies are more likely to be born prematurely, have low birth weights, and die as newborns. Anemic preschoolers face impaired health and limited learning capacity. Even when iron deficiency does not progress to anemia, it can reduce work performance. It causes annual economic losses of nearly 2 percent of gross domestic product (GDP) in Bangladesh, over 1 percent in Pakistan, and nearly 1 percent in India, for a total of $5 billion per year. Vitamin A deficiency affects 100-140 million children, mainly in Sub-Saharan Africa and South Asia. One-quarter to half a million go blind each year, and half of them die within 12 months of losing their sight (ACC/SCN 1997; ACC/SCN and IFPRI 2000; Gillespie and Haddad 2003; WHO 2001).

CAUSES OF FOOD INSECURITY

Poverty is the principal cause of food insecurity; hunger endures amidst adequate food supplies mainly because food insecure people cannot afford the food that is available, and lack land and other resources to produce food for themselves. Household surveys in a number of countries indicate that child malnutrition rates for the poorest 20 percent of households significantly exceed those of the wealthiest 20 percent. Globally, 1.2 billion people (20 percent of the world's population) live on the equivalent of less than US$1 per day; 70 percent of them live in South Asia and Sub-Saharan Africa (World Bank 2001a). Despite rapid developing country urbanization, 75 percent of poor people live in rural areas (IFAD 2001). The World Bank projects that in 2015, poverty will persist at high levels in South Asia, and will increase substantially in Sub-Saharan Africa (Table 1) (World Bank 2001a).

Given the rural center of gravity of poverty, broad-based agricultural and rural development is essential for food security. For every new U.S. dollar of farm income earned in low-income developing countries, income in the economy as a whole rises by up to US$2.60, as growing farm demand generates employment, income, and growth economy-wide (Delgado *et al*. 1998).

Several additional factors cause food insecurity. These include powerlessness; conflict; and discrimination based on gender, age, race, and ethnicity. Furthermore, a number of key developments on the global agricultural front will significantly influence future food security. These may be clustered into five categories, each of which is discussed below: natural resources, production systems and structures, technology, trade and markets, and changes in food systems.

KEY DEVELOPMENTS ON THE GLOBAL AGRICULTURAL FRONT

Natural Resources

Unsustainable management of the natural resource base upon which agriculture depends impinges considerably on food security. In many developing countries, poverty, low agricultural productivity, and environmental degradation interact in a vicious downward spiral. This is especially true in resource-poor areas with fragile soils, irregular rainfall, relatively high population concentration and growth rates, and stagnant productivity in agriculture. Such areas are home to hundreds of millions of food-insecure people. Nearly two-thirds of the rural population of developing countries (1.8 billion people) lives in such areas, including marginal agricultural areas, forests and woodlands, and arid zones. Low agricultural productivity and land degradation are severe, cereal yields are exceedingly low, and deforestation, overgrazing, soil erosion, and soil nutrient depletion are widespread. The threat of famine is severe. Failure to address natural resource issues effectively will not result in sustainable food security (Hazell, 1999; Pender and Hazell, 2000).

Some natural resource degradation in agricultural areas has been caused by misuse of modern farming inputs (especially pesticides, fertilizers, and irrigation water in high-potential areas). But a great deal of environmental degradation, particularly soil degradation and deforestation, is concentrated in resource-poor areas that have not adopted modern technology, where yield growth has failed to keep up with population growth. Poor rural people often cannot afford to invest in land improvements. Degradation and lack of access to high-quality land frequently push poor people into clearing forests and pastures for cultivation at the expense of wildlife habitat and park land, contributing to further degradation, productivity losses, and reduced biodiversity. Since 1980, 20-30 percent of forest land has been converted to agricultural uses. Farming practices have also led to aquifer depletion (as irrigation uses water more rapidly than it can be replenished trough rainfall) and water pollution from farm chemical runoff (Wilson, 2001; Wood, Sebastian, and Scherr, 2001; Rosegrant *et al*., 2001; Rosegrant and Hazell, 2000; Pender and Hazell, 2000; Scherr, 1999).

