Brian Thompson
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The Impact of Climate Change and Bioenergy on Nutrition

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Inhassune village, Inhambane Province, Mozambique, November 2009
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Planting rice, Lao People's Democratic Republic
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Photo 3
Group of women harvesting vegetables, Lubumbashi, Democratic Republic of Congo
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A view of a dry reservoir seen from the Ibohamane Dam, Democratic Republic of Niger
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Chapter 1
Summary

Brian Thompson, Marc J. Cohen and Janice Meerman

Background: Unacceptably Slow Progress in Reducing Hunger and Malnutrition

Food security has deteriorated since 1995 and reductions in child malnutrition are proceeding too slowly to meet the Millennium Development Goal (MDG) target for halving hunger by 2015. Moreover, three major challenges threaten current and future efforts to overcome food insecurity and malnutrition: climate change, the growing use of food crops as a source of fuel and soaring food prices.

Food security has four dimensions: food availability, stability of supply, access to adequate quantities and varieties of safe, good quality food and its utilization by the body. It is a key factor in good nutrition, along with health, sanitation and care practices.

Present global food stocks would be more than adequate to provide everyone in the world with the number of calories required for a healthy life, were food supplies equally distributed. But with an estimated increase of 105 million undernourished people in 2009 alone, the most recent estimate from the Food and Agriculture Organization of the United Nations (FAO) puts the number of people suffering from

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hunger at approximately 925 million, almost one in six of all humanity; over 60% of these people live in Sub-Saharan Africa and South Asia.

Even if a person consumes enough calories, this does not guarantee adequate intake of essential micronutrients – vitamins, minerals and trace elements. Micronutrient malnutrition ("hidden hunger") has serious public health consequences. For example, over one billion people consume diets deficient in iron. Iron deficiency is responsible for roughly half of the global prevalence of anaemia. Iron deficiency anaemia causes 20% of global maternal mortality, can impair children's health and development and has been shown to reduce adult work performance and labour productivity. Another common micronutrient disorder, vitamin A deficiency, affects 40 million people worldwide, causing blindness and contributing to infections and death.

In addition to micronutrient deficiencies, chronic undernutrition and poor quality diets are endemic in many poor countries. An estimated 171 million children under five years of age suffer from mild, moderate or severe stunting (low height for age) in the developing world. Eighty percent of these children live in just 20 African and Asian countries. Even mild stunting is associated with higher rates of illness and death, impaired cognitive function and reduced school performance in children. Stunting also lowers adult productivity and reduces lifetime earnings.

In sum, chronic malnutrition during the first 2 years of life usually results in irreversible harm. At each stage in the lifecycle, malnutrition has consequences for each successive stage and/or the next generation. Malnourished mothers are more likely to have low birthweight babies. These infants face higher mortality and disease rates, compromised mental and physical development and increased risk of adult chronic diseases. Stunted children living with inadequate food, health and care become stunted adolescents; the girls among them too often grow up as the next generation of malnourished mothers.

In addition to the direct effects of malnutrition on health, malnutrition also interacts with many infectious diseases, increasing the severity of symptoms and raising mortality rates. For example, HIV/AIDS interacts negatively with malnutrition. Poor nutrition can accelerate the spread of HIV, both by increasing people's vulnerability to the virus and by increasing the risk of infection following exposure. In turn, HIV infection can lead to nutritional deficiencies through decreased food intake and malabsorption, which hasten the onset of AIDS. In addition, HIV typically impairs the immune system and so can lead to additional infections. (See Box 4.1 in Chap. 4 for a detailed explanation of the interaction between nutrition and infection).

People displaced by natural and man-made disasters are especially susceptible to malnutrition and disease, as they often depend on food aid that may be inadequate in both quantity and quality. Due to more frequent extreme weather events, the number of natural disasters has increased in recent years. Moreover, aid donors routinely fail to provide all of the resources requested through humanitarian appeals. In its Consolidated Humanitarian Appeal for 2011, the United Nations called for a total of $7.4 billion to fund urgent humanitarian assistance for 50 million people in 28 countries. This is the largest sum sought for such aid since the Appeal's inception 1991.

Causations and Linkages: Conceptual and Analytical Frameworks

The costs of inaction are huge; reducing malnutrition in all its forms should be a priority for global policy agendas. Inadequate dietary intake and disease are the immediate causes of malnutrition in that inadequate food consumption heightens vulnerability to infectious diseases, which subsequently keep the body from absorbing adequate food. These immediate causes stem from insufficient access to adequate quantities and quality of food in terms of variety, diversity and safety, poor maternal and child care practices and inadequate access to clean drinking water, safe sanitation and health services. Ultimately, these factors are embedded in the larger political, economic, social and cultural environment. Food insecurity, ill health and sub-optimal caring practices are all closely related to poverty. Poor people generally consume fewer than the minimal average requirement of 2,100 calories per day and lower-income households experience significantly higher rates of preschooler stunting and illness and worse care practices than better-off families.

Taken together, chronic and acute child malnutrition, low birthweight, suboptimal breastfeeding and micronutrient deficiencies lead to the deaths of 3.6 million mothers and preschool children each year, accounting for 35% of all preschooler deaths and 11% of the global disease burden. Difficult pregnancies and illnesses due to malnutrition cost developing countries $30 billion annually. Lost productivity and income resulting from early deaths, poor school performance, disability and absenteeism raise the yearly total into the hundreds of billions of dollars. Malnutrition also reflects and contributes to inequity, disproportionately affecting poor, marginalized and extremely vulnerable groups. While the policies and programmes needed to address malnutrition require substantial resources, the costs of not tackling malnutrition are considerable. Furthermore, food insecurity and malnutrition infringe on the human right to adequate food.

Future Challenges, Major Issues and Risks

In addition to climate change, rising bioenergy demand and soaring food prices, the following factors will impede efforts to reduce malnutrition:

- demographic forces and urbanization;
- structural shifts in food and agricultural systems;
- transboundary movement of disease; and
- environmental and energy pressures.

Demographic Forces and Urbanization

World population will increase by 37%, to approximately nine billion people by 2050. Anticipated economic growth of 6% per year in developing countries during

the next few years and rapid urbanization will also lead to increases in demand and structural shifts in diets.

Structural Shifts in Food and Agriculture Systems

The global food system has a dualistic structure. The vast majority of the world's farms (85%) are small-scale operations of less than 2 hectares (ha). But the 0.5% of farms that exceed 100 ha capture a disproportionate share of global farm income, enjoy privileged access to policy makers and – particularly in developed countries – receive generous subsidies. Further, buying power is increasingly concentrated in the hands of agribusiness and other powerful corporate actors. And although preferences of affluent consumers in richer countries are shaping global food and agricultural systems in ways that offer opportunities to small producers (e.g. fair trade coffee), many smallholders are unable to meet international production standards.

Transboundary Movement of Disease

Intensification of agricultural production systems, rapid growth in international trade and more frequent international travel offer opportunities to bolster rural livelihoods. However, there are also substantial risks involved in the globalization of agriculture. The spread of plants and animals across international borders will accelerate dispersal of plant pests, animal diseases and invasive species. Climate change will further heighten these risks.

Environmental and Energy Pressures

Efforts to intensify agricultural production have helped boost food output, but some agricultural practices have taken a heavy toll on the natural resource base. In the absence of technological innovation, increases in food production may come from expanding cultivation into areas that are fragile or marginal. Maximizing yields by encroaching on fragile ecosystems accelerates destruction of forests and wildlife habitat, causing biodiversity loss and increased greenhouse gas (GHG) emissions. By April 2008, crude petroleum prices reached an all-time high of US$120 per barrel and helped to raise demand for biofuels. This meant increased costs for fertilizer, operating farm machinery and transportation of both inputs and output. Moreover, food and agricultural production faces growing competition for water from home and industrial use.

Climate Change and Food and Nutrition Security

Climate change and variability will have significant impacts on food security and malnutrition. They are already leading to more intense and longer droughts, and the frequency of heavy precipitation events has increased in many areas. It is very likely that heat waves and heavy precipitation events will continue to become more frequent and that future tropical cyclones and severe weather events will become more intense. The risk of flooding may increase, from both sea-level rise and increased heavy precipitation in coastal areas. This is likely to increase the number of people exposed to diarrhoeal and other infectious diseases, thus lowering capacity of those individuals to utilize food effectively. Droughts and water scarcity diminish dietary diversity and reduce overall food consumption and this may lead to malnutrition. Finally, during the course of the twenty-first century, water supplies stored in glaciers and snow cover are projected to decline, reducing water availability in regions that are home to one-sixth of the world's population.

Deforestation, agriculture and livestock production systems further accelerate climate change. The expansion of livestock and biofuel sectors has a major role in deforestation and land degradation. Vulnerability to adverse effects from climate change differs by region, ecosystem, population group and gender. The most vulnerable people will suffer earliest and most, as they will be most limited in terms of coping mechanisms, insurance and social safety nets. The regions likely to be adversely affected are those already most vulnerable to food insecurity and malnutrition, notably Sub-Saharan Africa. In seasonally dry and tropical regions, crop productivity is projected to decrease with even small local temperature increases. In Africa, by 2020, 75–250 million people will be exposed to increased water stress due to climate change. In much of Africa, agricultural production and access to food are projected to be severely compromised.

Projected climate-change related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity, through:

- increased deaths, disease and injury due to climate-related events – heat-waves, floods, storms, fires and droughts;
- increased malnutrition due to reduction in both quality and quantity of food intake;
- increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change;
- altered spatial distribution of some infectious-disease vectors; and
- increased burden of diarrhoeal diseases.

Malnutrition exacerbated by extreme climatic events may be one of the most pernicious consequences of climate change. The food and nutritional security of a very large number of people worldwide may be affected. Populations at risk include smallholder and subsistence farmers, pastoralists, traditional societies, indigenous people, coastal populations and fisherfolk. Moreover, the gender inequality which currently compromises development in many poor countries could be exacerbated by climate-related extreme weather. Many of the world's poorest people are rural women who depend on subsistence agriculture to feed their families. Climate change

could add to water and food insecurity, thus increasing these women's work levels and curtailing opportunities for education and other types of empowerment.

Impacts on Agricultural Production

Multiple socio-economic and environmental stresses, such as globalization, limited availability of water resources, loss of biodiversity, the HIV/AIDS pandemic and conflicts, are increasing sensitivity to climate change and reducing agricultural resilience.

Climate change is likely to reduce reliability of irrigation water supplies, leading to increased competition for water. Water scarcity in turn may lead to multiple adverse health outcomes, including waterborne diseases, exposure to chemicals, vector-borne diseases associated with water-storage systems and malnutrition.

Impacts on Food and Nutrition Security

There are many pathways through which climate change and variability may impact food and nutrition security:

- increased frequency of extreme climatic events;
- sea-level rise and flooding of coastal lands, leading to salination and/or contamination of water and agricultural lands;
- impacts of temperature increase and water scarcity on plant and animal physiology;
- beneficial effects on crop production through CO_2 "fertilization";
- influence on plant and livestock diseases and pest species and livestock diseases;
- damage to forestry, livestock, fisheries and aquaculture; and
- impaired sustainability: socio-economic, political/armed conflict and demographic impacts.

Climate change will affect all four dimensions of food security via these above-mentioned pathways. Agricultural output in developing countries is expected to decline by 10–20% by 2080. Globally, food production is projected to grow with increases in local average temperature over a range of 1–3°C, but above this it is projected to decrease. In seasonally dry and tropical regions, even slight warming (1–2°C) reduces yield. Thus temperature increases of more than 3°C may cause food prices to increase by up to 40%.

Temperature increases are also leading to changes in the distribution of marine fisheries. For example, increases in atmospheric CO_2 are raising ocean acidity. In addition, atmospheric temperature increases are associated with rising seawater temperature, which is itself associated with a host of negative environmental impacts. For example, increased seawater temperature leads to increased densities of *Vibrio* spp. in shellfish, a pathogen known to cause diarrhoea.

Changes in the patterns of extreme weather events will affect the stability of, as well as access to, food supplies. Increasing frequency of crop loss due to climatic shocks may overcome positive effects of moderate temperature increases. For forests, elevated risks of fires, insect outbreaks and wind damage are projected. Food insecurity and loss of livelihoods might be further exacerbated by the loss of cultivated land and nursery areas for fisheries through inundation and coastal erosion in low-lying areas.

Climate-related animal and plant pests and diseases and alien invasive aquatic species will reduce food availability, influence production system stability and reduce food access through reduction of income from animal production, lower crop yields, lessened forest productivity and changes in aquatic populations, as well as increased costs of control.

Climate change may affect health outcomes and food utilization with additional consequences for malnutrition. Water scarcity or flooding is one way this might happen. Populations in water-scarce regions are likely to face decreased water availability, thus increasing potential for poor hygiene and sanitary practices as well as increased use of non-potable water for drinking and cooking. In other areas, flooding, increased precipitation and higher temperatures are likely to increase the incidence of infectious and diarrhoeal diseases. In both scenarios, climate change will aggravate the vicious synergism that exists between malnutrition and infectious disease. As climate change is projected to increase the burden of diarrhoeal diseases in low-income regions by approximately 2–5% by 2020, a concomitant rise in malnutrition is to be expected.

A further example of the relationship between climate change, health outcomes and food and nutrition security is malaria. In the long term, the geographical range of malaria will contract in areas experiencing desertification (due to decreased humidity and water required for mosquito breeding). But elsewhere, the parasite's range will expand and the transmission season may change and lengthen. It is estimated that in Africa, climate change will increase the number of person-months of exposure to malaria by 16–28% by 2100. Longer transmission seasons will in turn reduce labour productivity, thus affecting food and nutrition security. Longer transmission seasons may also increase the absolute numbers of people suffering from malaria. In this sense, climate change affects food and nutrition security by compromising individuals' immune systems and their ability to utilize nutrients.

Social Impacts of Climate Change

Smallholder and subsistence farming households in the dryland tropics are particularly vulnerable to increasing frequency and severity of droughts. Droughts lead to higher likelihood of crop failure, increased diseases and mortality of livestock, indebtedness, out-migration and dependency on food relief. Droughts also negatively impact human development indicators such as health, nutrition and education. Drought and the consequent loss of livelihoods are also triggers for

population movements, particularly rural to urban migration. Rapid mass migration creates urban slums with very high prevalence of malnutrition, diarrhoea and other communicable diseases. The challenges posed by urban slums are some of the most pressing in the world. Cities are often unable to cope with the massive public health issues they pose, and the problem is typically compounded by high rates of crime and violence. Climate change may, in many countries, further aggravate things. For example, the United Nations projects that up to 50 million people will flee environmental deterioration by 2020. Many of these people will migrate to cities, where they will be vulnerable to food and water emergencies, ill health and malnutrition and increased likelihood of conflict and violence.

Adaptation and Mitigation Strategies for Climate Change

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." In contrast, the IPCC defines mitigation as "an anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks" (IPCC 2007). Simply put, adaptation strategies work to offset or take advantage of the impacts of climate change, whereas mitigation strategies address its root causes by aiming to reduce emissions and increase carbon sequestration.

Adaptation strategies to climate change for protecting and promoting food and nutrition security can be autonomous or planned. Many autonomous adaptation options are extensions or intensifications of existing risk-management or production-enhancement activities. Using inputs that are resistant to drought, altering fertilizer rates, changing water management practices, improving pest management, maintaining quarantine and monitoring programmes and using climate forecasting all have substantial potential to offset negative climate change impacts and take advantage of positive ones. However, it is important to note that there are limitations to adaptation strategies.

First, adaptation policies are not "gender-proofed". Since adaptation strategies use the status quo to build on existing systems, they may further exacerbate gender inequalities related to land access, credit, extension services and other inputs. Thus many women may be unable to access the benefits of adaptation projects and programmes.

Second, adaptation strategies to climate change for food and nutrition security are complex and often involve trade-offs. For example, shifts to crops such as cassava in countries that are severely affected by droughts or HIV/AIDS should take into consideration the potential impact on diets and on nutrition. Cassava, while hardy, easy to grow and drought resistant, is very low in protein and hence can pose a threat to dietary quality if it is not consumed as part of an adequately diversified diet. Planned adaptation efforts to breed nutrient-rich food crops should thus be integrated with autonomous efforts to breed crops that are drought-resistant and water-tolerant.

Third, adaptation potential depends almost wholly on smallholder capacity. Extension services, topography, degree of economic development, natural resources, social context, institutions, governance and technology are just some of the variables which can make or break local efforts to adapt to climate change. For example, the benefits of adaptation tend to increase with the degree of climate change up to a 3°C temperature increase, at which point adaptive capacity in low latitudes is exceeded, and mitigation strategies are required.

The main mitigation potential of agriculture lies in improved crop and grazing land management to increase soil carbon sequestration. Additional options include restoration of degraded lands, improved rice cultivation and improved nitrogen fertilizer management to reduce emissions of the GHG nitrous oxide. Key mitigation strategies in livestock include reducing emissions via improved diets to reduce fermentation in ruminants' digestive systems and improved manure and biogas management.

With regard to the forestry sector, there is agreement and considerable evidence that forest-related mitigation activities using commercially available technologies can considerably reduce emissions and create synergies with strategies for adaptation and sustainable development (including employment and income generation, reduced poverty, biodiversity and watershed conservation, and developing sources of renewable energy). Curbing deforestation is a highly cost-effective strategy for reducing GHG emissions and has the potential for quick impact. Deforestation created by burning to make way for agricultural production accounts for 20% of global carbon emissions, so reducing deforestation has a very high potential for GHG emission reduction. Use of financial and market incentives to reduce burning and other deforestation activities which cause GHG emissions (REDD or Reducing Emissions from Deforestation and Forest Degradation) is one strategy being used in a number of countries to increase adoption of good forest management practices. New technologies are also being developed to promote innovative, non-invasive farming methods which do not require deforestation.

Nutrition and Bioenergy

Rising petrol prices have made biofuels, such as ethanol and biodiesel, an attractive alternative energy source, and technological development has recently made them more cost-effective and energy-efficient. But biofuels offer only a very small gain in energy efficiency and their use as a fuel source only minimally reduces GHG emissions. Moreover, the production of biofuels made from food crops (e.g. maize, sugarcane) has been criticized by some for a number of food-security-related reasons. Research is underway to develop cellulosic biofuels from low value non-food crops, such as grasses or wood, but these substances are more difficult to process than starch or sugar crops and it is not clear that their production will expand significantly in the near future.

Biofuel production can have both positive and negative impacts on nutrition: positively through increased incomes of those involved in cultivation and marketing; negatively through increased GHG emissions that may result from burning forests

to clear land for crop cultivation, as well as through direct effects on health and sanitation and reduced food availability and associated price effects. One major problem is diversion of food and feed crops to biofuel production, as returns to biofuel production are often greater than the returns a farmer might get were the same crops sold for food, or for non-biofuel crops. Such practices can reduce food availability and may consign food and feed production to less productive land, thus reducing yields and food security.

In relation to such effects, the International Food Policy Research Institute (IFPRI) estimates that rising bioenergy demand accounted for 30% of the increase in weighted average grain prices between 2000 and 2007. The impact was 39% of the real increase in maize prices.

A rise in the food bill for households that are net buyers of food may lead to the substitution of starchy staples for micronutrient-rich animal source foods, legumes, processed foods, fruits and vegetables and to a reduction in the average number of meals and the amount of food consumed and therefore to reduced micronutrient intakes among poor people. Extremely poor people will experience decreased calorie consumption. IFPRI projects that in 2020, if biofuel development proceeds at or exceeds its current pace, calorie availability will decline and child malnutrition will increase substantially, particularly in Sub-Saharan Africa.

Growth of the biofuel sector may also lead to water shortages and contamination. Cultivation of sugarcane, one of the most popular biofuel feedstocks, is particularly water-intensive. As mentioned above, water scarcity in developing countries is a cause of concern for agricultural productivity, health and sanitation. Poorly managed input use in energy crop cultivation could pollute drinking water, adversely affecting human and animal health.

Appropriate policies can make bioenergy development more pro-poor and environmentally sustainable. Poor farmers might be able to grow energy crops on degraded or marginal land not suitable for food production. Further investment is needed in developing technologies to convert cellulose to energy, which could provide smallholders with a market for crop residues. Biofuel production is labour-intensive, offering new job opportunities. Organizing groups of smallholders through contract farming schemes to grow and market biomass would be more pro-poor than plantation production. Technologies, institutional arrangements and bioenergy crop choice are important to determining impacts on poverty and the environment. Outgrower schemes could allow for technology spillovers to food crops, meaning additional growth and poverty reduction benefits, as well as increased food availability. There may be barriers to female farmers taking advantage of opportunities, as they have less access than men to land, water, credit, inputs and services.

Policies and Programmes for Improving Nutrition

The ultimate causes of food insecurity and undernutrition are social, economic, cultural and political. Therefore, it is essential that efforts to achieve food and nutrition security address these causes.