Between 5 and 12 million hectares of arable land are lost each year as a result of salinization, flood-induced erosion, or nutrient mining, with the problems being most acute in Sub-Saharan Africa. There, three decades of inadequate investment in soil improvement have caused severe nutrient depletion, leading to increasing degradation and desertification. The mean cumulative crop yield losses due to past erosion in the region between 1945 and 1990 were 6.2 percent (Rosegrant *et al*. 2001). IFPRI research in eastern Uganda has found that the value of mined soil nutrients averages 18 percent of household income. Farmers rely heavily on soil nutrient mining for survival.

Losses to pests reduce potential farm output value by 50 percent. In developing countries, losses greatly exceed agricultural aid received. Developing countries' share of the global pesticide market is expected to increase significantly during the early 21st century. Insecticides now used in developing countries are often older, acutely toxic, and banned in developed countries except for export (Yudelman, Ratta, and Nygaard 1998).

Unless properly managed, fresh water may emerge as the key constraint to global food production. Developing countries are projected to increase water withdrawals by 27 percent between 1995 and 2025, with the share of domestic and industrial uses in total water demand doubling at the expense of agriculture (Rosegrant *et al*. 2002).

Currently, there is inadequate public investment locally, nationally, and internationally in conservation and sustainable utilization of genetic resources. This poses a grave threat to biodiversity and food security, and increases exposure to unforeseen risks of crop diseases.

Policies aimed at achieving food security must incorporate the likely consequences of climatic change. Agriculture accounts for 20 percent of the "greenhouse gasses" that lead to warming. Agricultural activities lead to increases in carbon dioxide (CO_2) emissions, but can also absorb CO_2 (Wilson 2001; Agence France Presse 2001; Annan 1999).

Production Systems and Structures

Rural poor people frequently lack access to land and other productive resources, and so cannot produce food for themselves or pursue opportunities to earn income through cash cropping. Owners of even marginal landholdings tend to have higher incomes and consume more food than landless people. Landless rural people are more vulnerable to famine. Poor people who do own land tend to have low quality soil, less water control, and less secure tenure. Throughout the developing world, land reforms that have resulted in more equitable patterns of ownership have been associated with reductions in poverty and accelerated economic growth (IFAD 2001). Unequal patterns of land ownership are closely associated with civil unrest and conflict (IFAD 2001; Messer *et al*. 1998).

The nature of farming is changing rapidly in many developing countries because of the aging of the farm population, changing roles for men and women in agriculture, the growing labor shortages and depletion of asset bases resulting from the HIV/AIDS crisis, and the decreasing cost of capital relative to labor. Small-scale family farms, traditionally the backbone of much of developing-country agriculture, are under threat, while globalization and domestic investments are encouraging production on a larger scale. These rapidly emerging factors call for innovative approaches to agricultural policy and rural institutions.

Despite the importance of broad-based agricultural and rural development to poverty reduction and economic growth in low-income countries, many development assistance donor agencies and developing country governments have regarded agriculture as a declining sector over the last 10-15 years, and have put resources instead into industry and urban development, which tend to have more powerful constituencies (World Bank 1997). In 1998, developing countries on average devoted 5 percent or less of their expenditures to agriculture (FAO 2001a). In contrast, governments of low-income countries on average allocate 13.3 percent of their budgets to military spending (World Bank 2001b).

For their part, aid donors must reverse the precipitous decline in assistance to agriculture, which in 1999 was below the 1990 level in real terms. Agricultural aid accounted for 15 percent of total official development assistance at the end of the 1990s, compared to well over 20 percent in the 1980s. The share of agricultural aid going to Africa declined from 30 percent in 1990 to 21 percent in 1998 (FAO 2000b, 2001a and b).

Technology

New technological advances in molecular biology, energy, and information and communications offer potential benefits for poor people that may advance food security. Furthermore, these advances are leading to increased demand for nontraditional agricultural products, such as agro-pharma products. However, there are serious concerns about what amounts to scientific and technological *apartheid,* wherein technological progress focuses primarily or even exclusively on non-poor people in industrialized countries (Serageldin 1999).

Breakthroughs in modern agricultural biotechnology, including those achieved through genetic engineering, offer substantial potential benefits for poor farmers and consumers in developing countries. These include the development of pest-resistant and drought- and salt-tolerant staple food crop varieties, crops capable of fixing nitrogen from the air, and more nutritious food crops. However, there are also serious questions about the capacity of many developing countries to manage potential risks, and particularly about their capacity to implement an appropriate biosafety framework. Furthermore, resistance to products derived from biotechnology among many consumers in both developed and developing countries is slowing application of the technology to the problems of poor people.

Rapid changes in the financing, management, and organization of agricultural research may require new policies to assure that low-income people benefit. The private sector accounts for a growing share of agricultural research and development, and subjects both products and research processes to intellectual property rights protection (Pardey and Beintema 2001).

Trade and Markets

Globalization offers developing countries significant new opportunities for broad-based economic growth and poverty alleviation, but it also carries significant risks, including the short-term inability of many developing-country industries to compete, potential destabilizing effects of short-term capital flows, increased price risk exposure, and worsening inequality within and between nations. Continued protection and subsidization of domestic agriculture and increasing food safety concerns in industrialized countries limit developing countries' market access. IFPRI research has found that developed-country trade policies deprive developing countries of $26 billion per year in agricultural and agro-industrial income (Diaz-Bonilla 2003). Africa's share of world agricultural trade continues to decline rapidly. Appropriate policies and institutions are needed to guide globalization to benefit low-income people (Diaz-Bonilla and Robinson 1999; Pinstrup-Andersen, Pandya-Lorch, and Rosegrant 1997, 1999). The present Doha Round of global agricultural trade negotiations is now in a crisis. The United States, European Union, and Japan cannot

expect the developing countries to endorse one-sided agricultural trade liberalization *ad infinitum*.

At the local and national level, the development of well-functioning and well-integrated markets for agricultural inputs, commodities, and processed goods, along with the supporting institutions and infrastructure, such as roads and storage, especially in rural areas, will contribute enormously to poverty alleviation, food security, and the overall quality of life in low-income countries. Market performance improves and marketing costs fall when the government no longer monopolizes trade and a competitive private sector emerges. Yet even as the government reduces its role, competent public administration will remain essential to assure that:

- contracts are enforced;
- grading and quality control standards are enacted and implemented (especially for export crops);
- market conduct and investment are appropriately and fairly regulated;
- safety net programs are provided for vulnerable groups;
- public health and safety are maintained;
- infrastructure is created;
- agricultural research and extension services are available; and
- credible and sustainable macroeconomic policies are implemented and provide a favorable environment for savings and investment and accurate and transparent incentives for consumers and producers alike (Kherallah *et al*. 2002).

It is crucial that public policies guarantee that infrastructure development is not biased against poor people or less-favored areas, and that there is equitable access to economic opportunities, e.g., export cropping and agricultural processing activities. As important as effective and efficient markets are, by themselves, markets cannot, and should not, be expected to assure equity.

Changes in Food Systems

A rapid and fundamental movement is underway toward industrialized food processing, long-distance marketing, and retail business dominance with far-reaching implications for poor consumers and smallholder farmers. In both Asia and Latin America, major European supermarket chains such as Carrefour, Ahold, and Makro, play an increasingly prominent role.