At the regional and national level, developing countries have issued national policies and developed plans of action on nutrition, but in practice, these are often not accompanied by adequate budgetary allocations, or do not incorporate the appropriate specific actions to address nutrition problems on the ground. While nutrition is receiving increased attention as a serious problem, few countries are choosing (or able) to follow up with adequately funded programmes of action.

Accelerated progress against food insecurity and malnutrition requires that governments put appropriate policy responses much higher on their agendas, with adequate resources provided. One example of a country where this has happened is Brazil. Brazil's *Fome Zero* (Zero Hunger) programme shows the tremendous difference it makes when governments make food and nutrition security a high priority. In addition to providing direct welfare and food aid to persistently poor families, *Fome Zero* provides conditional cash transfers to families throughout Brazil on the condition that children attend school and receive routine vaccinations, and that pregnant women receive pre-natal care and nutrition education. Through this combination of basic welfare grants and conditional cash transfers, *Fome Zero* attempts to (1) reduce immediate poverty through direct welfare grants, (2) break the intergenerational transmission of poverty with the transfer conditionalities which are designed to increase human capital via improved health and education outcomes and (3) empower beneficiary families by linking them to complementary services. *Fome Zero* thus addresses the longer-term structural socio-economic causes of food and nutrition insecurity as well as providing short-term direct food aid to beneficiaries.

In order for programmes like *Fome Zero* to be successful, donors must provide technical and financial support. Within the climate change and bioenergy contexts, the urgency for action increases. Harmonised, large-scale, multi-component programmes are required to make a difference and should include the following steps:

- create an enabling environment to promote peace, eradicate poverty and reduce gender inequality;
- promote a fair and market-oriented world trade system;
- increase investments in human resources, sustainable food production systems and rural development;
- implement policies to improve physical and economic access to sufficient, nutritionally adequate and safe food and its effective utilization;
- focus on participatory and sustainable agriculture;
- use a "nutrition lens" to direct multi-sectoral actions to improve household food security; improve food quality and safety; prevent, control and manage infectious diseases and micronutrient deficiencies; promote appropriate diets, including breast-feeding and healthy lifestyles; provide care for the vulnerable, including people living with HIV/AIDS; introduce productive safety nets and provide direct assistance;
- prevent and prepare for emergencies; and
- build anti-hunger alliances.

Governance Issues

A number of governance issues have considerable bearing on food security and nutrition. Both food security and nutrition are multi-sectoral issues; determinants include health, education and agriculture. Hence a comprehensive national nutrition strategy requires cross-sectoral collaboration between these areas. But developing-country governments are composed of sectoral ministries that frequently view budgetary allocation as a zero-sum game. Since each sector is competing with others for funding to carry out its own mandate, and since improved nutrition outcomes are not typically used as performance indicators for most ministries, it can be hard to incentivize nutrition-based mandates across a multiplicity of ministries. For example, most country leaders will not judge the effectiveness of their Ministry of Education based on reductions of iodine deficiency among schoolchildren. Nor do senior decision makers always recognize the costs of undernutrition. As long as nutrition is perceived primarily as an output, rather than an input, to growth and development, it will not receive adequate recognition or funding. In addition, determinants of nutritional status are often poorly understood by policy-makers and politicians. Finally, many developing countries lack adequate human resources to implement nutrition-based agendas.

In addition to these country-level problems, a fragmented and incoherent international nutrition system complicates the picture. Resources for nutrition are inadequate. Annual donor funding runs at less than US$300 million, compared to US$2.2 billion for HIV/AIDS and several billion dollars in food aid. In real terms, aid to agriculture is about half the level of 25 years ago. Governments of low-income countries devote 19% of their budgets to military expenditures, compared to less than 5% for agriculture. Military expenditures account for 2.6% of GDP in low-income countries, compared to 1% for public health. However, there are some indications that priorities are changing. The African Union seeks to boost agriculture to 10% of member budgets and bring agricultural growth to 6% per year, and the World Bank is putting renewed stress on both nutrition and agriculture.

A Revitalised Twin-Track Approach

There is an urgent need to reform global humanitarian assistance, for example by moving towards a more insurance-oriented approach that guarantees a rapid response.

At the International Conference on Financing for Development held in 2002, FAO, the International Fund for Agricultural Development (IFAD) and the World Food Programme (WFP) agreed upon a “twin-track approach” for combating hunger and poverty: strengthening the productivity and incomes of hungry and poor people, targeting the rural areas; and direct and immediate access to food by hungry people and social safety nets. The latter include food transfers, conditional and unconditional cash transfers and public works programmes and may be targeted or universal.

Examples of the "twin-track approach" include introducing improved water management, use of green manures, agroforestry and other low-cost, simple technologies designed to strengthen rural infrastructure. These methods not only enhance the productivity and incomes of small farmers, but also empower them in their role as stewards of natural resources. Investing in rural infrastructure can also reduce the lethal impact of water-borne illnesses, improve access to health care, prevent thousands of needless child and maternal deaths and open links to markets where farmers can sell surplus produce and acquire fertilizer and other inputs at reasonable prices.

High food prices exacerbate food insecurity and create social tensions, but high agricultural commodity prices also present a potential opportunity for reversing the decline in public investment in agriculture. More food needs to be produced where it is urgently needed to contain the impact of soaring prices on poor consumers and simultaneously maximize production to create more income and employment opportunities for rural poor people. The "twin-track approach" increases smallholder farmers' access to resources, infrastructure and services so they are better equipped to increase their supply response to higher prices. Agricultural growth will also stimulate growth in other sectors. Appropriate policies and institutions, such as organization and collective action, can help facilitate smallholder participation in value chains on a fair basis.

Agricultural and rural development strategies must recognize the important roles that women play in food security and nutrition. Hence the "twin-track approach" also includes measures to provide direct access to food for the neediest families such as feeding programmes for mothers and infants. These programmes target the hub of the vicious cycle of hunger and malnutrition that undermines maternal health, stunts children's physical and cognitive growth, impairs school performance and impedes progress towards gender equality and the empowerment of women.

FAO and other development partners need to retain a focus on the twin-track approach. We need to make more explicit and put into effect policies and programmes that boost supply, not only by the larger commercial farmers but also by smallholders, while at the same time designing social protection and safety nets that protect the vulnerable and include direct nutrition interventions.

Direct Nutrition Interventions

Good nutrition makes an essential contribution to the fight against poverty. It protects and promotes health; reduces mortality, especially among mothers and children; encourages and enables children to attend and benefit from school; and enhances productivity and incomes in adulthood. The increased participation of poor and vulnerable people and of women in the development process that may arise from effective community nutrition programmes will likely lead to more effective demands for improved services and to better use of existing resources.

With regard to preschooler malnutrition, the crucial "window of opportunity" is from conception through the first 18–24 months of a child's life. Effective interventions targeting infants and young children include improving food consumption and nutrient intakes through breastfeeding promotion, improved complementary feeding and dietary diversity, salt iodisation, vitamin A and zinc supplementation, vitamin A fortification, hand-washing and hygiene interventions and treatment of severe acute malnutrition. Whenever possible, interventions should not neglect other age groups, other family members or low-income childless households who may equally be in need of support. For example, the care of adolescent girls and pregnant women is vital for protecting their own health and that of their future children.

A relatively new approach to tackling micronutrient malnutrition in infants, children and adults is through "biofortification", which involves developing micronutrient-dense staple crop varieties. A number of biofortified varietals are also being developed with agronomically desirable traits, such as increased resistance to pests and disease. In the long run, biofortification may be more sustainable than supplementation or fortification, as it has lower recurrent costs.

Direct nutrition interventions are especially crucial within the context of HIV/AIDS-related illnesses. For those living with the disease, better nutrition can postpone onset and severity of diarrhoea, pneumonia and tuberculosis. Nutrition policies can provide incentives for improving the diets of HIV-positive individuals, for strengthening the nutrition focus of anti-retroviral and other HIV-oriented health services and for ensuring nutritionally balanced food aid as a safety net in populations where HIV is prevalent.

Educating Girls

IFPRI research has shown that improvements in girls' education had the biggest impact (relative to other underlying factors) in reducing child malnutrition in developing countries during 1970–1995, accounting for 43% of the decline. But at present, 100 million primary school-aged children are not enrolled and 57% of these children are girls. School meals and food-for-education programmes can help achieve full enrolments, educational gender equality and improved food security.

Responding to Threats to Nutrition from Climate Change and Biofuel Demand

A combination of adaptation and mitigation measures, sustainable development and research can diminish the threats to nutrition from climate change. Changes in policies and institutions will be needed to facilitate progress in all these areas. For example, financial incentives can help reduce deforestation and improve maintenance of soil carbon content. In addition to their direct impact on emissions, these

incentives encourage broader synergies with sustainable development practices and efforts to reduce vulnerability. With regard to the livestock sector, stronger regulation and incentives to improve waste management enhance the sanitary environment and increase returns to health-based interventions. In addition to sector-specific approaches, agriculture, food and nutrition security issues need to be placed onto national and international climate change agendas, in order to devise effective and pro-poor nutrition-sensitive policies. The expiration of the Kyoto Protocol in 2012 offers an opportunity to bring these issues to the table.

There are multiple ways food and nutrition security can be promoted and protected from the adverse effects of biofuel production. Biofuel production in developing countries should be carefully designed, so as not to crowd out other development investments. Policies should ensure that smallholders, including women farmers, have access to resources so that they can participate in biofuel production on a fair basis. Policies also need to examine and regulate the environmental consequences of biofuel development. Further, increased investment in agricultural productivity will help developing countries increase their own food production and be able to engage in the biofuel market. Global cooperation is needed on R&D to bring technologies on line that will allow production of biofuels from non-food crops. Developed-country governments should remove trade barriers to developing-country biofuel exports and, along with international organizations such as FAO and the international financial institutions, provide financial and technical assistance to pro-poor, sustainable biofuel projects in developing countries. Finally, developing-country governments need to conduct food and nutrition security impact assessments before launching biofuel projects.

The approaches discussed in this book are proven, practical and affordable. Each can be effectively adapted and applied to meet local requirements, monitored to ensure that they are effective and scaled up as they prove successful and as sufficient resources are mobilized. Moreover, since the primary goal of all of these measures is to support the resilience of food systems and improve food and nutrition security, they are crucial to meeting the challenges to nutrition posed by climate change and growing demand for biofuel.

Chapter 2
Introduction

Brian Thompson and Marc J. Cohen

Purpose

Despite a dozen years of solemn pledges by global leaders to take action to drastically decrease world hunger – promises made at the World Food Summit in 1996, the Millennium Summit of 2000 and high-level follow-up meetings held since then – global food security has been *deteriorating* since 1995. This has contributed to the unacceptably slow pace of reducing hunger and undernourishment and of cutting the prevalence of malnutrition. Between 1990 and 2005, the prevalence of underweight children under 5 years of age in the developing world only fell from 30% to 23%. In 34 countries in 2009, progress in reducing child underweight was very slow, and 20 countries had made no progress at all. With an estimated increase of 105 million undernourished people in 2009 alone, the Food and Agriculture Organization of the United Nations (FAO) estimates that approximately 925 million individuals went hungry in 2010 (FAO 2010d). For many developing countries, meeting the Millennium Development Goal (MDG) of halving prevalence of underweight (target 1.8) and undernourishment[1] (target 1.9) between 1990 and 2015 will not be possible. Against this disappointing background, three major challenges have arisen that further threaten efforts to overcome food insecurity and malnutrition: climate change, the growing use of food crops as a source of fuel (bioenergy) and volatile food prices.

[1] See Box 3.1 for definitions.

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As a result of climate change, agricultural production and the availability of and access to food are likely to decline drastically in Sub-Saharan Africa and South Asia. This will increase the risk of hunger and malnutrition in the two regions that are home to three of every five undernourished people. Projected increases in the frequency and intensity of droughts and floods and their potential impact on crops and livestock are especially worrisome. Furthermore, climate change is expected to increase undernutrition through its effects on illness, such as diarrhoea and other infectious diseases (see Box 4.1). For example, while drier weather may reduce the transmission of malaria in some places in Sub-Saharan Africa, in other regions, the geographical range will expand and the transmission season may change (Metz et al. 2007).

For its part, rising bioenergy demand is likely to affect nutrition through a number of pathways. First, production of staple food crops, particularly maize, for biofuel markets can have a negative impact on the availability of grain for direct human consumption and for use as livestock feed. Second, as demand for biofuels is likely to remain high and be met with food crops for the foreseeable future, the clearing of biodiversity-rich land for cultivation (e.g. tropical forests and wetlands) may result. Not only will clearing of land destroy precious natural resources, it will also reduce food production yields. Third, burning of forests will increase emissions of the greenhouse gases (GHGs) that cause global warming. Although there are no direct nutrition implications from increased GHG emissions, the impact they have on global warming is inextricably related to desertification and other weather-based threats to food and nutrition security. Fourth, intensified production of energy crops such as sugarcane, as well as increased cereal production to meet competing demand for food, feed, fibre and fuel, may mean excessive or poorly managed use of water and farm chemicals, causing illnesses and deterioration in environmental health, with negative implications for nutrition.

In addition, increased demand for bioenergy is a significant driver of the dramatic increases in food prices seen over recent years. According to an analysis by the International Food Policy Research Institute (IFPRI), between 2000 and 2007 bioenergy demand accounted for 30% of the escalation in global cereal prices and for nearly 40% of the increase in the real global price of maize (Rosegrant 2008). Increased food prices are likely to result in calorie deficits, but even more importantly, they will probably cause micronutrient malnutrition, as low-income people may reduce their consumption of micronutrient-rich foods (such as animal products, legumes and fruit and vegetables) in an effort to maintain consumption of increasingly expensive staples. Leading experts have suggested that biofuel production has a serious negative effect on the realisation of the right to food because it exerts upward pressure on food prices and negatively affects access to food for low-income consumers (Ferrett 2007; Eide 2008). One, Jean Ziegler, the former Special Rapporteur on the Right to Food of the UN Human Rights Council, has gone so far as to call the growing use of food crops to produce biofuels “a crime against humanity” (Ferrett 2007).

Nevertheless, strong bioenergy demand also offers opportunities to smallholder farmers. If the right policies are in place, they may be able to boost their incomes and take advantage of technological spillovers to improve food crop production

alongside their energy crops. This has positive implications for both food availability and access, key inputs for good nutrition.

A human-rights-based approach – a conceptual framework that is normatively based on international human rights standards and operationally directed to promoting and protecting human rights – can provide the tools for balancing many factors, reaching easier consensus and conducting a more effective and complete analysis, as well as a more authoritative basis for advocacy and for claims on resources. The human-rights framework also offers the opportunity of embracing environmental concerns more explicitly and is thus highly relevant to assessing the challenges of climate change and bioenergy for nutrition.

To explore these issues in greater depth, the Food and Agriculture Organization of the United Nations (FAO) organized a special event on Climate Change and Bioenergy: Implications for Nutrition, Food Safety and Human Health during the High-Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy, in 2008. This book is based on the series of background documents that were prepared for this side event, as well as related post-2008 research findings. It was jointly written by teams from FAO and the International Food Policy Research Institute (IFPRI). The book examines the consequences of climate change and rising bioenergy demand for sustainable development, food security and nutrition throughout the lifecycle.

Concept and Content

Chapter 3 provides an in-depth review of recent and projected trends in global food insecurity and malnutrition. It explores causes and consequences. In addition to a detailed review of the health costs of malnutrition (e.g. compromised physical growth, reduced cognitive function, increased vulnerability to infectious disease), the chapter includes discussion of the economic costs of malnutrition. The chapter concludes with a review of factors that are likely to contribute to malnutrition in the future. These challenges are related to climate change and increased demand for biofuel, and include, *inter alia*, structural shifts in food and agricultural systems, transboundary movement of disease and widespread land degradation.

Chapter 4 provides an overview of current and projected effects of climate change. It looks at how climate change is impacting specific environments and populations, and includes analysis of the links between climate change, food security and nutrition. The chapter examines the impact of climate change on each dimension of food security (availability, stability of supply, access, and utilization) as well as malnutrition. This discussion includes sections on food safety, health and sanitation and a number of other food security related subjects. The chapter concludes with a discussion of adaptation and mitigation strategies for the agriculture, livestock and forestry sectors.

Chapter 5 examines the direct nutrition effects of rising bioenergy demand, as well as its contribution to rising food prices. It cites the environmental implications

of biofuel production and models the effects of price increases and increased demand for biofuel on regional calorie availabilities. Chapter 5 also discusses potential strategies for cultivation of bioenergy crops that can contribute to poverty reduction, food security and sustainable natural resource management.

Chapter 6 discusses policies and programmes and provides a number of specific examples for improving food and nutrition security at the international, regional and country level. This chapter also reviews policy options for responding to threats to nutrition from climate change and growing demand for biofuel.

The final chapter is divided into three sections: “Responding to Climate Change”, “Assuring Pro-poor and Sustainable Biofuel Development” and “Making Nutrition a Development Priority”. Each section includes specific recommendations guided by a pro-poor, rights-based, MDG-focused normative framework.

Chapter 3
World Food Insecurity and Malnutrition: Scope, Trends, Causes and Consequences

Brian Thompson, Marc J. Cohen and Janice Meerman

Abstract This chapter provides an in-depth review of recent and projected trends in global food insecurity and malnutrition. It explores causes and consequences. In addition to a detailed review of the health costs of malnutrition (e.g. compromised physical growth, reduced cognitive function, increased vulnerability to infectious disease), the chapter includes discussion of the economic costs of malnutrition. The chapter concludes with a review of factors that are likely to contribute to malnutrition in the future. These challenges are related to climate change and increased demand for biofuel, and include, *inter alia*, structural shifts in food and agricultural systems, transboundary movement of disease and widespread land degradation.

Keywords Food and nutrition security • HIV/AIDS • Iron deficiency • Lifecycle approach • Low birthweight • Micronutrient deficiency • Millenium Development Goals • Nutrition sensitive agriculture • Poverty • Population growth • Underweight • Stunting • Vitamin A deficiency • Wasting • Zinc

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Dimensions of the Nutrition Problem

Apart from considerations of the impact of current and future climate change and bioenergy demand, the world food and nutrition security situation and outlook are worrisome. Food insecurity and malnutrition represent serious impediments to sustainable development, poverty reduction, equity and achievement of the Millennium Development Goals (MDGs).

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). It has four dimensions (see Box 3.1): food availability, stability of supply, access to adequate quantities and varieties of safe, good quality food and utilization by the body. Stability of supply

Box 3.1 Key Definitions and Use of Terminology

- **Food security** exists when all people, at all times, have physical, social and economic access to sufficient, safe food that meets their dietary needs and food preferences for an active and healthy life. Household food security is the application of this concept to the family level, with individuals within households as the focus of concern. There are four dimensions of food security: availability, stability of supply, access and utilization.
- **Food insecurity** exists when people do not have adequate physical, social or economic access to food as defined above.
- **Nutrition security** exists when food security is combined with a sanitary environment, adequate health services and proper care and feeding practices to ensure a healthy life for all household members. In addition to proper hygiene, health and care, nutrition security also requires consumption of a diet that is adequately diversified in terms of macro and micronutrients.
- **Food and nutrition security** is a term used to emphasize the importance of nutrition considerations in discussions of food security. Food security is an essential input to nutrition security, but is insufficient in and of itself to guarantee improved nutrition outcomes. Programmes focused on increasing food production and raising incomes will not reduce the burden of malnutrition as effectively as those which recognize the importance of diet quality and diversity as well as the other components essential to nutrition security. In addition to increasing yields and purchasing power, programmes focused on food *and* nutrition security include interventions aimed directly at improving individual nutrition outcomes. Depending on the scope and size of the programme, these interventions could include strategies to increase home production of micronutrient rich foods,

(continued)

Box 3.1 (continued)

strategies to improve complimentary feeding practices for infants, growth monitoring and assessment of household level dietary diversity. Regardless of scale and design, food and nutrition security programmes always target the most vulnerable, focus on women's empowerment and aim to improve equitable intrahousehold resource allocation. This book refers to food *and* nutrition security throughout, as the role of nutrition security in reducing the burden of malnutrition is unequivocal.

- **Undernourishment** refers to food intake that is insufficient to meet dietary energy requirements. Undernourishment occurs among the portion of the population where energy intake is below the minimum amount necessary to achieve a minimum acceptable weight for attained height and that which is required to sustain light activity. Undernourishment calculations are based on three key parameters at national level: the average per capita dietary energy supplies available for consumption as derived from FAO's Food Balance Sheets, the minimum number of calories required for an average person and an estimation of the level of inequality in access to that food as calculated by income inequality. Undernourishment levels within a country may vary from year to year, depending on food availability, the gender and age structure of the population and changes in income distribution. Undernourishment is often considered synonymous with "hunger".
- **Undernutrition** exists when insufficient food intake and repeated infections result in one or more of the following: underweight for age, short for age (stunted), thin for height (wasted), and functionally deficient in vitamins and/or minerals (micronutrient malnutrition).
- **Malnutrition** is a broad term that refers to all forms of poor nutrition. Malnutrition is caused by a complex array of factors including dietary inadequacy (deficiencies, excesses or imbalances in energy, protein and micronutrients), infections and socio-cultural factors. Malnutrition includes undernutrition as well as overweight and obesity.

depends on food production, incomes, markets and transfer programmes (both public and private) and can be adversely affected by shocks due to weather, price fluctuations, human-induced disasters and political and economic factors. Utilization refers to the proper use of food and includes the existence of appropriate food processing and storage practices, adequate knowledge and application of nutrition and child care and adequate health and sanitation services (FAO 2000; FANTA 2006). Food security is a key factor in good nutrition, together with health, sanitation and care practices (Fig. 3.1).