At the same time, consumers in developed countries are increasingly concerned about the safety of their food supply. Outbreaks of animal diseases such as bovine spongeform encephalopathy (BSE, or “mad cow disease”) and foot and mouth disease in Europe, as well as instances of food contamination and outbreaks of food-borne illness in both Europe and North America, have contributed to heightened attention to food safety among Northern consumers, as well as to a growing market for organic produce, increased interest in vegetarianism, and demands for more stringent safety requirements with respect to imported food. In turn, this has spawned concern in developing countries about the use of food safety standards as non-tariff trade barriers.

There is a third new factor in the global food system. Contrary to the generalized optimism about capacity to cope with famines of the early 1990s, the problem of famine has re-emerged, especially in Sub-Saharan Africa, in what some analysts consider to be a "new variant." It appears that global climatic change is contributing to more frequent and more severe natural disasters. Moreover, the HIV/AIDS epidemic appears to have increased susceptibility to other shocks and undermined resilience by reducing people's capacity to cope with scarcity short of famine (de Waal and Whiteside 2003).

EXPECTED SUPPLY/DEMAND: 2020 BASELINES AND MAJOR DRIVING FORCES[4]

Future food supply and demand will be influenced by income growth, population growth, and urbanization. IFPRI projects income growth in all regions over 1997-2020, with slowest growth in Sub-Saharan Africa. Urban population in developing countries is expected to double between 2000 and 2030 (U.N. Population Division 2002), and to account for most of the increase in global population during that period. When people move to cities, they tend to shift consumption to foods requiring less preparation time and to more meat, milk, fruit, vegetables, and processed foods (Garrett and Ruel 2000).

Several other factors will affect future food supply and demand. These include advances in research, particularly agricultural research; investments in public goods such as infrastructure and irrigation; the sustainability or degradation of natural resources such as water and soil; changes in governance; and the nature of policies and the extent to which they support or work against agriculture.

IFPRI's projections suggest that under the most likely or baseline scenario (where governments make no major changes in their agricultural and economic policies and investments and where population grows at the rate given in the United Nations' medium-variant projections) global demand for cereal will increase by 35 percent between 1997 and 2020. Developing countries will experience a 50 percent increase in cereal demand whereas developed countries will experience a much smaller increase of 13 percent. Developing countries in Asia, because of their larger and more urbanized populations and rapid economic growth, will account for half of the increase in global demand for cereals, with China alone accounting for one quarter. Maize will account for 38 percent of the increase in cereal demand during 1997-2020, followed by wheat and rice. Global demand for maize is growing much faster than demand for other cereals, driven to a large extent by the growing demand for animal feed.

The world's demand for meat is growing tremendously – a demand-driven "livestock revolution" is underway. Global demand for meat is forecast to grow by more than 55 percent between 1997 and 2020, with most of the increase occurring in developing countries, where demand will nearly double. China alone will account for more than 40 percent of this increase. Poultry will account for 40 percent of the global increase in demand for meat to 2020, followed by pork at 31 percent and beef at 24

[4] Unless otherwise noted, this section is drawn from Rosegrant *et al*. (2001).

percent. Global demand for milk is projected to increase by 40 percent between 1997 and 2020. South Asia will continue to dominate milk consumption in the developing world, with demand increasing from 43 to 47 percent of the developing world total (Rosegrant *et al*. 2001).

Because new agricultural land will be scarce, increasing cereal production will require increased productivity, i.e. higher yields. But increases in yields are slowing for all cereals and for nearly all regions, so developing-country production will not keep pace with projected demand. By 2020, international trade will play a larger role in providing food to many regions of the world. The United States will become an even more dominant force in agricultural markets, while Europe will continue to be a major agricultural exporter. Net cereal imports by developing countries will more than double to 2020, with Asian countries, particularly China, boosting their imports enormously. However, countries that falter economically, leaving them unable to secure enough foreign exchange to pay for adequate levels of food imports, will become increasingly vulnerable to food shortages.

International cereal prices are projected to remain steady or decline only slightly during the next two decades, a significant break from past trends of steeper decline. Shocks to agriculture, particularly failure to meet farmers' needs for water and other inputs, could push food prices up significantly.