With regard to food availability, present global food supplies are more than adequate to provide everyone with all the *calories* needed for an active and healthy life, if the food were equally distributed. As Fig. 3.2 indicates, *per capita* daily

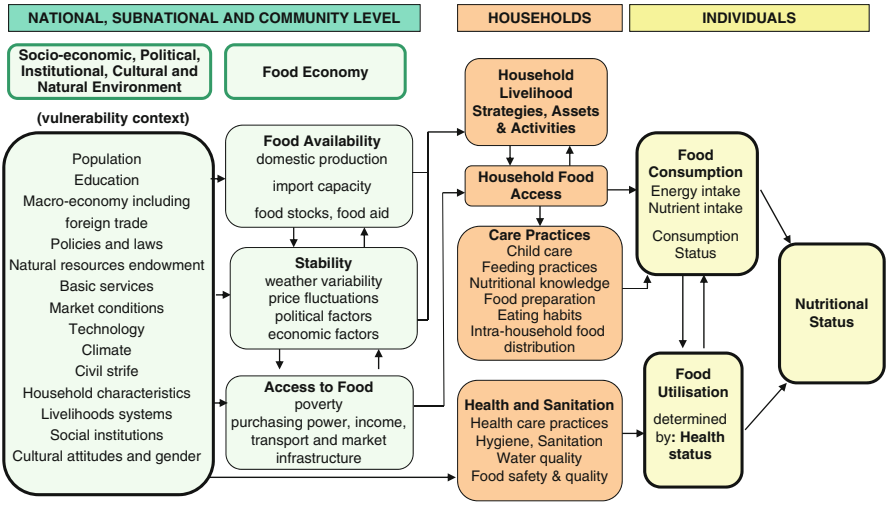

Fig. 3.1 FAO/FIVIMS nutrition framework: linkages between the overall development context, the food economy, households and individual measures of wellbeing (Source: FAO 2008e)

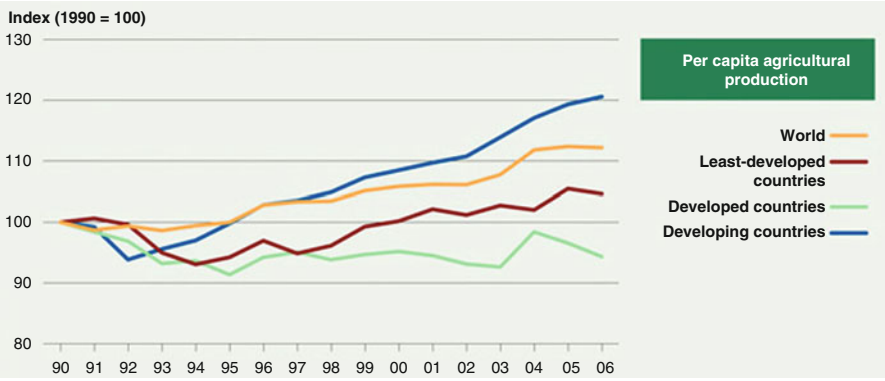

Fig. 3.2 Agricultural production indices: total and per capita (Source: FAO 2007)

calorie availability currently exceeds 2,100 (the average energy requirement for adults undertaking light activity) in all global regions, though barely so in Sub-Saharan Africa. However, this abundance of food is *not,* in fact, equally distributed, so hundreds of millions of people in developing countries actually consume less than their minimum requirements. According to the latest data, 925 million people are undernourished, i.e., their diets are calorie-deficient. The highest prevalence is in Sub-Saharan Africa, where one in every three persons experiences chronic hunger. The greatest absolute number of undernourished people is in Asia and the Pacific (578 million), followed by sub-Saharan Africa (239 million). In Latin America and the Caribbean 53 million individuals are hungry; in the Near East and North Africa the number is currently 37 million (FAO 2010d) (Fig. 3.3).

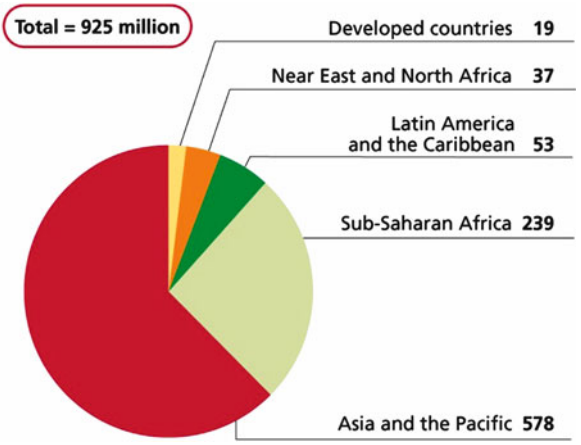

Fig. 3.3 Undernourishment in 2010 (millions) (Source: FAO 2010d)

These statistics can be viewed as an infringement on the human right to adequate food, which implies availability and accessibility of food in sufficient quantity for all (UNCESCR 1999).

Ironically, half of all food-insecure people are small farmers. Even though they grow food, they lack the resources to meet all of their needs through either production or purchase. Another 30% of hungry people are fishers, herders or landless rural people and the remainder are poor urban dwellers (UN Millennium Project 2005).

Hidden Hunger

Even if a person consumes enough calories, this does not guarantee adequate intake of essential micronutrients – vitamins, minerals and trace elements. Micronutrient malnutrition – often called "hidden hunger" because often only the most severe deficiencies are clinically visible – afflicts a far greater proportion of humanity than insufficient calorie intake. Moreover, insufficient calorie consumption often goes hand-in-hand with micronutrient malnutrition (FAO 2004).

Micronutrient deficiencies can have grave public health consequences. Iron deficiency is the most common micronutrient deficiency in the world. Roughly one in four people globally consumes a diet deficient in iron; most of the affected people are children of preschool age and women (Thompson 2011; UNICEF 2009; Trowbridge and Martorell 2002). Iron deficiency is responsible for roughly half of the global prevalence of anaemia. Anaemia among adults compromises work performance. Furthermore, iron deficiency can reduce work performance even if it does not result in anaemia (ACC/SCN and IFPRI 2000). In adults, iron deficiency has been estimated to decrease national labour productivity by up to 17% (Horton 1999).

Anaemia affects at least 500 million women worldwide (SCN 2010a), including approximately 56% of pregnant women in developing countries and over three-quarters of pregnant women in South and Southeast Asia. Anaemic mothers are more

likely to deliver prematurely, to deliver babies with low birthweights and to have babies who die as newborns. Around 115,000 women die in childbirth each year as a result of iron deficiency anaemia, accounting for 20% of global maternal mortality (ACC/SCN and IFPRI 2000; Black et al. 2008). Anaemia also affects approximately 63% of preschool children in South and Southeast Asia, and 39% of all developing-country preschoolers (ACC/SCN and IFPRI 2000; HarvestPlus 2007). Anaemia among children can impair health and development, limit learning capacity and weaken immune systems. The highest proportions of preschool-age children suffering from anaemia are in Africa, where prevalence is over 60% (SCN 2010a).

Iodine deficiency is also a problem in many developing countries and some developed countries. Lack of adequate iodine in maternal diets can lead to spontaneous abortion and stillbirths. Iodine deficiency in pregnancy results in the mental impairment of almost 18 million babies each year. Even mild to moderate iodine deficiency can lower IQs by 10–15 points (World Bank 2006). When deficiency *in utero* is severe, infants may be born with cretinism, a serious and irreversible form of mental retardation (WHO 2006).

Vitamin A deficiency remains a public health challenge across Africa and Asia and in some countries of Latin America. An estimated 30% (163 million) of preschool-age children are vitamin A deficient worldwide (SCN 2010a). The number jumps to over 40% in Africa and some parts of Asia (UNICEF 2009; SCN 2010a). Insufficient vitamin A intake in children impairs the immune system, increases susceptibility to infections and can impair night vision, sometimes to the point of blindness. Vitamin A deficiency (VAD) is also associated with maternal mortality. Approximately 15% of pregnant women (19 million women) have VAD (WHO 2009). These women face increased risk of mortality and mother-to-child HIV transmission, as well as impaired night vision and blindness (WHO 2001). The prevalence of VAD declined in all developing regions during the 1990s, but at extremely slow rates and has remained unchanged in Sub-Saharan Africa since the mid-1990s (MI and UNICEF 2005).

Inadequate dietary zinc can lead to stunting (low height for age) and greater susceptibility to infections. Over 60% of the developing world is thought to be at risk of low zinc intake; the figure is 70% in Southeast Asia and 95% in South Asia (de Benoist et al. 2007).

The Deadly Scourge of Child Malnutrition

Malnutrition takes a particularly severe toll among preschool children. One in three developing-country preschoolers – 171 million children under the age of five – suffers stunting as a result of chronic undernutrition (WHO 2007; Black et al. 2008). Per Box 3.2, 80% of these children live in just 24 countries, the vast majority of which are in Africa and the Asia (Bryce et al. 2008). In India, approximately 61 million preschoolers (48% of the children under the age of five) are stunted. Both the number and the prevalence of under-five stunting in India exceed the figures for all of Africa (57 million and 40%) (Black et al. 2008; UNICEF 2009).

Box 3.2 Twenty-Four Countries are Home to 80% of the World's Stunted Preschoolers

Africa	Asia-Pacific
Democratic Republic of Congo	Afghanistan
Egypt	Bangladesh
Ethiopia	China
Kenya	India
Madagascar	Indonesia
Niger	Myanmar
Nigeria	Mozambique
South Africa	Nepal
Sudan	Pakistan
Tanzania	Philippines
Uganda	Viet Nam
Mexico	Yemen

Source: Bryce et al. (2008)

Stunting is associated with higher rates of illness and death, reduced cognitive ability and school performance in children and lower productivity and lifetime earnings for adults. Indeed, height-for-age among 2-year-olds is the best predictor of adult human and physical capital. Chronic malnutrition during the first 2 years of life usually results in irreversible harm. Children become stunted not only as a result of insufficient calorie intakes, but also because of poor quality diets that limit their linear growth. Some suggest that children who become stunted in the first 2 years of life and gain weight rapidly after that may be at high risk of nutrition-related chronic diseases, such as obesity, diabetes and hypertension in later life (Hoddinott et al. 2008; Victora et al. 2008; World Bank 2006). Up to 4% in lost productivity and earnings has been attributed to moderate stunting, while up to 10% in lost productivity and earnings has been attributed to severe stunting. These figures are especially pertinent in terms of *future* development goals. Decelerated economic growth and compromised human capital accompany each cohort of children whose development is stunted (FAO 2004).

According to the latest available data, 13% of children under 5 years old in the developing world are wasted (two standard deviations below the World Health Organization, or WHO, child growth standards), and 5% are severely wasted (three or more standard deviations below the WHO growth standards); an estimated 26 million children in total (UNICEF 2009).

Each year, over 19 million babies are born in developing countries with low birthweights (less than 2.5 kg), accounting for 16% of the developing world's annual births. In South and Central Asia, the figure is 18%. These children face four times the risk of neonatal death than those with normal birthweights and they have much higher rates of stunting (Black et al. 2008; FAO 2004; UNICEF 2009).

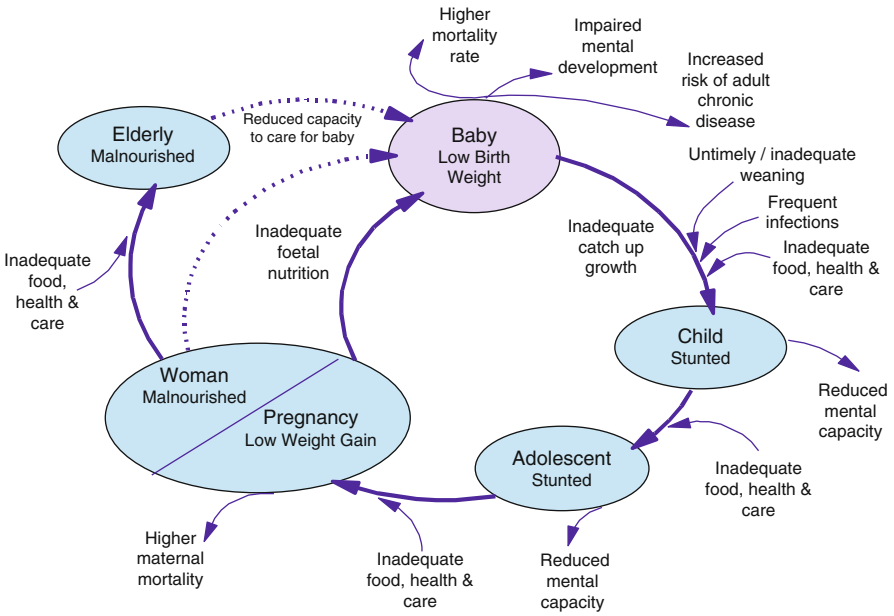

Fig. 3.4 Nutrition throughout the lifecycle (Source: ACC/SCN and IFPRI (2000))

Nutrition Throughout the Lifecycle

As Fig. 3.4 indicates, at each stage in the lifecycle, malnutrition has consequences for each successive stage and/or the next generation, particularly among low-income households in developing countries. Mothers who suffer chronic caloric and/or micronutrient deficiencies are more likely to have low birthweight babies: in effect, they pass their malnutrition on to the next generation (Black et al. 2008; World Bank 2006; FAO 2004). These mothers also face increased risk of death in childbirth. Low birthweight babies face higher mortality rates and impaired mental and physical development. If these conditions are combined with poor care and feeding practices, inadequate food and health and, as a result, frequent infections, the child will either die prematurely or face high risk of reduced mental and physical capacity. Stunted children living with inadequate food, health and care remain stunted as adolescents and face reduced physical capacity. The girls among them, with continued inadequate food, health and care, grow up too often as another generation of malnourished mothers who have low birthweight babies of their own. Adults affected by chronic energy malnutrition have a low body mass index which may be masked if there is presence of nutritional oedema (retention of fluid). If malnourished adults continue to have inadequate food, health and care into old age, they remain malnourished, are more susceptible to infection and less able to assist in caring for children (Victora et al. 2008; SCN 2004).

HIV/AIDS and Nutrition

HIV/AIDS affects approximately 33 million people – 67% of whom are in Sub-Saharan Africa. Outside of Africa, infections are on the rise in a number of countries. The overall number of people living with HIV has increased due to increased incidence of infection and reduced mortality from antiretroviral therapy (UNAIDS 2008).

HIV interacts negatively with malnutrition. Poor nutrition and food insecurity can accelerate the spread of HIV, both by increasing people's exposure to the virus and by increasing the risk of infection following exposure. In turn, HIV infection can lead to nutritional deficiencies through decreased food intake and malabsorption, which hasten the onset of AIDS. Malabsorption occurs because HIV impairs the immune system and compromises the body's ability to absorb and metabolize nutrients. Malabsorbtion leads to additional infections, such as tuberculosis and malaria that subsequently worsen nutritional status, creating a vicious synergism of malnutrition and infection which is, in the case of AIDS, typically fatal (Gillespie and Kadiyala 2005) (See Box 4.1 in Chap. 4 for a detailed explanation of the interaction between nutrition and infection).

Water, Sanitation and Nutrition

Efforts to achieve the MDG hunger target aim principally at increasing food and therefore caloric intakes by the hungry. But maintaining energy balance depends on caloric use as well as on caloric intake. For many impoverished people significant calories are expended in the hard labour required for farming and especially for women, for collecting water, fire wood and fodder over great distances. Due to frequent infection and illness, what food is consumed may not be fully utilized as their bodies are unable to absorb food properly due to diarrhoeal disease. Populations suffering from hunger are often the same as those that lack adequate water and sanitation. Globally, one billion people are currently without access to safe water and over two billion lack adequate sanitation facilities.[1] Roberto Lenton, former director of the UN Development Programme's (UNDP) Sustainable Energy and Environment Division has commented, "We need to develop strategies ensuring that policies that target caloric intake are accompanied by strategies to reduce caloric losses through better water, sanitation and hygiene" (Rahman 2008, Policy Division, International Fund for Agricultural Development, Personal communication, 9 May). Improving food safety is essential to the success of these strategies. See Chap. 4's discussion of climate change and food safety for more on this topic.

[1] See http://www.wssinfo.org/en/welcome.html, website of the World Health Organization/UN Children's Fund Joint Monitoring Programme for Water Supply and Sanitation.

The Double Burden of Malnutrition

Malnutrition takes many forms. Globally, more than a billion adults are overweight, of whom some 300 million are clinically obese. In Latin America, over 30% of the children aged 5–17 years are overweight, with nearly 8% obese. In Asia, the figures are more than 10% and 3%, respectively (WHO 2010). Obesity greatly increases the risk of contracting nutrition-related chronic diseases, such as heart disease, stroke, cancer and diabetes. Undernutrition and overweight increasingly co-exist in communities, and even in the same households, including many poor households, in both developed and developing countries; this has been called the "double burden" of malnutrition (SCN 2004, 2006; Doak et al. 2006). In Mexico, overweight and obesity nearly doubled among low-income people between 1988 and 1998, and the prevalence is now 60%. Yet, almost half the low-income preschoolers remain stunted (Hawkes and Ruel 2006a). The main causes of overweight and obesity are increased consumption of energy-dense foods and reduced physical activity (SCN 2004, 2006). Increases in both the supply of, and demand for these foods are associated with globalization and increased urbanization (Hawkes and Ruel 2006a).

Hunger Crises

For 2011, the United Nations appealed for food and other humanitarian assistance for 50 million people in 28 countries affected by conflict and its aftermath or serious political and economic breakdown (OCHA 2010a). Refugees and internally displaced people are particularly susceptible to malnutrition because they frequently depend on food aid rations that are often inadequate in both quantity and quality. An analysis of 41 mortality and malnutrition surveys carried out in refugee camps in 2005 found that half indicated an acute malnutrition emergency and among these emergency situations, and 90% featured a "critical" prevalence of global acute malnutrition, in excess of 15% (CE-DAT 2006). According to the Office of the UN High Commissioner for Refugees, micronutrient deficiencies are widespread in camps due to unbalanced rations. For example, lack of B vitamins is a serious problem in camps in Nepal and Bangladesh (UNHCR 2005). Nevertheless, aid donors routinely fail to provide all of the resources called for in UN humanitarian aid appeals (Fig. 3.5). According to the UN Office for the Coordination of Humanitarian Affairs, donor response fell far short of the amounts requested in every year between 2000 and 2009. For example, in 2009, the international community provided just 71% of the amount sought for all sectors in the consolidated appeal, ($6.9 billion out of the $9.7 requested; Fig. 3.5). Although the food aid response reached 92%, neither water and sanitation nor health appeals (both nutrition-related) garnered even 50% of the requested funds (OCHA 2010b).

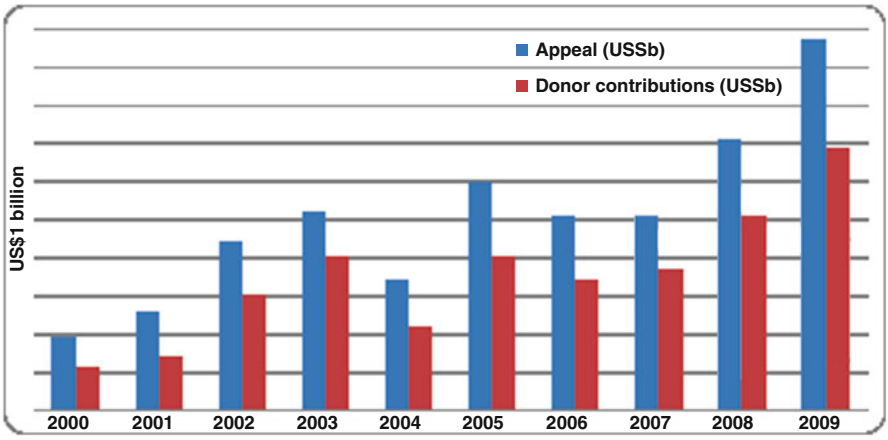

Fig. 3.5 UN humanitarian appeals and donor response (US$ billion) (Source: UN Office for the Coordination of Humanitarian Affairs, Financial Tracking Service (2010b))

Unacceptably Slow Progress in Reducing Hunger and Malnutrition

The UN Millennium Project has adopted two country-level indicators to measure progress toward the MDG 1 target of halving, between 1990 and 2015, the proportion of people who suffer from hunger. The first indicator for this target (1.C, 1.8) is prevalence of underweight[2] among children under 5 years of age, the second (1.C, 1.9) is the proportion of the population below minimum level of dietary energy consumption.[3] The World Food Summit goal is to reduce, between 1990–1992 and 2015, the total number of undernourished people in the world by 50%. This section discusses what headway has been made for both the MDG target and the World Food Summit goal.

Over the last 20 years, 22 countries have made encouraging progress on undernourishment, and are likely to meet or exceed the undernourishment reduction requirement for MDG 1 by 2015. Most of these countries are in East Asia and Latin America. For instance, undernourishment decreased among tens of millions of people in China during 1990–2003, while Southeast Asia and South America also recorded substantial progress during that period. In Africa some countries have made progress, with Namibia, Mozambique, Ghana and Nigeria all likely to achieve the hunger target in terms of undernourishment. However, large increases in the undernourished populations of South Asia outside India, Eastern Africa and the Near East, plus a doubling of the ranks of the hungry in Central Africa (driven in large part by war and political chaos in the Democratic Republic of the Congo) offset these gains (Fig. 3.6).

[2]Underweight: Weight-for-age of two or more standard deviations below the median of the WHO child growth standards.

[3]Also referred to as "undernourishment". See Box 3.1 for a detailed definition.

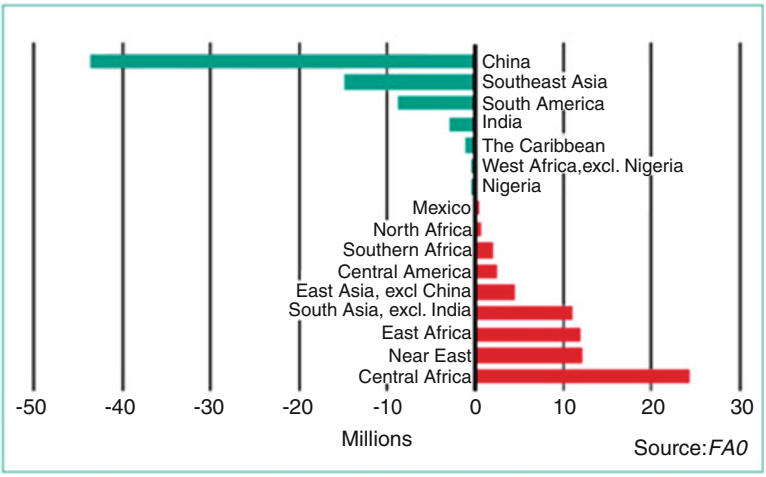

Fig. 3.6 Changes in number of undernourished in subregions from 1990 to 2003 (Source: FAO 2004)

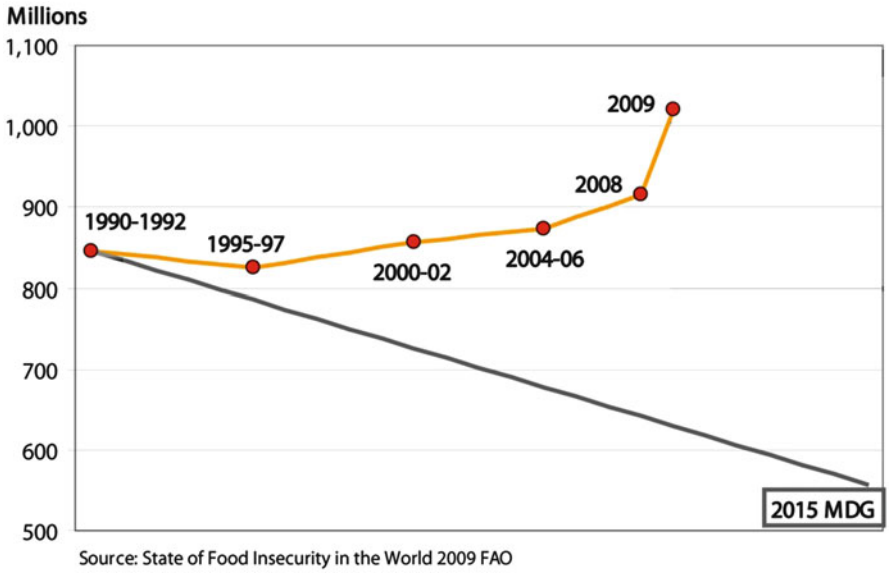

Fig. 3.7 Number of undernourished people in the developing world, 1990–2009 (Source: FAO 2009a)

Globally, progress towards the MDG 1 undernourishment indicator has faltered. Absolute numbers for undernourishment have been increasing for over a decade, most precipitously between 2008 and 2009, due to food price volatility and the global economic recession (Fig. 3.7). Progress towards the World Food Summit goal has slowed as well.

In terms of underweight, 63 countries (out of 117 with available data) were on track as of 2010 to meet the MDG 1 target. However, in 34 countries, progress is currently insufficient, and 20 have made no progress at all. Progress towards the reduction of underweight prevalence has been especially limited in Africa; most of the 20 countries that have made no progress are sub-Saharan. African prevalence rates decreased on average by only 3% points between 1990 and 2008 (from 28% to 25%). And although progress has been slightly better in Asia, with 37% underweight prevalence around 1990 and 31% around 2008, underweight rates in South Asia continue to exceed those for Africa. This phenomenon is known as the "South Asian enigma," because on most indicators of human well-being (access to safe water, school enrolment, food availability per person, income per person, degree of democratic governance), people in South Asia are better-off than those in Africa. But the female-to-male life expectancy ratio – a measure of women's social status relative to that of men – is higher in Africa than in South Asia (Smith and Haddad 2000).

Causations and Linkages: Conceptual and Analytical Frameworks

As illustrated by the "South Asian enigma" described above, an understanding of the socio-economic causes and consequences of malnutrition is essential for formulating appropriate policies to improve nutrition. It is imperative that strategies be tailored to local conditions. For example, low food production caused by insufficient agricultural productivity is a primary reason for hunger in tropical Africa and remote parts of Asia and Latin America; limited markets and poor infrastructure may also limit access to food in these areas. In contrast, income poverty may be the primary reason for hunger in South and East Asia, Latin America, Central Asia and the Middle East. That is, in some contexts, lack of access to food is the primary cause of malnutrition; in other scenarios, there is plenty of food available, but prices prove prohibitive for many consumers.

In addition to access to and affordability of food, disease is often a key factor in malnutrition. Inadequate food consumption increases vulnerability to infectious disease. In turn, infection – particularly malaria, measles, persistent diarrhoea and pneumonia – prevent the body from absorbing adequate food and nutrients (WHO 1997; see Box 4.1, Chap. 4). This vicious circle occurs at the individual level, but stems from a complex set of underlying *household level causes:* insufficient access to food – one aspect of food insecurity – poor maternal and child caring practices, and inadequate access to clean drinking water, safe sanitation and health services. Ultimately, these factors are themselves embedded in the larger political, economic, social and cultural environment in which households find themselves.

Food insecurity, ill health and sub-optimal caring practices are all closely related to poverty. The one billion people who live in extreme poverty – on the equivalent of less than US$1 per day – generally also consume fewer than 2,100 calories per day. The world's 163 million ultra poor people whose incomes are less than half that level, on average consume less than 1,600 calories a day (Ahmed et al. 2007).

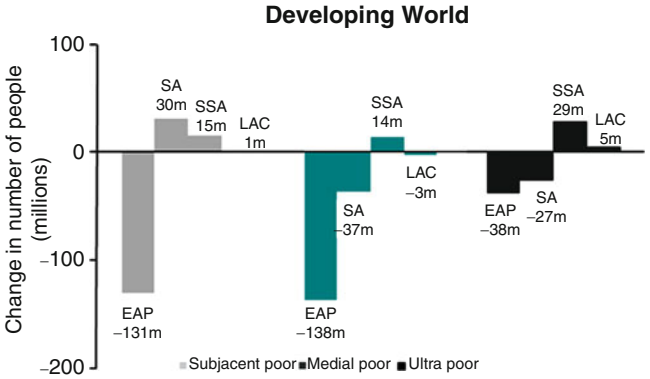

Fig. 3.8 Regional poverty trends, 1990–2004
(Note: *EAP* East Asia & the Pacific, *SA* South Asia, *SSA* Sub-Saharan Africa, *LAC* Latin America & the Caribbean, *Subjacent poor* those living on between $0.75 and $1 a day, *Medial poor* those living on between $0.50 and $0.75 a day, *Ultra poor* those living on less than $0.50 a day. Source: Ahmed et al. (2007))

Moreover, in all regions of the developing world, lower-income households experience significantly higher rates of preschooler stunting than better-off families (Van de Poel et al. 2008). Poverty assessments in Bangladesh, Viet Nam and Guatemala similarly indicate a higher incidence of illness in poor households than among better-off families (Ahmed et al. 2007). With regard to caring practices, even when exclusive breastfeeding for the first 6 months of life is widely practiced, poor households often engage in sub-optimal complementary feeding practices once children reach 6 months of age. Poor families cannot afford to purchase animal source foods that are rich in protein, fat and bioavailable micronutrients (Black et al. 2008).

A high percentage of the world's extremely poor people live in South Asia. However, ultra poverty is heavily concentrated in Sub-Saharan Africa. While South Asia made progress against the deepest poverty during the 1990s and the first years of the 2000s, both extreme poverty and ultra poverty increased in Sub-Saharan Africa (Fig. 3.8) (Ahmed et al. 2007).

Discrimination, geography and environmental factors also play a role in poverty, food insecurity and malnutrition. In both South Asia and Latin America, indigenous people, members of ethnic minority groups and socially excluded people, such as members of "secluded" and "backward" castes in India, are over-represented among poor people and especially among ultra poor people. In Guatemala, the proportion of indigenous preschoolers who are stunted is more than double the rate for non-indigenous children. Gender discrimination also influences malnutrition: in South Asia, in relation to the "South Asian enigma" cited above, there is evidence that women consume less food and have lower quality diets than men, mainly as a result of food distribution within households (Ahmed et al. 2007).

Poverty rates tend to be higher in more remote areas with difficult access to roads, markets, communications infrastructure, schools and health services (Ahmed et al. 2007). Such areas are often "less-favoured" in terms of their natural resource endowments as well as in socio-economic and political terms (Pender and Hazell 2000).

In an effort to increase accountability among policy-makers and politicians, FAO and other UN agencies have developed a rights-based approach to food and nutrition security. This perspective presents the achievement of food security and good nutrition as integral to the state's efforts to protect and promote internationally recognized human rights, including the right to life, the right to adequate food, the fundamental right of everyone to be free from hunger and the right to the highest attainable standard of health. This model provides the framework for a more effective and proactive treatment of the underlying causes of hunger and malnutrition. For example, it requires UN member states to assess and provide progress reports regarding existing policies, laws and institutions focused on economic, social and cultural rights.

Costs of Malnutrition

Taken together, stunting, severe wasting, low birthweights due to intrauterine growth retardation, sub-optimal breastfeeding (non-exclusive in the first 6 months and discontinued before 1–2 years) and deficiencies of vitamin A, zinc and iron lead to the deaths of 3.6 million children under 5 years of age each year (Black et al. 2008). Moreover, these forms of malnutrition together account for 35% of all preschooler deaths and 11% of the global burden of disease[4] (Black et al. 2008). Thus, malnutrition is a calamity that deprives humanity of countless millions who die prematurely or grow up without reaching their full potential.

Moreover, malnutrition places a heavy burden on the economies of developing countries. Difficult pregnancies and the illnesses that malnourished mothers and their children experience cost an estimated $30 billion annually. Lost productivity and income due to early deaths, poor school performance, disability and absenteeism likely raise the yearly total into the hundreds of billions of dollars (Victora et al. 2008; Behrman et al. 2006; FAO 2004). Lost income due to iron deficiency alone reduces gross domestic product by as much as 8% in Bangladesh and a still significant 2% in Honduras (SCN 2004). Not only is malnutrition a significant drain on economic growth, but it also reflects and contributes to inequity, as it disproportionately affects poor, marginalized and extremely vulnerable groups. While the policies and programmes needed to address malnutrition will require substantial resources, it is essential to recognize that the costs of *not* tackling malnutrition are considerable.

Future Challenges, Major Issues and Risks

Chapters 4 and 5 examine the effects of climate change and rising bioenergy demand on nutrition. However, some additional factors will constrain efforts to reduce malnutrition in the coming years:

[4]Where the global burden of disease is defined as the total gap between current global health status and an ideal situation where everyone lives into old age in full health.

- demographic forces and rapid urbanization;
- structural shifts in the food and agricultural system;
- transboundary movement of disease; and
- environmental and energy concerns.

Demographic Forces and Rapid Urbanization

According to UN population data, between 2009 and 2050, world population will increase by 34%, from 6.8 billion to 9.1 billion people, with the net increase equivalent to the 2009 population of China and India combined. Africa will have the highest rate of population growth of any region during this period, 1.7% per year (UN Population Division 2009).

Population growth alone will increase demand for food, requiring a 50% increase in production. In addition, anticipated economic growth of 6% per year in developing countries during the next few years will lead to additional increases in demand, as will rapid urbanization (Von Braun 2007a).

Virtually all global population growth between 2010 and 2050 will occur in the cities of the developing world. Indeed, the net increase in urban population during that period will exceed net growth in overall population, as cities will also absorb migrants from rural areas. The world's urban population will increase by 80% during this period, rising from 3.5 billion to 6.3 billion people. By 2025, a majority of the developing world's populace will live in cities and towns (UN Population Division 2008, 2010). These trends have implications for food demand and nutrition. People in cities and towns have fewer opportunities than rural people to produce their own food and so must rely on purchases and the cash economy to eat. A sharp increase in food prices will have a large impact on people who rely almost entirely on cash income. Higher food prices will impact the urban poor in particular, who spend a significant proportion of their incomes on food (IFPRI 2002).

Low income urban dwellers, especially women, typically face high opportunity costs on their time, and hence spend less of it purchasing and preparing food compared to their rural counterparts. As a result, city dwellers often shift consumption from staple foods that require significant time and energy to prepare (e.g. sorghum, millet, maize and root crops) to less labour-intensive and more nutritious staples like rice and wheat. Urbanites also often have greater intake of meat, milk, fruit, vegetables and processed foods than rural populations (Garrett and Ruel 2000). Street foods in particular contribute significantly to daily energy and nutrient intakes. In Nigeria, for example, city dwellers spend as much as half their food budgets on street foods. In one study conducted in Bamako, Mali, street foods provided 134–417 calories per person per day (Ag Bendech et al. 2000).

Street foods provide cheap sources of often nutritious food. These products are also a good source of income for informal food sector workers, most of whom are women and more likely than men to invest earned income in the wellbeing of their

children. Moreover, as the cost of food and cooking fuel increases, consumption of street foods increases concomitantly, as prices in this informal sector rise slower relative to formal sector prices, due to economies of scale in production. In other words, households tend to prepare even less foods at home and eat out more since street food vendors are able to buy ingredients and fuel at cheaper prices than households normally would be able to do from the market (IFPRI 2002).

Lack of infrastructure (i.e. water, sanitation), lack of basic training in food hygiene of vendors and weak or arbitrary enforcement of the legal framework (if street food-specific regulations do exist at all) are all factors contributing to the variable and sometimes poor safety of street foods. However, the contribution of street foods to food security (ensuring cheap, nutritious and easily available food to urban dwellers), as well as to poverty reduction, is such that high priority should be given by local authorities (for example, municipalities) to promote the street food sector while reducing threats to food safety. In particular, emphasis should be given to training of street foods' vendors in food hygiene, insisting on an adequate and consistent enforcement of local food regulations and improving basic infrastructure to the vendors allowing them to respect the most basic principles for hygienic food preparation (IFPRI 2002).

Poorer urban dwellers often live in unhealthy environments. Because of the rapid rate of urbanization in developing countries, it is uncertain that provision of clean water and safe sanitation will keep pace with growing need. This has implications for food safety, health and nutrition. Also, many urban poor people work at low-paying, seasonal, or informal sector jobs, limiting their ability to afford decent housing, transportation or fees for public services. While health services may be readily available in urban areas, poor people may not have access due to high cost, lack of transportation and time constraints (IFPRI 2002).

Finally, urban life can affect maternal and child care practices. Because low-income mothers often must work outside the home, they frequently terminate breast-feeding early. They often do not have access to child care centres that are convenient to their homes or workplaces. Low-income urban mothers also frequently lack access to the extensive family and social networks on which rural women can rely for assistance with child care (IFPRI 2002; Ruel and Quisumbing 2006).

Structural Changes in the Food and Agricultural System

Productivity growth in cereals, the main staple food crops, declined dramatically in the 1990s and continues to decline for maize (which is important as a source of feed and biofuel as well as food) (Fig. 3.9). A major reason for this is underinvestment in agriculture and in agricultural research. Growth of public agricultural research expenditures slowed in the 1990s and in 2000, developing countries – excluding China and India – accounted for only a small share of that spending. In addition, funding for the international agricultural research centres supported by the Consultative Group on International Agricultural Research (CGIAR) has stagnated (Pardey et al. 2006).

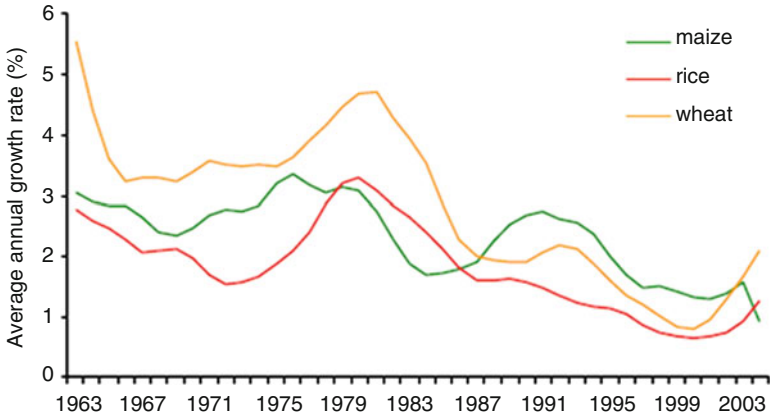

Fig. 3.9 Cereal productivity growth is declining (Source: World Bank 2007b)

Public research is essential for addressing the problems of poor farmers and consumers in developing countries, as private firms are unlikely to do so.

In addition to declining productivity, global food and agricultural systems are increasingly being shaped by preferences of affluent consumers in high- and middle-income countries. Production and value chains no longer respond simply to price signals. Instead, concerns such as quality, food safety, convenience and choice have become decisive. For example, developed-country consumers seek pre-washed, pre-cut and bagged salads that are ready to eat, rather than just the raw materials for making a salad. The mad cow, foot-and-mouth and highly pathogenic avian influenza scares in Europe and North America over the past 10 years have also heightened attention to food safety and quality, health and environmental issues. Consumers demand to know where food came from and how it was produced. Animal welfare is also increasingly an issue in food marketing. There are standards organizations that award products labels indicating their status as organic, fair trade, environment-friendly and cruelty-free. This new situation offers smallholders opportunities and niche markets among high-income buyers. But the transaction costs of meeting required production standards (e.g. organic soil) and of undergoing periodic audits may prove too high for low-income farmers (Hazell et al. 2007). That is, as global food and agricultural systems increasingly require investment in knowledge and equipment on the part of producers, the ability of poor smallholders to produce for global markets is subsequently constrained, thus threatening income and consequently, food and nutrition security.

The global food system now has a dualistic structure. On the one hand, the vast majority of farms (85%) remain smallholder operations, of less than 2 ha in size, that are home to more than two billion people (Hazell et al. 2007). In many countries, small farmers account for a considerable share of output. In India, they grow more than 40% of the cereal grains, own the majority of the livestock and account for most dairy production. In Sub-Saharan Africa, smallholders account for 90% of

all agricultural production (IFPRI 2005). On the other hand, the 0.5% of the world's farms that exceed 100 ha in size claim a disproportionate share of global farm income, enjoy privileged access to policy makers and, particularly in developed countries, receive the lion's share of tens of billions of dollars in subsidies each year (IFPRI 2005; OECD 2007).

Moreover, outside of farming, growing concentration, vertical integration and consolidation characterizes the global food system. At the top of the food chain, the ten leading food retailers enjoy a 24% share of the $3.5 billion global market and grocery stores have expanded their operations in developing countries at a rapid pace (ETC Group 2005, 2007). Between 2004 and 2006, the sales of agricultural input firms grew 8%, the revenues of food processors and traders jumped 13% and retail food sales grew by a whopping 40% (Von Braun 2007a). At the end of February 2008, the giant agricultural input and grain trading firm Cargill announced a nearly 100% increase in revenues over a year earlier due to rising cereal prices (*Washington Post* Staff and Wire Reports 2008).

As buying power is increasingly concentrated in the hands of supermarkets and other powerful corporate actors, especially in Latin America, Southeast Asia and China, small farmers often find themselves at a disadvantage. As mentioned above, trends in consumer preferences are leading buyers to have increasingly stringent demands regarding quality, timeliness and conditions of production, and it is not clear that small farmers will be able to comply with all these requirements (Hazell et al. 2007). Even if they are, their ability to bargain for a fair price may be limited, especially in situations where vertical integration and consolidation create monopolies of purchasing power.