Summing up the baseline prospects for food to 2020: (i) almost all of the increase in world food demand will take place in developing countries; (ii) the "livestock revolution" will considerably increase demand for cereals for feeding livestock; (iii) most of the increases in production will have to come from yield increases; (iv) net cereal imports by developing countries will almost double, with half of them likely to come from the United States; and (v) cereal prices will remain steady or fall slightly.

BREAKING TREND LINES: SCENARIOS AND RISKS

The baseline projections presented above reflect the best assessment of a wide range of underlying policy, technological, and behavioral assumptions. But baseline outcomes may change significantly in the face of widely varying policy strategies and development paths for key drivers of the global food economy. Investments in the agriculture, water resources, and social sectors may decline, and slow progress on economic policy reform may dampen economic growth. Or, policymakers may take more aggressive steps toward improving agriculture and other rural economic sectors, boosting investment, and accelerating the pace of policy reform. Here, we briefly discuss three alternative scenarios.

What would be the impact on world food markets if yields and cultivated area in India and China increased only half as rapidly as expected in the baseline? Essentially, both India and China would be forced to turn increasingly to food imports. China's net cereal imports in 2020 would nearly double from 48 million tons under the baseline scenario to 89 million tons, while India would shift from near self-sufficiency in 2020 under the baseline scenario to net imports of 30 million tons. Yet, rising imports of this magnitude would not throw international cereal markets

into disarray or provoke devastating price increases; wheat and maize prices would be higher by about 9 percent each compared to the baseline scenario.

What would happen if crop yields grow more slowly than in the baseline? Under a scenario where irrigation does not grow at all and where yield growth rates decline by 50 percent from the baseline level in the developed world and by 40 percent in the developing world, supplies of food would be unable to keep pace with population and income growth at prevailing prices. Food would become more scarce, resulting in sharply higher cereal prices. Rice would be 46 percent more expensive and maize prices would be 34 percent higher in 2020 relative to the baseline scenario.

What if water policies change? What if further inattention to water-related investments and policies produces a severe water crisis that in turn leads to a food crisis? Or what if a commitment to sustainable use of water, through appropriate policies and investments, leads to a water- and food-secure world? Scarce water is a significant cause of the slowdown in cereal yield growth in developing countries.

With increased water stress relative crop yields decline, representing an annual loss in crop yields forgone. In a water crisis scenario, cereal production losses would exceed 400 million tons. This scenario has severe consequences for food production. Total cereal production in 2025 is projected to be 250 million tons, or 10 percent less than under the business as usual scenario. This is equivalent to the annual loss of the entire Indian cereal crop. The decline in food production will help push up food prices sharply under the water crisis scenario, with rice prices rising by 40 percent, wheat by 80 percent, and maize by 120 percent. These high prices dampen food demand and, compared with business as usual, net trade will decline.

There are a number of other major risks to and uncertainties in agriculture with significant implications in particular for the people who depend on agriculture for their food security and livelihoods. Here we identify three sets of such risks:

- Adverse Resource Management and Technology Interactions:
    - Rapid climate change;
    - Questionable sustainability and even collapse of marine fisheries;
    - Rapid increase in invasive plant special and the emergence of new plant and animal pests and diseases; and
    - Stalemate on the biotechnology front.

- Health and Food Crises:
    - Continuation or persistence of hunger and malnutrition;
    - Further spread of HIV/AIDS and the onset of other epidemics that have significant direct or indirect implications for agriculture;
    - Expansion of unhealthy diets; and
    - Bio- or food terrorism.

- Governance and Policy Crises:
    - Erratic changes in agricultural trade policies, possibly leading to a breakdown of the WTO;
    - Persistence of civil conflicts (local, regional, or cross-border);

- Decline in the quality of governance (corruption, inept public administration, abuse of human rights); and
- Collapse of small farms.