Transboundary Pests and Diseases

Agricultural intensification, rapid growth in international trade and more frequent international travel offer opportunities to bolster rural livelihoods through productivity gains, entry into export markets, earnings from ecotourism and the ability to purchase a wider array of affordable goods and services. However, there are also substantial risks from the spread of plant and plant pests, animal diseases and invasive species across international borders. Climate change will heighten these risks. This threatens ecosystems, water and biodiversity (World Bank 2007b). For example, the wind-borne Ug99 wheat rust fungus has spread from Uganda to Kenya, Ethiopia, Yemen and Iran and threatens crops in South and Central Asia. It has devastated entire fields and in 2007 caused substantial losses in both Kenya and Ethiopia. Up to 80% of African and Asian wheat varieties are susceptible to wheat stem rust, so the disease has the potential to drive further escalation of wheat price inflation and severely harm rural livelihoods, with negative implications for nutrition (FAO 2008a). Also, some transboundary animal diseases pose serious and costly threats not only to rural livelihoods, but to human health as well, e.g. highly pathogenic avian influenza (bird flu) (World Bank 2007b).

Environmental and Energy Concerns

Many key ecosystem services provided by biodiversity, such as nutrient cycling in soils, pest regulation and pollination, sustain intensive agricultural productivity. Promoting the healthy functioning of ecosystems ensures the resilience of agriculture as it intensifies to meet the stress of growing demands for food production.

For the past 40 years or more, efforts to intensify agricultural production have helped boost food output, but some agricultural practices have taken a toll on the natural resource base on which agriculture depends. Some 1.4 billion people live in river basins where water use exceeds recharge rates (UNDP 2006). Poor management of irrigation systems has contributed to land degradation, causing salination and waterlogging of soils. Overgrazing and deforestation also contribute to land degradation and climate change (UNDP-Global Environmental Facility 2004; Scherr 1999). In Sub-Saharan Africa, where farmers apply an average of 9 kg of fertilizer per hectare (compared to 142 kg in South-east Asia), insufficient fertilizer use (rather than overuse) leads to degradation, as the cultivation and harvesting of products lead to a net loss of soil nutrients. Unsustainable agricultural practices (such as failure to maintain soil cover or obstruct water run-off) can contribute to soil erosion. Degraded soils reduce agricultural productivity and eventually become unable to produce crops (Scherr 1999). Large-scale livestock operations and inappropriate management of farm chemicals have contributed to degradation of freshwater ecosystems, causing pollution that can threaten the health of humans and livestock (Millennium Ecosystem Assessment 2005). Crop genetic diversity is essential for food and nutrition security, as it is the basis of both farmers' livelihoods and agricultural innovation. However, repeated planting of a limited number of varieties or even a single variety can erode genetic diversity (Bioversity International 2008).

Without the wider utilization of effective and efficient existing technologies and in the absence of a technological breakthrough that will boost yields on existing farmland, increases in food production to meet growing demand will have to come from the expansion of agriculture into new areas. This will likely put more fragile marginal land under cultivation, as well as destroy forests and wildlife habitat, cause loss of biodiversity and increase GHG emissions from burning, decomposition of organic matter and loss of carbon sinks. Unless constraints to existing farmland productivity are addressed, environmental degradation will deteriorate markedly. An additional serious constraint, especially in fast-growing Asia, is the rapid conversion of farmland to such other uses as residential, commercial and industrial (Reuters 2008; Ding 2004). Furthermore, food and agricultural production faces growing competition for water for home and industrial use, although agriculture continues to account for over 80% of water use (FAO 2008b; UNDP 2006). All of these factors impinge on food availability.

According to the UN Office for the Coordination of Humanitarian Affairs (OCHA), vulnerability to disasters caused by extreme weather events, such as hurricanes, cyclones, droughts and floods, remained high through 2010; the 2011 appeal is for $7.4 billion (OCHA 2010a). While these disasters stem from natural events,

human activity – frequently related to agriculture, fisheries or forestry – often exacerbates their impact. Logging, forest clearing for agricultural development and destruction of mangroves for aquaculture dismantle natural barriers to storms and floods, creating "unnatural disasters". The devastating effects of the 2008, 2009 and 2010 cyclones in Myanmar are a prime example: clear-cutting of mangroves heightened the vulnerability of coastal lands. Deforestation on the hillsides of Honduras facilitated large-scale mudslides when Hurricane Mitch hit in 1998. Total economic losses from this disaster exceeded the combined national incomes of Honduras and Nicaragua, the two most severely affected countries, for that same year. Globally, natural disasters in the 1990s caused losses of over $600 billion, more than those of the previous four decades combined (Abramovitz 2001).

With regard to energy pressures, by April 2008, crude petroleum prices reached an all-time high of US$120 per barrel (Lazo 2008) and helped to raise demand for biofuels as an alternative source of energy. Energy costs are likely to remain high for the foreseeable future, due to war and political instability in the Middle East, the supply-constraining policies of the Organisation of Petroleum Exporting Countries and the growing consolidation of the petroleum industry into transnational mega-firms. These conglomerates are using windfall profits to repurchase shares and pay dividends instead of aggressively exploring new reserve options (*Science Daily* 2007). Increased energy costs have a direct bearing on food production and rural livelihoods, as they increase costs for operating farm machinery, inputs and transportation of both inputs and farm products (Von Braun 2008). The price of mineral fertilizer, a by-product of fossil fuels, increased 150% over the past 5 years. However, it is important to note that – according to the World Bank – higher energy and fertilizer costs account for only about 15% of recent increases in food prices (World Bank 2008).

Chapter 4
Climate Change and Food and Nutrition Security

Maria Cristina Tirado and Janice Meerman

Abstract This chapter provides an overview of current and projected effects of climate change. It looks at how climate change is impacting specific environments and populations, and includes analysis of the links between climate change, food security and nutrition. The chapter examines the impact of climate change on each dimension of food security (availability, stability of supply, access, and utilization) as well as malnutrition. This discussion includes sections on food safety, health and sanitation and a number of other food security related subjects. The chapter concludes with a discussion of adaptation and mitigation strategies for the agriculture, livestock and forestry sectors.

Keywords Climate change • Environmental change • Malnutrition • Nutrition security • Food security • Health • Sustainability • Food crisis • Food prices • Human rights • Adaptation • Mitigation • Global warming • Soil salinization • Intergovernmental Panel on Climate Change

Overview of Climate Change – Evidence and Effects

Climate change is driven by what is often referred to as "global warming" or "global climatic disruption"; these shifts in the composition of the global atmosphere are caused by increased emission of greenhouse gas (GHGs). Climate change can be attributed to natural variability as well as human (anthropogenic) activity.

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Evidence

According to the Fourth Intergovernmental Panel on Climate Change[1] Assessment Report (IPCC AR4), global atmospheric concentrations of GHGs – carbon dioxide (CO_2), methane, nitrous oxide and ozone – have increased markedly as a direct result of human activity. For example, by 2005, the global atmospheric concentration of CO_2 far exceeded the natural range of the preceding 650,000 years (Forster et al. 2007). Climatic disruption may result in patterns of warming or cooling; overall, however, the trend has been towards global warming. Over the past 100 years, arctic temperatures increased at a rate almost double to that of the historical average (Lemke et al. 2007); total temperature increases during the twentieth century have been 0.76°C , far higher than previously recorded increases (Trenberth et al. 2007; Holdren 2008).

Continued GHG emissions at or above current rates are predicted to cause further warming and disruption of the global climate system during the twenty-first century (Meehl et al. 2007). According to the IPCC's Special Report on Emissions Scenarios (SRES; see Appendix 1), the best estimate for the lowest impact scenario is a temperature increase of 1.8°C. The best estimate for the high SRES scenario is 4.0°C (Meehl et al. 2007).

Estimations from the IPCC AR4 may be somewhat conservative. Subsequent research shows increased rates of greenhouse gas emissions, temperature rise, ice melt and sea-level rise. Studies of carbon sinks also show these estimations are much more severe than expected (Le Quéré et al. 2009; Slingo et al. 2009).

Effects

Climate change increases risk of severe weather events, namely droughts and flooding, the former due to desertification and rising temperatures, the latter due to sea-level rise and increased heavy precipitation (Meehl et al. 2007; Trenberth et al. 2007). It is very likely that heat waves and heavy precipitation events will continue to become more frequent[2] and that future storms and hurricanes will become more intense as a result of climate change (Meehl et al. 2007; Trenberth et al. 2007).[3]

Another major effect of climate change is sea-level rise and consequent salination of groundwater and estuaries (Kundzewicz et al. 2007). According to estimations for

[1]The IPCC is a scientific intergovernmental body set up by the UN World Meteorological Organization and the UN Environment Programme to provide decision-makers and others with objective information about climate change. The scientific community generally regards its reports as authoritative (Sample 2007).

[2]IPCC AR4 Working Group I, 10.3.

[3]IPCC AR4 Working Group I, 9.5, 10.3, 3.8.

Box 4.1 The Interaction Between Nutrition and Infection

Malnutrition can make a person more susceptible to infection, and infection also exacerbates malnutrition, which causes a vicious cycle. Insufficient energy intake results in weight loss, lowered immunity, mucosal damage, invasion by pathogens and impaired growth and development in children. Nutrition outcomes in an individual who is already suffering from an infection are compromised by diarrhoea, malabsorption of nutrients, loss of appetite, diversion of nutrients for the immune response and urinary nitrogen loss, all of which lead to nutrient losses that would not occur in a healthy individual and which further damage defence mechanisms. These symptoms, in turn, cause reduced dietary intake. Fever also increases both energy and micronutrient requirements.

Text adapted from Katona and Katona-Apte (2008).

unmitigated emissions scenarios by the IPCC AR4, global sea-level rise will be approximately 40 cm higher than today by the 2080s (Meehl et al. 2007). Climate change has also contributed to the accelerated decline of glaciers and snow cover. In some areas (e.g. Greenland, Antarctica) these widespread decreases in glaciers and ice caps have contributed to sea-level rise (Lemke et al. 2007).

Water availability will be affected by climate change. For example, water availability is predicted to be reduced in regions supplied by meltwater from major mountain ranges; these regions are home to more than one-sixth of the world's population (Kundzewicz et al. 2007). In addition, the increased salination of groundwater and estuaries will result in decreased availability of coastal freshwater for humans and ecosystems.

According to the IPCC AR4, climate variability and climate change will have significant impacts on food security and malnutrition. First, droughts and water scarcity reduce overall food security and diminish dietary diversity. Any reduction in the quantity and quality of foods available for consumption will tend to lead to increased levels of malnutrition, including protein-energy malnutrition and/or micronutrient deficiencies. Second, infectious disease, which shares a vicious circle with malnutrition (see Box 4.1), will also increase as a result of climate change. For example, flooding, especially flash flooding caused by a single severe weather event which occurs with little warning, is likely to result in an increase in the number of people exposed to diarrhoeal and other infectious diseases, reducing nutrient absorption capacity and compromising immunity to infection.

The following sections provide more detail regarding the effects of climate change on the human and global environment, the effects of climate change on food security, the effects of climate change on nutrition, social impacts of climate change, and adaptation/mitigation strategies.

Impacts of Climate Change on the Human and Global Environment

Specific repercussions of climate change which threaten the human and global environment include soil salination, desertification, stratospheric ozone depletion, loss of biodiversity and changes in hydrological systems and supplies of freshwater (WHO 2005a).

Vulnerable Regions

Regions most likely to be adversely affected by climate change are those already vulnerable to food insecurity and malnutrition, namely Sub-Saharan Africa and Asia. It is within these regions that the IPCC estimates the largest number of people will be affected (Nicholls et al. 2007).[4] Substantial amounts of agricultural land have already been compromised or lost due to desertification, soil salination and other climate-change related trends in both areas. Projections indicate that these negative effects will continue and perhaps even accelerate in the future. For example, the Organisation for Economic Co-operation and Development (OECD) predicts that Bangladesh, which has already suffered permanent loss of land due to persistent and extreme flooding, may experience salinity intrusion of up to 60 km within the next century (OECD 2005).

Coastal areas, especially the heavily-populated mega-deltas of Asia, are and will remain at risk for increased flooding from oceans and rivers (Cruz et al. 2007). Small islands, whether located in the tropics or higher latitudes, are also vulnerable to some of the effects of climate change, namely sea-level rise and extreme weather events (Mimura et al. 2007).

In the polar regions, the main projected biophysical effects are reductions in thickness and extent of glaciers and ice sheets and changes in natural ecosystems with detrimental effects on many organisms including migratory birds, mammals and apex predators (Anisimov et al. 2007)[5].

Vulnerable Ecosystems

Terrestrial ecosystems considered highly vulnerable to climate change include boreal forests, the Amazon rainforest, and Arctic tundra (Lenton et al. 2008). Examples of other delicate ecosystems that are already being affected include mountain and Mediterranean regions. However, all terrestrial ecosystems are or will

[4]Note that IPCC assessments provide only weak information at the regional level and none on a national basis.

[5]Predators at the top of their respective food chain.

be affected to some degree. Approximately 20–30% of plant and animal species assessed so far are believed to be at increased risk of extinction should increases in global average temperature exceed 1.5–2.5°C (Fischlin et al. 2007).

In addition to global warming per se, a number of related risks currently threaten terrestrial ecosystems around the world. These include events directly linked to climate change, namely increased flooding and drought, and associated disturbances such as wildfires and insect plagues. Many of these events are now occurring in close proximity to each other, creating situations that are unprecedented in terms of the number of hazards threatening a single ecosystem within a given, often short, time period. When combined with pollution and overexploitation of resources, vulnerability increases (Fischlin et al. 2007).

Marine ecosystems are also threatened by global atmospheric disruption and associated environmental change. A 2007 study predicted that the progressive acidification of oceans would have negative impacts on marine shell forming organisms (e.g., corals) and their dependent species (Nicholls et al. 2007).[6] And an assessment published by the United Nations Environment Programme in 2010 reported that rising CO_2 concentrations were increasing the vulnerability of phytoplankton, seaweeds and corals in aquatic ecosystems (UNEP 2010).

Vulnerable Populations

Although almost all human populations are or will be affected by climate change, certain demographics are particularly vulnerable. Most of these groups remain heavily reliant on natural resources for food and livelihoods. Smallholder farmers, pastoralists, traditional societies, indigenous people and coastal populations are examples (Easterling et al. 2007). These populations have extremely low incomes and lack adaptive capacity.[7] They are often politically marginalized, risk averse, and may have little or no access to social protection programmes or healthcare. They are also frequently concentrated in those areas most exposed to climate change (see section "Vulnerable Regions" above).

Many of the world's poorest and most vulnerable people are women living in rural areas in developing countries who are wholly dependent on subsistence agriculture to feed their families. Rural women, female smallholders in particular, may be disadvantaged in terms of access to key productive assets for farming and services such as land, water, rural infrastructure, technology and information, credit and extension services (World Bank, FAO and IFAD 2008; Brody et al. 2008).

[6] WG2 6.4.

[7] Adaptive capacity: the ability to change behaviour in response to a changing climate. This can include devising and implementing solutions to protect livelihoods from negative climate change impacts or allow individuals or households to benefit from positive climate change impacts (IPCC 2007).

These women therefore tend to have limited adaptive capacities, and are highly dependent on climate sensitive resources such as local water and food supplies (IPCC 2007). Climate change is expected to exacerbate these gender inequalities with women being disproportionately affected by depletion of natural resources and reduced agricultural productivity (Parikh and Denton 2002) (see the section on "Adaptation and Mitigation Strategies" for a discussion of "gender proofing" adaptation to climate change).

In the longer term, vulnerable (and other) populations will be faced with additional climate-related challenges. These include snow-pack decrease, sea-level rise and increased prevalence of disease (e.g. diarrhoea and vector-borne diseases such as malaria). As discussed above and below, each of these effects has consequences, such as decreased water availability, soil salination, reduced yields, increased out-migration and decreased labour productivity. The vast majority of these repercussions have negative implications for food and nutrition security.

Impacts on the Four Food Security Dimensions: Availability, Stability, Access and Utilization

Climate change will affect all four dimensions of food security: food availability, stability of food supplies, access to food, and food utilization. Availability of food is determined by domestic production, import capacity, existence of food stocks and food aid. Stability of supply (as well as access) depends on weather, price fluctuations, man-made disasters and a host of other political and economic factors. Access to food depends on household purchasing power, prices, existence of transport and market infrastructures, and food distribution systems. Safe and healthy food utilization depends on care and feeding practices, food safety and quality, access to clean water, health and sanitation (FAO 2008g).

There are many pathways through which global climate change and variability are affecting food security. First and foremost, climate change affects food availability via its impact on yield. In most cases, production and subsequent availability is reduced. In some cases, yields may actually be increased due to CO_2 "fertilization". Additional, less direct pathways involve the demographic and socio-economic repercussions of climate change, which also effect food security:

- Impacts of severe weather events, gradual temperature increases and water scarcity on plant and animal physiology
- Increased crop and livestock diseases and pest infestations
- Reduced production in forestry, wild fisheries and aquaculture

} Direct

- Demographic shifts due to due to disease and migration
- Decreased labour supply due to disease and migration
- Political unrest due to competition for diminished resources
- Reduced reach of government and social services due to political unrest

} Indirect

Climate Change Impacts on Food Availability

Evidence from models from the Fourth IPCC assessment suggests that moderate local increases in temperature (1–3°C), along with associated CO_2 increase and rainfall changes, can have small *beneficial* impacts on major rain-fed crops (e.g. maize, wheat, rice) in mid- to high-latitude regions. However, in seasonally dry and tropical regions, even slight warming (1–2°C) reduces yield. Further warming (above a range of 1–3°C) has increasingly negative impacts on global food production in all regions. Overall, tropical and sub-tropical developing countries, many of which have poor land and water resources and are already faced with serious food insecurity, are thus facing reductions in production potential due to climate change (Hitz and Smith 2004; Fischer et al. 2005; Parry et al. 2005).

Sub-Saharan Africa, for example, is being and will continue to be hard hit unless significant adaptation and mitigation measures are put in place (Clements 2009; FAO 2010a). Africa is highly vulnerable for a host of reasons, including its heavy reliance on rain-fed agriculture, the poor level of water control and the poor replenishment of reservoirs (FAO 2010a). With regards to the IPCC prediction cited above, reduced yields of rice, maize and wheat, key to many African diets and export markets, are anticipated even if temperature increases are very slight (1–2°C). Subsequent impact on continental GDP could be significant, ranging from 1.7% to 10%, depending on the degree to which temperatures increase (Clements 2009).

In Africa and elsewhere, trade in cereal crops, livestock and forestry products will likely increase in response to climate change; with regard to national level food availability, dependence on food imports for most developing countries is projected to grow. Exports of temperate zone food products to tropical countries will rise, while the reverse may take place in forestry in the short-term (Easterling et al. 2007).

Sea level rise as a result of climate change poses a major threat to food availability in coastlands, lagoons and mangrove areas around the world. Coastal areas are also threatened by increases in temperature leading to changes in the distribution of marine fisheries and community interactions (Parry et al. 2005). Regional changes in the distribution and productivity of particular fish species are expected due to continued warming and local extinctions will occur at the edges of species ranges, particularly in freshwater and diadromous[8] species such as salmon and sturgeon (Easterling et al. 2007).

Inundation of fishery nurseries is also a threat (FAO 2003b). Inland fisheries – most of which are in developing African and Asian countries – are at particularly high risk, potentially reducing food availability for some of the world's poorest populations. There are also consequences for aquaculture, which is especially significant for populations in Asia (FAO 2010b). Overall, global warming is confounding the impact of natural variation on fishing activity and complicating management (Easterling et al. 2007; FAO 2010b).

[8] Migratory between fresh and salt water.

Climate Change Impacts on Food Stability and Access

Increased frequency of extreme weather events as well as climate change-related pests and diseases will affect stability of and access to food supplies. In addition to destabilizing production systems, each of these challenges increases risk of reduced access. Purchasing power of smallholders and others whose livelihoods are based in agriculture or aquaculture may be reduced. Decreased crop yields, lower forest productivity, changes in aquatic populations, and increased costs of control all increase budget constraints (FAO 2008c).

Climate variability and change also appear to be contributing to rising food prices (Cline 2007; Von Braun 2007a). In 2010 alone, Russian wheat crops were devastated by a season of unusual drought and wildfire, Pakistan's crop yields were reduced because of floods and in Laos and Cambodia, food production was compromised by delayed and erratic rains. In November 2010, FAO's food price index confirmed that prices of major food commodities were creeping closer to the high reported in June 2008; the report cited adverse weather effects as one of the primary drivers of the wheat production shortfalls experienced earlier that same year (FAO 2010c). By February 2011, the same index averaged 236,[9] the highest (in both real and nominal terms) since its inception in January 1990 (FAO 2011).