ACHIEVING SUSTAINABLE FOOD SECURITY FOR ALL: POLICIES, PRIORITIES, RESPONSIBILITIES

There is nothing inevitable about the rather pessimistic food security outlook presented here. If developing and developed countries alike implement appropriate policies and establish appropriate institutions, progress against food insecurity and child malnutrition could accelerate substantially. Some of the key policy actions are outlined below.

Broad-based Agricultural and Rural Development

Policies must assure that rural poor people have access to:

- Productive resources, including land, water, credit, tools, fertilizer, pest management, and technical assistance;
- Yield increasing crop varieties – including pest-resistant and drought- and salt-tolerant varieties – improved livestock, and other yield-increasing and environment friendly technology; and
- Basic education, primary health care, clean water, safe sanitation, and good nutrition.

Policies and programs must be supported by good governance – rule of law, transparency, sound public administration, democratic and inclusive decision making, and respect for human rights. Agricultural and rural development programs must engage low-income people as active participants, not passive clients. Poor people must have effective organizations that are accountable to them and articulate their interests vis-à-vis power holders (Kherallah *et al*. 2002; Pinstrup-Andersen 1993). Trade, macroeconomic, and sectoral policies must not discriminate against agriculture, poor people, or less-favored areas (Tweeten and McClelland 1997; Drèze and Sen 1989; Sen 1999; Pender and Hazell 2000).

Women play a central role as producers of food, managers of natural resources, income earners, and caretakers of food and nutrition security. In Africa, when women farmers obtain the same levels of education, experience, access to services such as extension, and farm inputs as male farmers, they increase staple food crop yields by 22 percent (Quisumbing and Meinzen-Dick 2001).

Pro-poor Agricultural Research

Public investment in agricultural research that can improve small farmers' productivity in developing countries is especially important for food security. It can boost agricultural productivity, thereby reducing gaps between food production and demand, further broad-based income growth, and lower unit costs in food production.

Pro-poor agricultural research must join all appropriate scientific tools and methods, including agroecology/organic farming, conventional research, and modern agricultural biotechnology, including genetic engineering, with better utilization of farmers' own knowledge. Agricultural research and development must put farmers in decision making roles, fully informing them of options for improving productivity, reducing risks, and increasing their families' well-being. Agricultural research must pay greater attention to sustainability and to resource-poor areas (Hazell 1999; Knox, Meinzen-Dick, and Hazell 2002). The private sector is unlikely to undertake much research needed by poor developing-country farmers because expected profits are unlikely to cover investment costs. On average, developing countries invest just 0.6 percent of agricultural GDP in public agricultural research, compared to 2.6 percent for developed countries. The average annual growth rates of public agricultural research expenditures in developing countries in the first half of the 1990s were significantly below those of the late 1970s, and in Sub-Saharan Africa, the rate turned negative. Aid donors' contributions to international agricultural research have stagnated over the past dozen years (Pardey and Beintema 2001).

Tackling Child Malnutrition

IFPRI research has found that improvements in women's education accounted for 43 percent of the reduction in child malnutrition in developing countries between 1970 and 1995. Improvements in per capita food availability accounted for an additional 26 percent of the reduction (Smith and Haddad 2000). Yet, in addition to low public investment in agriculture and agricultural research, developing country governments often drastically underinvest in education. Globally, only 46 percent of school-aged girls are enrolled. Since 1990, aid to education has consistently accounted for 10 percent of ODA, even as aid levels have fallen (Watkins 2001; UNICEF 2000).

Fighting Micronutrient Deficiencies

Food fortification and supplementation are cost-effective approaches to reducing micronutrient malnutrition. Promotion of dietary diversity has great promise for improving iron and vitamin A intakes. Development of iron- and vitamin A-rich staple crops through conventional breeding and biotechnology ("biofortification") may be more sustainable than supplementation or fortification, as it only requires a fixed, one-time investment. All of these strategies should be viewed as complementary, not either-or choices (Bouis 2000; WHO 2001).

Making Globalization Work for Poor People

Developing countries must participate effectively in global agricultural trade negotiations, pursuing better access to industrialized countries' markets. Coalitions with some higher-income countries may help improve their bargaining position, e.g., the Cairns Group, which brings together non-subsidizing agricultural exporters from both the developing and developed worlds. However, without appropriate domestic economic and agricultural policies, as discussed above, developing countries in general and poor people in particular will not fully capture potential benefits from trade liberalization (Diaz-Bonilla *et al*. 2000; Pinstrup-Andersen, Pandya-Lorch, and Rosegrant 1997, 1999; Diaz-Bonilla and Robinson 1999).

Policies for Sustainable Natural Resource Management

A high degree of complementarity amongst agricultural development, poverty reduction, and environmental sustainability is more likely when agricultural development is broad-based and inclusive of small- and medium-sized farms, market-oriented, participatory and decentralized, and driven by technological change that enhances productivity without degrading natural resources. Policies aimed at achieving sustainable agricultural development must take into account the role of property rights and collective action in natural resource management. Many natural resource management technologies and practices take years to give full returns, e.g., terracing. Without secure rights to resources, farmers lack incentives to adopt these approaches. Some technologies need to be adopted over a wide area to be effective, e.g., integrated pest management (IPM), so adopting farmers must cooperate with their neighbors in collective action. Effective institutions are needed to monitor and enforce specified rights (Hazell 1999; Knox, Meinzen-Dick, and Hazell 2002).

Promoting Sustainable Development in Less-Favored Areas. Although productivity is lower in less-favored areas, these zones usually have comparative advantage in some agricultural production or nonfarm activities if investment in infrastructure and institutions is adequate. IFPRI research has found that public investment in less-favored areas of China and India results in high returns that sometimes exceed those to investment in favored areas in terms of both economic growth and poverty reduction. Investments in agricultural research, education, roads, and irrigation have greater incremental impact in less-favored areas in these two countries, in part because opportunities for investment in these areas have been neglected. Both countries have invested heavily in high-potential areas, so additional investments there exhibit diminishing returns. In Sub-Saharan Africa, where overall agricultural public investment is low, additional investment in both high-potential and less-favored areas remains critical (Hazell and Pender 2000).

Soil Fertility Management. Low soil fertility and lack of access to reasonably priced fertilizers, along with failure to replenish soil nutrients, must be rectified through efficient and timely use of organic and inorganic fertilizers and improved soil management. Chemical fertilizer use should be reduced where heavy application causes environmental harm. Fertilizer subsidies that encourage excessive use should be removed, but subsidies may remain necessary for less-favored areas where current use is low and soil fertility is being mined. Presently, mineral fertilizer use in Sub-Saharan Africa is just 13 kilograms per hectare of arable land, compared to 241 kilograms in East Asia and 127 in the higher income countries. An integrated, holistic approach to soil fertility management is essential, embracing the full range of driving factors and consequences – biological, physical, chemical, social, economic, and political. Policies should raise the value of forests and pastures, offer incentives for sound management, and help create nonfarm employment opportunities (Pinstrup-Andersen, Pandya-Lorch, and Rosegrant 1997,1999; Hazell 1999; Scherr 1999; World Bank 2002).

IFPRI research in the East African highlands indicates that intensive extension service contact is essential to help address soil fertility depletion problems. In eastern Uganda, where soil nutrient balances are highly negative, only farmers who have

more than a threshold level of contact with extension agents tend to adopt fertility enhancing technologies. We found a similar pattern in the Amhara region of Ethiopia.

Integrated Pest Management. Until recently, developing country governments and aid donors encouraged use of synthetic pesticides. Now, consensus is emerging on IPM, emphasizing more judicious use of synthetics (e.g., applying minimally adequate quantities at the right time) and greater reliance on alternative means of pest control such as natural predators, biological pesticides, crop rotations, and pest-resistant crop varieties. The latter may be developed through either conventional means or biotechnology (Yudelman, Ratta, and Nygaard 1998). International agricultural research centers in Africa and Latin America collaborated to identify parasitic wasps that control the cassava mealy bug, which caused losses of up to 80 percent. The $15 million research investment saved $2.2 billion in output (Gabre-Madhin and Haggblade 2003).