Although climate change is only one of the variables affecting food price volatility, it appears to be an important one. According to one model, temperature increases of more than 3°C could increase prices up to 40% (Easterling et al. 2007). A more recent, albeit less specific, model predicts that overall decreases in production could lead to price increases for staple crops of 25–150% by 2060 (Parry et al. 2009).

In terms of stability and access, high food prices can benefit net food producers at all levels, from individual smallholders to countries which export more food than they import. However these benefits may not fully offset the reduced purchasing power of net food consumers, especially in areas where the most vulnerable belong to the latter category. Of note is the fact that most African countries are net importers, with over 50% of North Africa's food requirement and between 25% and 50% in Sub-Saharan Africa imported (FAO 2006b). Sub-Saharan Africa's cereal import bill, estimated at about 9.8 billion in Sub-Saharan Africa in 2008, represents a 35% increase over the 2007 level (Kamara et al. 2009).

Climate Change Impacts on Food Utilization

Food utilization refers to the degree to which an individual is able to secure or utilize essential nutrients from the food he or she consumes. It is the dimension of food security which is most directly linked to nutrition outcomes at the individual level.

[9] 2002–2004 = 100.

As mentioned above, food utilization depends on care and feeding practices, food safety and quality and access to clean water, health, and sanitation. Climate change can affect each of these variables.

Care and Feeding

Climate change exacerbates many of the socio-economic and environmental variables which can affect care and feeding practices. These include increased competition for natural resources, loss of biodiversity, HIV/AIDS and other pandemics and social and armed conflicts. Each of these stresses has been shown to reduce resilience in agriculture and related sectors, with associated welfare effects (FAO 2003a). For example, HIV/AIDS in Southern Africa is adversely impacting agriculture through increased mortality and morbidity of adults in their prime. Household labour productivity is reduced, assets are eroded and the intergenerational transmission of agricultural knowledge is handicapped. Floods, droughts, rising temperatures and other impacts of climate change further exacerbate this situation, increasing the vulnerability of households who are already at a severe disadvantage in terms of labour and capital. In situations like these, good care and feeding practices may be practically impossible. Exclusive breastfeeding of newborns and provision of nutritious complimentary foods during weaning, for example, may not be an option for overworked mothers who are malnourished themselves, and who are already dealing with sick family members, severe budget constraints, lack of potable water and drought-stricken crops.

Food Safety

Climate change implications for food safety are being increasingly discussed. The various climate-change-related phenomena – changes in temperature and precipitation patterns, increased frequency and intensity of extreme weather events, ocean warming and acidification – are thought to present a number of direct and indirect challenges to food safety.

Direct effects of changing weather patterns on food safety hazards relate to impact of ambient temperature, salinity and pH on the survival, multiplication and distribution of micro-organisms. Indirect effects might include: mis-use of agricultural chemicals in response to unexpected patterns of plant and animal disease leading to unacceptably high chemical residues in foods, and heightened or altered food safety risks due to changes in eating habits caused by natural disasters. Climate change is also expected to affect incidence and distribution of both chemical and biological hazards (FAO 2008h).

While there is growing evidence of some expected effects on food safety, others remain largely speculative. Below we describe selected food safety effects of climate change for which some evidence currently exists.

Food-borne diseases such as salmonellosis have been found to increase by 12% for each degree increase in weekly or monthly temperatures above 6°C (Kovats et al. 2004). Rising temperatures have also been found to increase prevalence of biotoxins (e.g. mycotoxins or marine toxins), chemicals and other food contaminants. For example, mycotoxins are a class of naturally occurring contaminants whose occurrence is greatly influenced by environmental factors, mainly temperature, humidity, insect attack, drought and stress condition of the plants. Mycotoxins can significantly reduce food security as they can contaminate staple crops such as maize, sorghum, other grains and nuts. Furthermore, aflatoxin (a type of mycotoxin)-contaminated animal feed can lead to the transfer of toxins through milk and meat to human beings.

Similarly, warmer seas may contribute to increased cases of human shellfish and ciguatera poisoning and poleward expansions of these disease distributions. For example, incidence of diarrhoeal disease has been associated with consumption of shellfish contaminated with *Vibrio parahaemolyticus.* Densities of this bacteria increase concomitant to rising water temperature (McLaughlin et al. 2005; Zimmerman et al. 2007). Higher ocean temperatures are also leading to increased levels of methyl mercury in fish and marine mammals. Concentrations of methyl mercury in fish increase by 3–5% for each 1°C rise in water temperature (Booth and Zeller 2005). The risks posed by this potential increase have prompted recommendations to limit intake of certain fish species and marine fats (Kuhnlein et al. 2002; Booth and Zeller 2005).

Assuring the safety of foods consumed by vulnerable populations is of fundamental importance in achieving food and nutrition security. Food-borne illness exacerbates malnutrition – together food-borne diseases and malnutrition cause an estimated 13 million child deaths annually (IAASTD 2008).

It is the role of food safety authorities to actively seek information on emerging hazards and risks and to re-orient national programmes as required to adequately deal with an evolving situation. This will require increased emphasis on integrated surveillance and sharing of data internationally.

Access to Clean Water

Access to safe water remains an extremely important global health issue. More than two billion people live in the dry regions of the world and suffer disproportionately from malnutrition and other risks related to contaminated or insufficient water (WHO 2005a). These include exposure to water-borne diseases such as cholera and schistosomiasis, exposure to chemicals and exposure to vector-borne diseases associated with certain water-storage systems (e.g. malaria). In addition to increasing the burden of adult disease and death, these adverse health outcomes also significantly increase infant morbidity and mortality.

By 2080, it is estimated that climate change will have increased the number of people suffering from water scarcity by 1.1–3.2 billion (Yohe et al. 2007).[10] Each of these individuals will be at increased risk of the exposures and poor health outcomes listed above. As in the section on "Health and Sanitation" below, almost all of the poor health outcomes associated with access to water are infectious-disease related, with direct implications for food utilization, nutrient absorption and subsequent malnutrition. (See Box 4.1 for a detailed explanation of the interaction between nutrition and infection.)

Health and Sanitation

Increased flooding, precipitation, rising temperatures and other aspects of climate-change are projected to increase the burden of diarrhoeal diseases in low-income regions by approximately 2–5% by 2020[11] (Campbell-Lendrum et al. 2003; McMichael et al. 2004). Higher temperatures have been associated with increased episodes of diarrhoeal disease in adults and children in Peru, where incidence was reported to have increased 8% per degree of temperature increase (Checkley et al. 2000). As mentioned above diarrhoeal food-borne diseases such as salmonellosis have been found to increase by 12% for each degree increase in weekly or monthly temperature above 6°C ambient temperature (Kovats et al. 2004). Also mentioned above, rising ocean temperatures are leading to increased densities of *Vibrio* spp., a diarrhoeal agent, in shellfish (Zimmerman et al. 2007).

In addition to diarrhoeal disease, climate change has been shown to play a role in the spatial and temporal distribution of malaria. However, the effect of climate change on malaria and other vector-borne diseases is hard to predict. In the long term, geographical range may contract in areas experiencing climate change-related drought.[12] Elsewhere, geographical range is expected to expand, lengthening the transmission season. It is estimated that in Sub-Saharan Africa, climate change will increase the number of person-months of exposure to malaria by 16–28% by 2100 (McMichael et al. 2004). Malaria directly impacts nutrient utilization because infected individuals are at increased risk of anaemia.

Finally, climate change is expected to increase the risk of emerging zoonotic diseases.[13] Changes in the survival of pathogens in the environment, changes in migration pathways, carriers and vectors and changes in the natural ecosystems are all predicted to increase risk. Increased prevalence of zoonotic diseases is

[10] Range is due to multiple scenarios modelled by the SRES.

[11] Countries with an annual GDP *per capita* of US$6,000 or more are assumed to have no additional risk of diarrhoea.

[12] The northern limit of *Plasmodium falciparum* malaria in Africa is the Sahel where rainfall is an important limiting factor in disease transmission.

[13] Diseases that normally exist in animals but that can be transmitted to humans.

particularly relevant with regard to continued increases in the global livestock population. Like diarrhoeal and other infectious diseases, zoonoses inhibit nutrient utilization via impaired absorption as well as increased nutrient requirements caused by the disease.

Links Between Global Climate Change, Food Security, Hunger and Nutrition

Due to the interaction between infection and malnutrition, increased prevalence of climate-change-related infectious disease will result in increased malnutrition. In addition to direct impacts on utilization, climate-change related incidents also affect nutrition via the other dimensions of food security. Although food availability, stability and access are not always directly related to malnutrition at the individual, biological level, they are most certainly major drivers, both in terms of access to a safe, diversified, high quality diet, and in terms of purchasing power. As discussed above, climate change is expected to reduce food production, particularly in regions where yields are already erratic and low. As a result, income generating opportunities and purchasing power may decrease for many populations (SCN 2010b). Also mentioned above is the relationship between climate change, decreases in production and price increases for staple crops.

Due to these wide causal pathways and the very large numbers of people that may be affected, the IPCC's AR4 concluded that undernutrition linked to extreme climatic events may be one of the most important consequences of climate change (Confalonieri, et al. 2007). Further, the Standing Committee on Nutrition of the UN System has appealed directly to the 16th Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC) to make nutrition a priority on its agenda (SCN 2010b). In its appeal, the SCN stated:

> Climate change affects food and nutrition security and further undermines current efforts to reduce hunger and protect and promote nutrition. Additionally, undernutrition in turn undermines the resilience to shocks and the coping mechanisms of vulnerable populations, lessening their capacities to resist and adapt to the consequences of climate change.

Recent projections support this statement. Should present trends continue, 21% more children are expected to be malnourished by 2050 than would be in a world where no climate change was occurring (Nelson et al. 2009). It has also been estimated that if current trends continue, 200–600 million more people will suffer from hunger by 2080 than would in a world where no climate change was occurring (Yohe et al. 2007).

A revitalized "twin-track approach" approach is one way to address the challenges posed by climate change to food and nutrition security. Track one focuses on direct and immediate nutrition interventions in agriculture and health. Track two promotes sustainable and climate-resilient agriculture and rural development programmes, health and social protection schemes, disaster risk reduction and management plans and community-based approaches for addressing highly vulnerable populations. This approach

can be integrated into broader efforts for managing climate change and is discussed further below (see section "Adaptation and Mitigation Strategies" as well as Chap. 6).

It is important to note that further research on the links between climate-change and malnutrition are necessary. There is also a need for methodologies to convert estimated losses in regional yields into estimates of changes in numbers of malnourished people. This has been recognized as one of the critical research needs by the IPCC AR4.

Social Impacts of Climate Change

Increasing scarcity of basic food and water resources increases the likelihood of competition for these resources as well as subsequent violent conflict (LEAD 2007). For example, in Sub-Saharan Africa, where cropping and grazing are often practised by different ethnic groups, the advance of crops into pasture land often results in conflict, as shown by major disturbances in the Senegal river basin between Mauritania and Senegal and in Northeast Kenya, between the Boran and the Somalis (Nori et al. 2005).

Climate change could exacerbate tensions in regions such as these. It could also conceivably catalyze tension in areas where competition is just beginning to develop. Both scenarios include the risk of a vicious circle developing between conflict and exploitation of resources. Indeed, the Southern African Millennium Ecosystem Assessment suggests a bidirectional causal link between ecological stress and social conflict: conflict may cause environmental degradation but the latter may also trigger conflict (Biggs et al. 2004). See Box 4.2 for a detailed explanation of how conflict in Darfur has been driven in part by climate change and environmental degradation (UNEP 2007).

Drought and the consequent loss of livelihoods are also major triggers for population movements, particularly rural to urban migration. Population displacement to urban slums can lead to increased competition for potable water and safe food. As discussed above, this increases the risk of infectious disease and concomitant malnutrition. Rural to urban migration has been implicated as a driver of HIV transmission and unplanned urbanization has been associated with the spread of *Plasmodium vivax* malaria and dengue fever in urban slums (Confalonieri et al. 2007).

Adaptation and Mitigation Strategies

The IPCC AR4 defines adaptation as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." In contrast, the IPCC defines mitigation as "an anthropogenic intervention to reduce the anthropogenic forcing of the

Box 4.2 Climate Change and Conflict in Sudan

Environmental issues and competition over agricultural land use are important causal factors in the instigation and perpetuation of conflict in Sudan. Resource-based conflicts between traditional farmers and nomadic herders have been present in Sudan throughout recorded history. The introduction of mechanized rain-fed agriculture systems has been found to further exacerbate and trigger conflict.

A UNEP assessment indicates a strong association between land degradation, desertification and the conflict in Darfur. Tensions between farmers and herders over disappearing pasture and evaporating water holes threaten to reignite other long-standing conflicts. The southern Nuba tribe, for example, has warned it could re-start the war as Arab nomads, pushed southwards into their territory by drought, are cutting down trees to feed their camels.

The assessment reveals that in the past 30 years, rainfall has dropped by 16% in southern Darfur and 34% in northern Darfur, the desert climate in Sudan has advanced southwards by 100 km over 40 years, deforestation has been accelerated while underground aquifers are being drained and yields of the local staple, sorghum, could drop by 70% by 2060.

At the same time the Darfur conflict has exacerbated Sudan's environmental degradation, forcing more than two million people into refugee camps. Currently, Sudan has the world's largest population of displaced persons, with over five million internally displaced persons and international refugees. This massive population displacement has led to human rights abuses, conflicts over resources, food insecurity and a high prevalence of severe malnutrition.

Source: UNEP (2007)

climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks."

Simply put, adaptation strategies work to offset or take advantage of the impacts of climate change, whereas mitigation strategies address its root causes by aiming to reduce emissions and increase carbon sequestration.

Adaptation Strategies

Adaptation strategies can be autonomous or planned. Autonomous adaptation relies on existing knowledge and technology to respond to climate change. In contrast, planned adaptation requires an increase in adaptive capacity. Institutions are created

or reinvigorated and policies are revised or formulated to create conditions favourable for effective adaptation. Unlike autonomous adaptation, planned adaptation typically requires investment in new technologies and infrastructure, and may also require changing the decision-making environment. However, many planned, policy-based adaptations to climate change will interact with, depend on or perhaps simply be a subset of broader policies on natural resource management, human and animal health, governance and human rights (Yohe et al. 2007).

Adaptation strategies for cropping systems include:

- using inputs that are resistant to heat shocks and drought;
- altering or reassessing fertilizer rates;
- altering the timing of irrigation and other water management practices;
- improving the effectiveness of pest, disease and weed management practices through wider use of integrated pest and pathogen management;
- maintaining or improving quarantine capabilities and sentinel monitoring programmes and
- using seasonal climate forecasting to reduce production risk (Yohe et al. 2007).

Adaptations for livestock production include:

- matching stocking rates with pasture production;
- rotating pastures;
- modifying grazing times;
- altering forage and animal species/breeds;
- altering the integration of mixed livestock/crop systems, including the use of adapted forage crops and
- ensuring adequate water supplies and using supplementary feeds and concentrates (Yohe et al. 2007).

If widely adopted, these strategies, singly or in combination, have substantial potential to offset negative climate change impacts and take advantage of positive ones. However, it is important to note that there are limitations to adaptation strategies.

For example, adaptation policies are not "gender-proofed". Since adaptation strategies use the status quo to build on existing systems, they may further exacerbate gender inequalities related to land access, credit, extension services and other inputs (see section "Vulnerable Populations", above). Thus many women may be unable to access the benefits of adaptation projects and programmes. Women have been largely absent in decision-making processes regarding climate change and environmental management; their roles in agriculture are often overlooked. But considering women's knowledge about management of natural resources, they could also play a crucial role in climate change mitigation and adaptation strategies (Lambrou and Piana 2006). For example, in the implementation of the Clean Development Mechanism (CDM) one of the Kyoto Protocol's flexible mitigation mechanisms, women in rural areas might be targeted for a range of low emission technologies related to household energy, agricultural and food processing, forest management and water pumping (Lambrou and Piana 2006). Equal access by

women to the CDM and other carbon funds and initiatives could promote the marketing of new efficient and renewable technologies to women on a large scale, for household energy usage as well as for charcoal production, brick making and agro-processing (Parikh and Denton 2002).

In addition, adaptation strategies to climate change to protect food and nutrition security are particularly complex and often involve trade-offs. For example, shifts to crops such as cassava in African countries that are severely affected by droughts or HIV/AIDS should take into consideration that these crops could be less nutritious. Cassava, while hardy, easy to grow, and drought-resistant, is very low in protein and hence can pose a threat to dietary quality if it is not consumed as part of an adequately diversified diet. Planned adaptation efforts to breed nutrient-rich food crops should thus be integrated with autonomous efforts to breed crops that are resistant to drought and water-tolerant.

In general, efforts to improve the climate resiliency of agriculture and related sectors should be "nutrition-friendly". This requires endorsement of the twin track approach mentioned above, which expands the strategic focus beyond increased yields to include goals focused on improving the diversity of crops produced, the quality and diversity of dietary intake patterns, health and social protection schemes, risk management plans and community approaches for addressing highly vulnerable populations (SCN 2010b).

While national adaptation policies and strategies are important, the implementation of these strategies at the local level will be the ultimate test of the effectiveness of adaptation. Crop and livestock productivity, market access, and the effects of climate change all are extremely location specific. Community-based adaptation strategies can help rural communities strengthen their capacity to cope with disasters, improve their land-management skills and diversify their livelihoods (SCN 2010b).

Greater investments in agricultural science and technology are needed to meet the demands of a world population expected to reach nine billion by 2050. Many of these people will live in the developing world, have higher incomes, and desire a more diverse diet. It has been estimated that in order to raise calorie consumption enough to offset the negative impacts of climate change on the health and well-being of children, additional investments of US$7.1–7.3 billion per year are needed to finance the necessary research, rural infrastructure and irrigation facilities (Nelson et al. 2009). The mix of investments differs by region: Sub-Saharan Africa requires the greatest overall investment and a greater share of investments in roads, Latin America in agricultural research, and Asia in irrigation efficiency (Nelson et al. 2009).

Mitigation Strategies

Agriculture, forestry and other land uses account for a significant amount – between 30% and 35% – of total GHG emissions (IPCC 2007; FAO 2009c). However, the agriculture and forestry sectors also have huge mitigation potential (FAO 2010e).

According to the IPCC AR4, efforts to mitigate global green house gas (GHG) have "substantial economic potential that could offset the projected growth of global emissions or reduce emissions below current levels" (IPCC 2007). Climate Smart Agriculture supports sustainable agricultural activities that can potentially benefit development, food security, adaptation and mitigation (World Bank 2010).

Through 2030, the IPCC sees the main mitigation potential of agriculture lying in improved crop and grazing land management to increase soil carbon sequestration. Additional options include restoration of degraded lands and improved rice cultivation and improved nitrogen fertilizer management to reduce nitrous oxide emissions (Metz et al. 2007).[14] Key mitigation strategies in livestock include reducing emissions via improved diets to reduce fermentation in ruminants' digestive systems and improved manure and biogas management (LEAD 2007).

Agricultural research can help create new technologies that will facilitate agriculture-based mitigation strategies. For example, research is underway at Consultative Group on International Agricultural Research(CGIAR)-supported international agricultural research centres to breed new, drought-tolerant varieties of sorghum that will provide food, feed and fuel all from a single plant, without current tradeoffs among uses. Rice research is underway aimed at promoting the development of production systems with lower emissions of GHGs and greater resilience to the impacts of climate change. Forage and wheat research seeks to develop varieties that slow nitrification and make fertilizer use more efficient (CGIAR 2008). New technologies that improve crop yields with fewer emissions are likely to be available before 2030. According to the IPCC, there is medium agreement and medium evidence on this range of agricultural mitigation strategies (IPCC 2007).

With regard to the forestry sector, there is agreement and considerable evidence that forest-related mitigation activities using commercially available technologies can considerably reduce emissions and create synergies with adaptation and sustainable development (including employment and income generation, reduced poverty, biodiversity and watershed conservation and developing sources of renewable energy) (IPCC 2007). Curbing deforestation is a highly cost-effective strategy for reducing GHG emissions and has the potential for quick impact. At present, deforestation through burning forest land to make way for agricultural production accounts for 20% of global carbon emissions. Thus reducing deforestation has a very high potential for GHG emission reduction. Use of financial and market incentives to reduce burning and other deforestation activities which cause GHG emissions (REDD or Reducing Emissions from Deforestation and Forest Degradation) is one strategy being used in a number of countries to increase good forest management practices. New technologies are also being developed to promote innovative, non-invasive farming methods which do not require deforestation. In Brazil, for example, soil science breakthroughs have allowed farmers to grow soybeans and

[14]Ordinarily, nitrogen fertilizer tends to break down into nitrous oxide, a greenhouse gas that also contributes to ozone depletion and nitrate, which aids crop growth, but also contaminates streams and groundwater, thereby threatening health and nutrition.

other crops in the low fertility Cerrado region, without having to clear the rainforest for cultivation (Stern 2006; CGIAR 2008).