Water Policy Reform. Comprehensive water policy reform is needed to help save water, improve use efficiency, and boost crop output per unit. Such reforms will be difficult, due to widespread practices and cultural norms that treat water as a free good and vested interests benefiting from current arrangements. Reforms might include secure and tradable rights for users, and subsidies targeted to poor water users in place of general subsidies. Devolving irrigation infrastructure and management to user associations, combined with secure access to water, will provide incentives for efficient use. Appropriate technology is needed to support conservation incentives (Rosegrant *et al*. 2002).

Global Warming. Small farmers can mitigate global warming by sequestering carbon through cropland, forest, and pasture management strategies that result in improved soil organic matter, improving nitrogen use efficiency, reducing nitrous oxide emissions, and improving water use efficiency. Avoiding deforestation, tree planting, and agroforestry (the integration of crop and tree cultivation) offer potential carbon gains. (Wood, Sebastian, and Scherr 2001; CGIAR 2001; Wilson 2001).

Meeting Health Challenges

Governments and international agencies should address health risks as a key part of their food security strategies. When problems interact and coexist, integrated solutions can achieve multiple benefits and be more cost-effective. Food supplements for nutritionally vulnerable pregnant women may be linked to primary health care programs. Multiple micronutrient supplementation can reduce micronutrient malnutrition and low birth weight, and prevent malaria. Drip irrigation, which reduces water waste, also reduces the habitat of malaria-spreading mosquitoes. Given the devastating impact of HIV/AIDS on agriculture, agricultural and rural development programs must integrate efforts to prevent and mitigate the spread of the disease (Flores and Gillespie 2001).

CONCLUSION

Enhanced agricultural productivity for long-term food security remains relevant for billions of people because of the strong connections to job creation, income generation, price levels, and nutritional well-being. Implementing the policy changes outlined here will be expensive, and will require difficult political choices. But the task is far from impossible. IFPRI forecasts that developing countries will make public investments of about $580 billion in irrigation, rural roads, agricultural research, clean water provision, and education between 1997 and 2020. Boosting this figure to $800 billion would reduce the projected number of malnourished preschoolers in developing countries from 132 million to 94 million by 2020. While this does not represent food security for all, it is a major step in the right direction. If total developing-country government expenditures remained constant at 1997 levels, the investments needed to achieve this more favorable child nutrition outcome would amount to just 4.9 percent of government spending. Moreover, on an annual basis, the needed additional public investment represents just 5 percent of current annual military spending in low- and middle-income developing countries (Rosegrant *et al*. 2001; World Bank 2001b). Accelerated progress toward sustainable food security will depend upon the willingness of governments, international agencies, nongovernmental organizations, business and industry, and individuals to back their anti-hunger rhetoric with action, resources, and changes in behavior and institutions.

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Table 1 X People living on less than $1 per day, 1990, 1998, and 2015 (millions of people and percent of population)

	1990		1998		2015 (optimistic)		2015 (pessimistic)	
	Number	Percent	Number	Percent	Number	Percent	Number	Pct.
Developing world	1,300	29	1,200	23	777	13	1,000	16
Sub-Saharan Africa	242	48	302	48	361	40	462	47
East and Southeast Asia	452	28	267	15	65	3	101	5
South Asia	495	44	522	40	297	18	426	25
Latin America and the Caribbean	74	17	61	12	43	7	58	9
West Asia and North Africa	6	2	6	2	5	1	6	2

Source: World Bank (2001a).
Note: The optimistic scenario for 2015 assumes moderate, broad-based economic growth worldwide, while the pessimistic scenario assumes slower growth and rising inequality.