Agroforestry – integration of tree and crop cultivation – is another mitigation strategy which not only captures carbon but also helps maintain soil health through nitrogen fixation and use of cuttings as fertilizer and mulch, as well as providing fodder, fruit, timber, fuel, medicines and resins to nearby cultivator households. For example, in Southern Africa, tens of thousands of smallholders are planting self-fertilizing trees to increase fertility on fallow land (CGIAR 2008). Forest-based technologies likely to come on line before 2030 include improved tree species that increase biomass productivity and carbon sequestration and improved remote sensing for analysis of vegetation and soil carbon sequestration potential, as well as mapping land use changes (CGIAR 2008; IPCC 2007).

Finally, existing waste management technologies for mitigation are available to contribute to improved public health as an input into good nutrition. These include waste incineration with energy recovery, composting of organic waste, controlled waste water treatment and recycling to minimize waste (IPCC 2007).

Chapter 5
Nutrition and Bioenergy

Noora-Lisa Aberman and Marc J. Cohen

Abstract This chapter examines the direct nutrition effects of rising bioenergy demand, as well as its contribution to rising food prices. It cites the environmental implications of biofuel production and models the effects of price increases and increased demand for biofuel on regional calorie availabilities. This chapter also discusses potential strategies for cultivation of bioenergy crops that can contribute to poverty reduction, food security and sustainable natural resource management.

Keywords Bioenergy • Biofuels • Ethanol • Biodiesel • Cellulosic biofuel • Jatropha • Feedstock • Outgrower schemes • Land tenure • Global standards • Food crop diversion

Overview

Bioenergy is energy produced from organic matter, or biomass. Biofuels are sources of energy derived from biomass. A wide range of biomass sources can be used to produce energy. Some have been used for millennia, such as fuelwood, charcoal and animal dung. Newer sources include ethanol, biodiesel and biogas. These new sources depend on natural vegetation, crops grown specifically for energy or agricultural or other biological forms of wastes and residues. Processing makes these biofuels cleaner and more efficient than traditional biofuels and if they are produced in a way that reduces net carbon emissions, they could contribute to

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mitigating climate change. Ethanol, for instance, can be made from sugars (e.g. sugar beets, sugarcane and sweet sorghum), grains (such as maize and wheat), root crops (such as cassava), cellulose and waste products. Biodiesel is made from vegetable oils or animal fats. Ethanol production is mostly concentrated in Brazil and the United States, while the European Union produces most biodiesel (FAO 2008d, e, g; Von Braun 2007b).

Rising petrol prices have made the new biofuels an attractive alternative energy source. Technological development has recently made them more cost-effective and energy-efficient. Research is underway to develop biofuels from low value non-food crops, such as grasses or wood. These feedstocks are, however, more expensive and more difficult to process than starch or sugar crops and it is not clear that their production will expand significantly in the near future. Moreover, biofuels offer only a very small gain in energy efficiency over petrol, and their production only minimally reduces GHG emissions. Further, while biofuels will offset only a modest share of fossil energy use over the next decade, they will have a much greater impact on agriculture, food security and nutrition (Von Braun 2007b; FAO 2008e, g).

Why Biofuel? Why Now?

The new biofuels have a high place on the global agenda, largely due to rising concerns about national energy security, higher petrol prices, political opposition to some energy alternatives such as nuclear and wind power and increasing concerns about global climate change, as well as the income expectations of farmers and other investors (Von Braun and Pachauri 2006).

Participants in the biofuel discussion are wide ranging and include farmer representatives, the energy industry, global environmental movements, large capital funds and science and technology lobbies. The extent to which biofuels remain on the agenda will depend on political pressures and security concerns. High levels of rent-seeking as well as political lobbying are already part of the biofuels political dynamics, and their impact is evident in current widespread and incoherent subsidy and trade policies (Von Braun 2007b).

Government Support and Subsidies

Governments around the world have enacted policies designed to encourage biofuel production and use, and to protect its producers from international competition. Some countries, such as the United States, have policies in place to do all three for the ethanol industry (Anderson et al. 2008).

Blending mandates are becoming prevalent in both developed and developing countries. The United States has mandated the use of 28.4 billion litres of biofuels for transportation by 2012. The European Union set a goal of 5.75% of motor fuel use from biofuels by 2010. Brazil required that all diesel oil contain 2% bio-diesel by 2008; this will rise to 5% in 2013. Thailand required 10% ethanol in all gasoline

starting in 2007. India mandates a 5% ethanol blend in nine states, and China is requiring a 10% ethanol blend in five provinces (World Bank 2008).

A report by the International Institute for Sustainable Development's Global Subsidies Initiative[1] examines biofuel subsidies and other support in a number of OECD countries. It finds that in 2006, the United States government spent US$6 billion on supporting biofuel production and consumption, while the European Union provided US$4.7 billion.

In addition to the mandates discussed above, the largest subsidy for ethanol in the United States is the Volumetric Ethanol Excise Tax Credit, which goes to blenders who combine ethanol with petrol, in the amount of 51 US cents per gallon of pure ethanol blended. The Energy Policy Act of 2005 mandates that four billion gallons come from renewable fuels in 2006, rising to 7.5 billion in 2012, providing a large implicit subsidy. The U.S. also has a tariff on ethanol imported from outside the Caribbean Basin, which protects the industry from imports (notably those from Brazil). There are numerous separate subsidies and tax breaks for investment in the infrastructure required for biofuel production (FAO 2008g). In addition, U.S. subsidies to corn growers favour the ethanol industry. In 2009 these are estimated to have totalled nearly US$4 billion.[2]

Prevalence of Biofuel Production

Globally, bioethanol production is mostly concentrated in Brazil and the United States, which together accounted for nearly 90% of the total in 2007. Biodiesel production is geographically concentrated within the European Union, which accounted for 60% of global output in 2007 (FAO 2008g). Ethanol accounts for 40% of non-diesel fuel in Brazil, which produces nearly 40% of the world's total production (19 billion litres in 2007). Biodiesel, which can be blended with petroleum diesel, requires more land-intensive production than ethanol, and so far represents only a fraction of ethanol production (Von Braun and Pachauri 2006).

In 2008, there were 147 ethanol plants in operation in the United States, with 55 more under construction. Over the past few years, the U.S. ethanol industry has been expanding as fast as plants could feasibly be built and will likely continue to do so (Anderson et al. 2008).

State of Technology

Technologies for these types of biofuels have been improving, making them more cost effective and energy efficient. Nevertheless, in terms of energy efficiency, biofuels still only offer a very small gain over petrol, and at present, there is minimal reduction in GHG emissions from their production (Von Braun 2007b).

[1] Posted at http://www.globalsubsidies.org/article.php3?id_article=48&var_mode=calcul; see also FAO (2008g).

[2] See data posted at http://farm.ewg.org/farm/progdetail.php?fips=00000&progcode=corn.

Environmental Implications

Biofuel demand puts pressure on limited land and water resources. Increasing prices are leading to the diversion of food and feed crops to biofuel production. For example, more than one-quarter of the 2009 U.S. maize crop was used to produce biofuel (*Guardian* 2010). Energy crop production may also lead to the clear-cutting of forests.

Even without the new pressure of biofuels, the world is already facing land and water constraints. In the United States, food and feed demands on farmlands will more than double by 2050. And to carry out government plans for ethanol expansion would probably require use of lower-quality farmland that was put aside for conservation purposes. This could mean the loss of many wildlife species and dramatic soil erosion as low-quality land is put into intense use (Avery 2006).

A study by the International Energy Agency (IEA 2004) assessed the impact on cropland if the United States and EU expand biofuel production according to current plans. The results show that up to 43% of cropland would be needed for biofuel production. A blending target of 15% biofuel for transport fuel (a goal that is aimed for in a number of countries) would mean that, for instance, in Japan, 300% of the country's actual crop land would be needed to produce biofuels. So, Japan will only meet the blending target if it imports biofuels or biomass. In this study, IEA applied this blending target to 102 countries and found that only 36 have adequate water, land and food security status to meet it with current technologies.

GHG reduction from biofuel use compared with fossil fuels depends upon land use and the source of land for biofuels production. In particular, clearing of new land for biofuels can generate large emissions of GHGs, referred to as "carbon debt." This varies by the biome in which the land conversion occurs and the crop planted for biofuel production. A recent study by Fargione et al. (2008) looks at the case of production of sugarcane for ethanol on land cleared in the Brazilian Cerrado. They estimate that 17 years would be required to repay this debt (in other words, 17 times the carbon savings per year from using ethanol produced from sugarcane on the Brazilian Cerrado versus petrol equals the carbon debt). Payback periods for other biomes and other crops are much longer.

Some studies have actually estimated that biofuels will have a negative effect on GHG emissions. Searchinger et al. (2008) suggested that farmers in the United States will convert forest and grassland to new cropland to replace the grain (or cropland) diverted to biofuels. Using a worldwide agricultural model to estimate emissions from land-use change, they found corn-based ethanol to nearly double greenhouse emissions over 30 years. In developing countries there is even more pressure on farm land from current food crop needs. Thus the possibility of diverting land away from foods crops is very real.

Likewise, the scarcity of water in developing countries is a concern for agricultural productivity and for health and sanitation, even in the absence of expanding production of bioenergy crops. In underdeveloped rural areas, there is evidence to suggest that energy crop production could divert water from other needs. Rosegrant et al. (2006)

modelled the possible effects of continued development of biofuels and found that stress on regional water supplies increased only marginally. However, a significant acceleration of biofuels expansion in areas requiring additional irrigation could cause much greater water scarcity problems and further push up cereal prices.

To be competitive from an energy perspective, biofuels must be produced in a way that results in an output of energy greater than the amount of energy used to produce them – that is, they should have a highly positive energy balance. Maize ethanol, of which the United States is currently the largest producer, has been controversial because until recently it had a negative energy balance. In 2002, however, the U.S. Department of Agriculture stated that maize ethanol had achieved an energy output–input ratio of 1.34:1, thanks to more efficient cultivation and processing practices. Brazil's large ethanol industry based on sugarcane is well established as a net energy producer (Von Braun and Pachauri 2006).

In terms of GHGs, use of maize ethanol produced in the United States may reduce emissions by 10–30% compared with petrol, whereas ethanol produced from sugar or cellulose could reduce them by 90% or even more. Farmers can contribute to greenhouse gas reductions by adopting cultivation practices that use less petrol-based fertilizer and fuel and that sequester more carbon in the soil. The greatest potential for reducing GHGs lies in successfully converting cellulosic and lignocellulosic feedstocks – derived from, for instance, trees, grasses, crop residues and municipal waste – into ethanol. In addition, making biofuels from these sources would not lead to tradeoffs among food, feed, fibre and fuel uses. These feedstocks are, however, more difficult to process than starch or sugar crops, and it is not clear that their production will expand significantly in the near future (Von Braun 2007b). A major R&D effort is needed to develop cellulosic ethanol, which could contribute to a much greater expansion in biofuels without adverse consequences (Von Braun and Pachauri 2006).

Nutrition Impacts

Biofuel production can have negative impacts on nutrition through three main pathways: increased GHG emissions, direct effects on health and sanitation and reduced food availability and associated price effects.

As explained in Chap. 4, biofuel production can increase malnutrition to the extent that it exacerbates climate change through, for example, burning of forests to clear land for production of bioenergy crops (UN-Energy 2007; Easterling et al. 2007) or water shortages and water contamination. Use of sugarcane as a feedstock, as in Brazil, is particularly water-intensive. The availability of water in developing countries is a cause of concern for agricultural productivity and for health and sanitation. In underdeveloped rural areas, where there is very high demand for access to water for irrigation, cooking and drinking, bioenergy crop production would compete for scarce water supplies. When climate change intensifies the dry season, water supplies become even scarcer. Acceleration of biofuel production in such areas increases

demand for irrigation water from already depleted aquifers, exacerbating water shortages and increasing cereal prices. Poorly managed use of inputs to cultivate energy crops (or in cultivation of crops for food, feed and fibre uses, for that matter) could pollute drinking water, adversely affecting human and animal health (UN-Energy 2007; Easterling et al. 2007; Rosegrant et al. 2006).

Diversion of Food and Feed to Fuel and Rising Food Prices

Biofuel demand puts additional pressure on limited land and water resources. In developing countries, there is intense pressure on farm land from current food crop needs, but expanded bioenergy crop production could divert land away from food crops.

Diverting cereal from food and feed to fuel use has the potential to reduce food availability. In addition, there is a risk that food and feed production will be consigned to less productive land, which may result in lower yields, while the most fertile hectares support high-value fuel crops.

The current consensus is that rising demand for biofuels contributed to the sharp increases in food prices in 2006–2008. Based on FAO's latest analysis, global expenditures on imported foodstuffs in 2007 rose by about 29% above the record of the previous year. The bulk of the increase was accounted for by rising prices of imported cereals and vegetable oils – commodity groups that feature heavily in biofuel production (FAO 2008g). Further, IFPRI estimates that rising bioenergy demand contributed significantly to the jump in global food prices between 2000 and 2007. Increased biofuel demand, compared with previous historical rates of growth, is estimated in IFPRI's analysis to have accounted for 30% of the increase in weighted average grain prices. The impact was even higher for maize prices, for which growing biofuel demand is estimated to have accounted for 39% of the real increase (Rosegrant 2008). The effects of higher commodity prices on national economies depend on country-specific circumstances. Higher commodity prices will have negative consequences for net food importers. And for low-income food deficit countries, food import bills will rise, precipitously in some cases. In addition, even for countries that are net food exporters, many smallholders and agricultural labourers are net purchasers of food. For example, empirical evidence from a number of Sub-Saharan African countries in no case finds a majority of farmers or rural households[3] to be net food sellers (FAO 2008g). Beyond studies based on modelling and projections, it is essential to have more empirical evidence on the actual impact of higher prices than is presently available.

A rise in the food bill for households that are net buyers of food will tend to result in reduced demand for foods of higher value and increased demand for staples within a given set of taste and food preferences. Bennett's Law describes this relationship between income and the share of starchy staples in the diet (Bennett 1941).

[3] Depending on the survey definition (FAO 2008g).

In many situations, depending upon local market conditions, food price increases may lead not only to a reduction in the average number of meals and the amount of food consumed but also to the substitution of cereals, root crops and cheaper cuts for higher value foods such as animal products, legumes, processed foods, fruits and vegetables. For rural communities, greater reliance upon gathered seasonal wild foods may occur. As prices continue to rise, poor people will experience a worsening of dietary quality and micronutrient intake and extremely poor people will experience an additional decrease in food energy consumption. Decreased overall food consumption in terms of calories, as well as of other essential nutrients including protein, fat and micronutrients, can lead to weight loss; impaired developmental, mental and physical growth in children and either sub-clinical or clinical micronutrient deficiency in all age groups. For adults, prolonged periods of inadequate nutrition reduce productivity through reduction in the physical ability to do work both by increasing the number of days taken by sick leave and reducing the rate and the amount of work that can be accomplished (Geissler and Powers 2005). As *The Economist* magazine (2008) editorialized, this can have devastating effects on nutrition, poverty and political stability:

> Famine traditionally means mass starvation. The measures of today's crisis are misery and malnutrition. The middle classes in poor countries are giving up health care and cutting out meat so they can eat three meals a day. The middle poor, those on $2 a day, are pulling children out of school and cutting back on vegetables so they can afford rice. Those on $1 a day are cutting back on meat, vegetables and one or two meals, so they can afford one bowl. The desperate – those on 50 cents a day – face disaster.
>
> Roughly a billion people live on $1 a day. If, on a conservative estimate, the cost of their food rises 20% (and in some places, it has risen a lot more), 100 million people could be forced back to absolute poverty. In some countries, that would undo all the gains in poverty reduction they have made during the past decade of growth. Because food markets are in turmoil, civil strife is growing; and because trade and openness itself could be undermined, the food crisis of 2008 may become a challenge to globalisation.

The extent to which households and individuals are affected depends considerably on their consumption behaviour and income status prior to the price shock (FAO 2008g). For example, Fig. 5.1 compares Malawi's and South Africa's responses to a 30% increase in the aggregate price of food (a modest escalation compared to the actual price rises of 2006 to early 2008). Using the price elasticities of demand[4] of different food groups for each country, we can examine the country-specific impact of increased food prices. South Africa is a middle-income, net maize exporter. Malawi, in contrast, is a net maize importer with high prevalence of food insecurity and malnutrition. Figure 5.1 shows the different effects of the price increase in the two countries.

The baseline data for Malawi in 2003 estimate *per capita* calorie consumption to be just above the 2,100 kcal daily minimum required for an adult. Though we see slivers of consumption of fruit, dairy and meat, the bulk of calories come from cereals

[4]The percentage change in quantity of a good demanded in response to a 1% change in price (holding constant all the other determinants of demand, such as income).

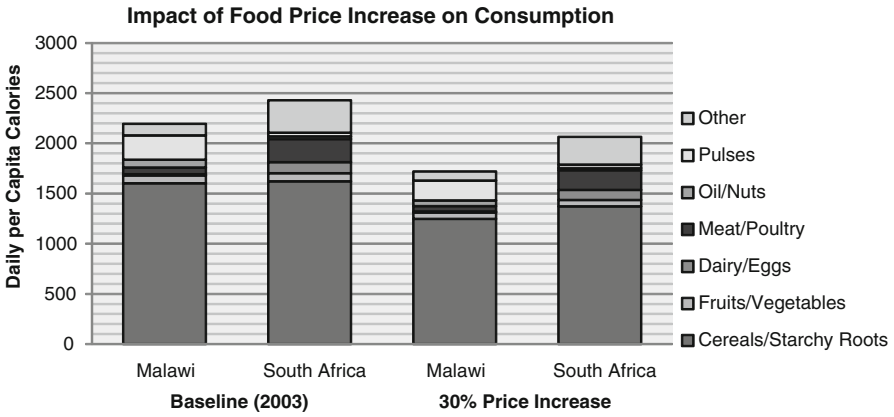

Fig. 5.1 Impact of food price increases on calorie consumption in Malawi and South Africa (Notes: Food and calorie data are taken from FAO country food balance sheets. Elasticities were estimated using IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (*IMPACT*). In this figure, own-price elasticities by country and specific food groups are used. (Source: Authors' calculations using FAOSTAT database and IFPRI IMPACT model)

and other starchy staples and pulses, indicating a lack of dietary diversity. The price increase squeezes consumption in all food groups, worsening both total energy intake and dietary diversity. The largest drop is seen in cereals and starchy roots, significantly decreasing calorie consumption well below the required minimum.

On the other hand, South Africa starts out well above the minimum daily calorie requirements, with much higher consumption of meat as well as dairy and eggs, though still limited consumption of fruits and vegetables. With the price increase, calorie consumption is shown to decrease in South Africa as well; however, the higher status at baseline of food energy consumption and dietary diversity mean that the impacts are not as damaging for nutrition status; calorie consumption remains close to the minimum required level and meat and dairy products still form a substantial part of the diet.

Figure 5.1 gives a revealing snapshot of how food price increases will have different effects on nutrition and food security depending on the baseline consumption basket. However, actual household food budgeting is more complex than a simple response to own-price elasticity. Furthermore, price changes due to rising biofuel demand and other factors are not equal across all foods. Thus changes in the price of one food may impact spending on another food, as households make decisions according to budget and preferences. For instance, when the price of maize rises, rather than simply decreasing consumption of starchy staples, a household may substitute another less preferred staple. Figure 5.2 uses own and cross-price elasticities[5] for cereals and starchy roots to illustrate this phenomenon in Malawi. Consumers

[5]Cross price elasticity: the percentage change in demand for a good that occurs in response to a percentage change in price for another good.

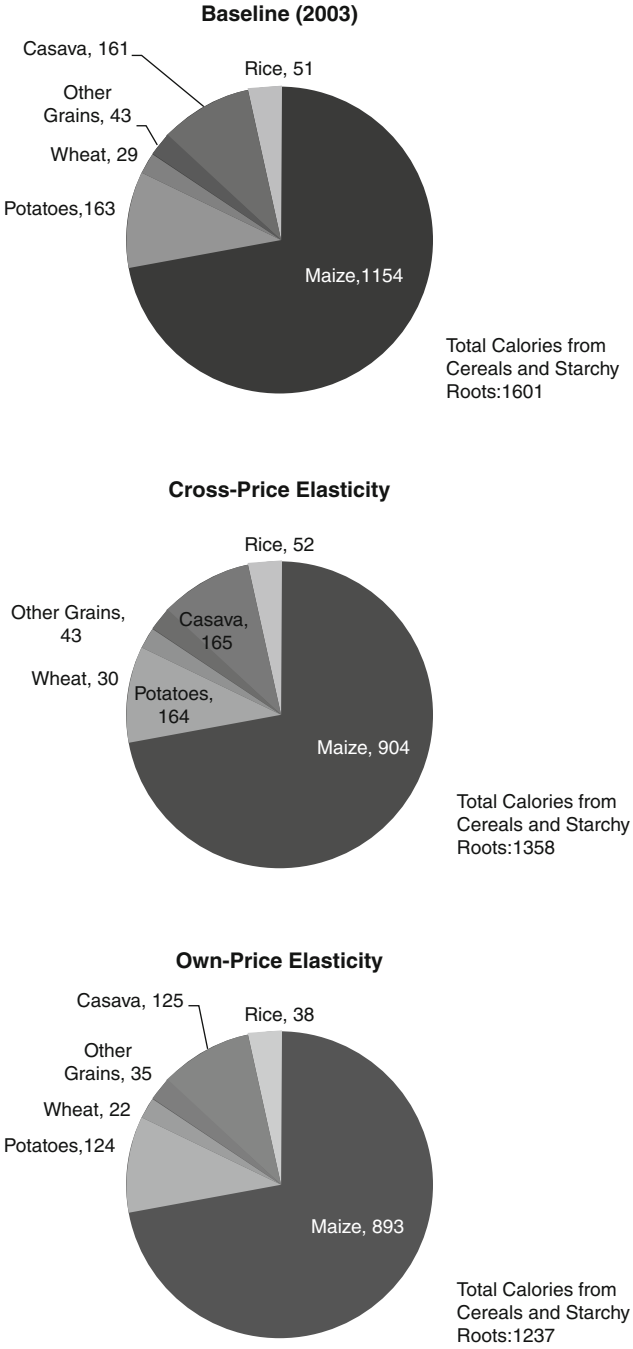

Fig. 5.2 Impact of price increases on root and grain consumption in Malawi: own and cross-price elasticity (Source: IFPRI IMPACT model)

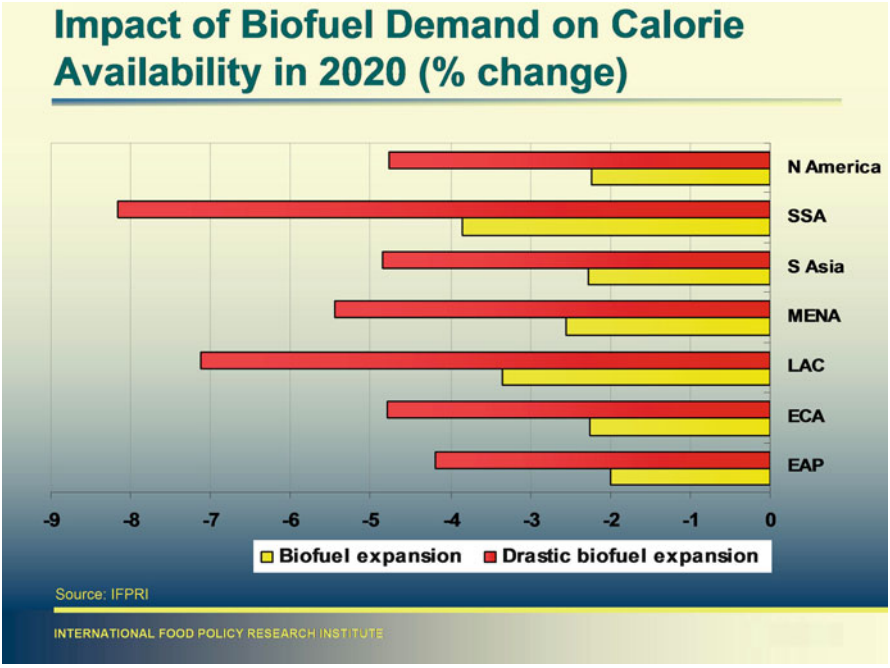

Fig. 5.3 Impact of biofuel demand on calorie availability in 2020 (% change) (Source: IFPRI IMPACT model)

substituted other starchy staples for maize when the latter's price increased by 30%. Although total energy intake is not reduced in this scenario, dietary diversity decreases, compromising nutrient intake and increasing risk of malnutrition.

Figures 5.3 and 5.4 report projections, using the IFPRI IMPACT model (see Appendix 2), of the effects of two different scenarios of biofuel demand on calorie availability and underweight preschool children in 2020 (as compared to 2000). The first scenario is based on actual biofuel investment plans, with assumed biofuel expansion in countries that have not specified plans. The second scenario assumes a doubled rate of biofuel expansion (Von Braun 2007b).

Mitigation of Negative Impacts of Biofuels

Appropriate policies can make bioenergy development more pro-poor and environmentally sustainable. Poor farmers might be able to grow energy crops on degraded or marginal land not suitable for food production, but appropriate soil and fertilizer management practices will have to be tailored to soil type and climatic conditions; otherwise bioenergy production may aggravate land degradation, generate GHG emissions and cause environmental problems through soil erosion and degradation

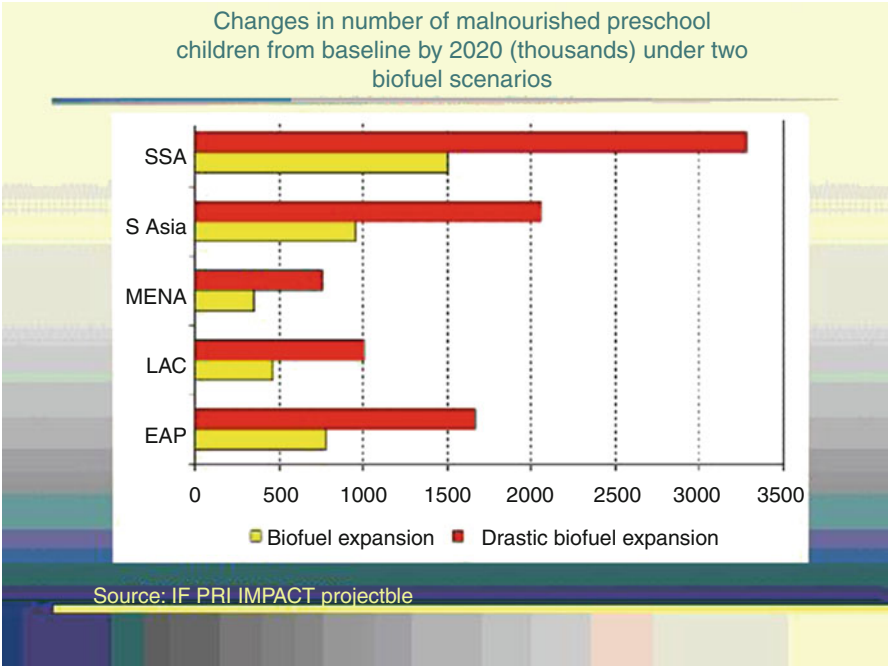

Fig. 5.4 Changes in number of malnourished preschool children from baseline by 2020 (thousands) under two biofuel scenarios (Source: IFPRI IMPACT model)

of water quality. Also, further investment is needed in developing technologies to convert cellulose to energy. Progress in this area could provide developing-country farmers, including smallholders, with a use for crop residues like stalks and leaves, which would be converted into ethanol for electricity, thereby benefiting both poor farmers with additional income and also poor consumers with cheaper energy. Improved conversion processes have positive food security implications because of their potential to improve access to food and their potential to reduce the impact of biofuel production on food systems and prices (Von Braun and Pachauri 2006). However, if the valuation of crop residues for biofuel increases significantly, this might reduce the availability of green manure for fertilizer.

Development of International Standards and a Regulatory Regime

Based on the implications that are now emerging, it is increasingly recognized that a more consistent set of policies and approaches towards biofuels is needed. Policies must be aimed at grasping the potential opportunities offered by biofuels, while simultaneously managing the risks they indisputably present. Policies should strive to make

biofuels "net carbon dioxide positive", protect forest, land, water and biodiversity from depletion and environmental damage and prevent excessive new loadings of pollutants. Policies must give priority to the right to food over biofuel production, protecting poor and food insecure people and focusing on the problems created by food deficits and dependence on oil imports for poor and hungry people. Policies should be developed with appropriate international coordination, to ensure that the international system supports broader social goals for agricultural development and poverty and hunger reduction (FAO 2008g; Eide 2008). In sum, biofuel policies should address the following key areas: environmental sustainability, food and nutrition security, agricultural development, energy security, reduction of GHGs and threats to land, water and biodiversity (FAO 2008g).

One way to achieve these biofuel policy goals is through the use of global standards. For example, an internationally recognized regulatory regime could be developed under the auspices of the Convention on Biological Diversity. Negotiating a biofuels protocol under the Convention will likely be a long and difficult process, but arriving at internationally agreed-upon rules to protect food and nutrition security and the environment would be worth the effort.

In the interim, a certification process, similar to that for "fair trade" coffee, "conflict-free" diamonds and "green" products could be developed, in order to constrain excessive exuberance on cultivating crops for use in biofuel. This would involve collaboration among civil society organisations, the private sector and governments to develop such standards. Certification would indicate that biofuel products were developed under appropriate energy, environmental and food security conditions, and would be subject to periodic independent audits. As an example, the Roundtable on Sustainable Biofuels (2009) has developed a third-party certification system for biofuels sustainability standards, encompassing environmental, social and economic principles and criteria for which biofuels producers can apply.

Sustainable and Pro-poor Production of Biofuels

In order to make a difference in the lives of poor people as both energy producers and consumers, and to make strong environmental and economic contributions, biofuel technology needs further advancement, and investments and policies facilitating agricultural innovation and trade will have to be considered (Von Braun and Pachauri 2006).

Cellulosic biofuel technologies are of great importance in enabling developing countries to benefit from biofuel demand. If these technologies, which rely on by-products of food and feed production and feedstock produced on nonfood-producing marginal lands, become commercially viable and widely adopted in about a decade, biofuels' impact on prices and food systems could be significantly mitigated. IFPRI's "aggressive biofuel growth" scenario for large-scale bioethanol and biodiesel production shows significant increases in world prices for the various feedstock crops used (Von Braun and Pachauri 2006).

In addition to exploring cellulosic conversion processes, biofuel technologies can also focus more on innovative feedstock solutions. For example, an oil-bearing crop called *Jatropha curcas* produces a seed that can be converted into non-polluting biodiesel. The crop is of special interest because it grows in infertile soil, even in drought conditions, and animals do not graze on it. India has 60 million hectares of waste land, of which it is estimated that half might be used for jatropha cultivation. The cost of producing biodiesel from jatropha is just Rs. 20–25 (US$0.43–US$0.54) per litre. The Energy and Resources Institute (TERI) of India announced in February 2006 that it is undertaking a 10-year project, in conjunction with British Petroleum, to cultivate 8,000 ha of wasteland with jatropha and install the equipment necessary to produce nine million litres of biodiesel a year. The project will include a complete analysis of the social and environmental impacts of the approach (Von Braun and Pachauri 2006). Mozambique is also exploring the option of outgrower cultivation of jatropha.

Because biofuel production is labour-intensive, it could be a boon to rural areas with abundant labour. In Brazil, one study showed that in 1997, the ethanol sector employed about one million people. Thirty-five percent of these jobs were temporary harvesting jobs employing many poor migrant labourers from the northeast (Brazil's poorest region), but 65% were permanent (Von Braun and Pachauri 2006). Furthermore, the Brazilian government offers tax incentives to biodiesel producers to purchase feedstocks from small family farms in poor regions, thus including smallholders in the biofuel value chain (FAO 2008g). Including production incentives for poor farmers and developing employment opportunities for the rural sector have positive implications for food and nutrition security, and are good illustrations of pro-poor biofuel policy.

Clearly, smaller-scale and rural-based production will open up opportunities for biofuel to be pro-poor. But how can smallholders organize effectively? One answer is via contract farming schemes where groups of farmers coordinate to grow and market biomass to processing plants (Hazell 2006). Such outgrower schemes are considerably more pro-poor than plantation-based production, as they require more labour and permit smallholders, rather than plantation owners, to reap land rents. Moreover, such schemes have the potential for technological spillover to other crops, including food crops and other cash crops, with additional growth and poverty reduction benefits resulting.

One country considering this type of outgrower scheme is Mozambique, which has already made substantial investments in biofuels. Currently, some six million hectares are planted to biofuel crops, and the government has received requests for use rights (as all land is state-owned) for over 12 million additional hectares for this purpose. Expansion could occur either via plantation production of sugarcane for ethanol or outgrower cultivation of jatropha for biodiesel. Preliminary results from an IFPRI macroeconomic analysis suggest that either option may lead to increased welfare and reduced poverty, due to income-earning opportunities, with positive implications for food security (Arndt et al. 2008). However, technologies and institutional arrangements are important to determining the impact of biofuel expansion on poverty. Jatropha is more environmentally friendly and less susceptible to economies of scale

than sugarcane (Arndt et al. 2008). It is thus far easier for smallholders to cultivate and may hence be the better expansion choice from a pro-poor perspective.

If smallholders have an opportunity to cultivate biofuel crops and gain from favourable prices, the subsequent increased income would enhance their ability to purchase food. In addition, biofuel crop production may help create on-farm employment opportunities, jobs at processing facilities, opportunities to open small-scale processing enterprises and, indirectly, other non-farm jobs through multiplier effects. For example, in Mauritius, processing plant workers hold shares in the Sugar Investment Trust and receive dividends that give them a stake in the industry (FAO 2008g).

Whether the on-farm employment impact is large depends on the labour requirements compared to those of alternative land uses. If the land used for energy crops was previously unused, then sowing it to biofuel feedstock will create new employment. However, if the land was already under cultivation, and the biofuel feedstock is less labour-intensive than the previous crops, there will be net losses in employment (FAO 2008g). Even within a single country and for one individual crop, labour intensity can vary. In Brazil, for example, sugar-cane production uses three times as much labour in the northeast as it does in the centre-south (Kojima and Johnson 2008; FAO 2008g). Net employment effects have implications for access to food.

A considerable body of research indicates that women are more likely than men to use income for the wellbeing of children, including nutrition (Quisumbing 2003). Biofuel development efforts therefore need to take women's role in agriculture and food and nutrition security into account so as to generate a better outcome from the point of view of equity, nutritional outcomes and overall performance (FAO 2008g). There may be barriers to female farmers taking advantage of opportunities created by biofuel demand. Women often have less access than men to land, water, credit, inputs and services, even when they are responsible for much of the agricultural work. In Cameroon, for instance, women comprise 75% of the agricultural labour force, but own less than 10% of the land, and in Brazil, women own only 11% of land under cultivation. Disparities in land-tenure rights and access to credit and inputs make it difficult for women – especially female heads of household – to benefit from energy crop production. Even use of marginal lands for biofuel crops may work against women. Such land is often considered common property and in both South Asia and West Africa, women are responsible for gathering on and use of common property resources, but often do not have decision-making authority over these public areas. Thus, expansion of bioenergy crop production on such land could adversely affect women's ability to produce food (Rossi and Lambrou 2008; FAO 2008g).

FAO Activities

FAO has a number of initiatives underway that seek to assure that bioenergy development in developing countries does not undermine food security. The Bioenergy and Food Security (BEFS) Project seeks to mainstream food security concerns into efforts to develop bioenergy production and processing. BEFS is currently working

in Peru, Tanzania and Thailand, and will establish national bioenergy teams that will review how bioenergy development will affect food systems and food security (FAO 2008e). The International Bioenergy Platform (IBEP) seeks to link bioenergy projects in developing countries to sustainable development, energy security, poverty reduction and climate change mitigation. IBEP offers guidance to policy makers on both the potential synergies and possible conflicts between bioenergy and food security, as well as on approaches to assessing the social and environmental impacts of bioenergy (FAO 2006b).

Chapter 6
Policies and Programmes for Improving Nutrition

Brian Thompson, Marc J. Cohen and Maria Cristina Tirado

Abstract This chapter discusses policies and programmes and provides a number of specific examples for improving food and nutrition security at the international, regional and country level. This chapter also reviews policy options for responding to threats to nutrition from climate change and growing demand for biofuel.

Keywords Governance • Right to Food • FAO Anti-Hunger Programme • Comprehensive Africa Agriculture Development Programme • Fome Zero • Twin-track approach • Safety nets • Community-based programmes • Education • Conditional cash transfers • Early childhood nutrition • Asset insurance

International Initiatives

For nearly two decades, the international community has repeatedly reaffirmed its commitment to eradicating malnutrition and assuring food security for all at high-level meetings attended by heads of state and government. These meetings have issued declarations and detailed plans of action, setting goals and timetables for achieving significant improvements. The 1992 International Conference on Nutrition, sponsored by FAO and the World Health Organization (WHO), met in Rome to

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discuss ways to eradicate hunger and malnutrition and unanimously adopted a World Declaration and Plan of Action for Nutrition (FAO 1992). Subsequently, the World Food Summit (FAO 1996) and its follow-up, the World Food Summit: *five years later* (FAO 2002), affirmed the ICN goals and adopted the Rome Declaration on World Food Security and the World Food Summit Plan of Action, which pledged concerted efforts towards eradicating hunger and as an essential first step, set a target of reducing the number of hungry people by half from 1990 to 1992 levels by 2015. The Millennium Summit (2000) and a series of follow-up meetings have repeated the commitments to achieve food security and good nutrition for all. A major milestone was the unanimous adoption, after 2 years of negotiations, of the Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security (Right to Food Guidelines) by FAO's top governing body, the FAO Council, in 2004 (FAO 2005b).

All of these declarations and plans of action strongly endorsed a rights-based approach to food security and nutrition. This entails a change in perspective: steps to achieve food security are no longer a matter of policy discretion but a legal obligation. Moreover, a rights-based perspective asserts that the right to food is not only a function of improving the availability of key livelihood assets such as the means to produce or procure food. It also requires institutions and processes that empower people, increase transparency and accountability and ensure access to those assets for poorer and more vulnerable groups. This perspective has implications for the formulation of policies, laws and programmes – in terms of both content and process. Perhaps most importantly, the rights-based approach frames the achievement of food security and good nutrition as integral to the state's efforts to protect and promote internationally recognized human rights, including the right to life, the right to adequate food, the fundamental right of everyone to be free from hunger and the right to the highest attainable standard of health. In other words, a rights-based approach to food security and nutrition considers states the primary duty-bearers with regard to human rights and it empowers citizens – as the people endowed with rights – to hold states accountable for their actions. In particular, this framework stresses the importance of empowering mothers to nourish themselves and their children with support from their families and communities, as well as their governments.

Despite the repeated agreement of the world's leaders on the urgent need to reduce hunger and malnutrition, progress in achieving the internationally endorsed goals and targets has been extremely disappointing, notwithstanding great strides in a number of individual countries (see Chap. 3, above).

On the positive side, since the 1990s, widespread consensus has developed on the causes and consequences of malnutrition and therefore on the tools necessary to overcome it. The conceptual framework used by the Food Insecurity and Vulnerability Information and Mapping System, managed by FAO (see Fig. 3.1) and the closely related UN Children's Fund (UNICEF) conceptual framework reflect this consensus. In particular, this framework insists that the ultimate causes of food insecurity and undernutrition are social, economic, cultural and political. Therefore, although technical nutrition considerations and direct nutrition interventions remain crucial to devising solutions, it is also absolutely essential that efforts to achieve food and

nutrition security address these ultimate causes. Among other things, this requires policies that treat poor, food-insecure and malnourished people as primary actors in creating and implementing the solutions, not mere passive vessels into which technical quick-fixes are to be poured. This perspective is consistent with the rights-based approach.

There are also regional food and nutrition security initiatives. For example, the African Union (AU) has adopted the New Partnership for Africa's Development (NEPAD) as a vision and framework for development on the continent. NEPAD includes a Comprehensive Africa Agriculture Development Programme (CAADP) and one of its strategic pillars focuses on increasing food supply and reducing hunger, with a nutrition component. The AU has devised a regional nutrition strategy under this framework. However, implementation has suffered from inadequate leadership, lack of capacity within the region (including at the AU Commission and in the regional offices of international organizations, as well as within national governments) and inadequate financial resources.[1]

At the national level, many developing countries have issued national policies and plans of action on nutrition. For example, a recent review of Poverty Reduction Strategy Papers (PRSPs) for 40 developing countries, half of them in Sub-Saharan Africa, found that over 70% identified malnutrition as a key development issue, and many proposed strategies to address nutrition problems. However, only 35% actually included budget allocations for explicit nutrition activities. Further, many of the PRSPs reviewed did not incorporate appropriate specific actions to address the problems identified even if they did include a nutrition strategy (Shekar and Lee 2006). This analysis is significant, since PRSPs, developed through multi-stakeholder processes that include developing-country governments, civil society and donors (particularly the international financial institutions) have become a key device for planning and executing development cooperation.

At the local level, community-centred, food-based strategies for alleviating and preventing malnutrition are considered a best bet for improving nutrition. When communities are empowered to take action through a process of social mobilisation, nutrition improvement strategies can be translated into action on the ground (Thompson 2004). For example, homestead gardening has significant potential to improve nutritional status when social marketing and education components are included in the project design (Arimond et al. 2007).

In sum, accelerated progress against food insecurity and malnutrition requires that governments put appropriate policy responses much higher on their agendas, with adequate resources provided. Donors must provide technical and financial support to these efforts. The potential impacts of climate change and bioenergy demand, discussed in Chaps. 4 and 5 above, increase the urgency of action. The remainder of

[1] The discussion of regional initiatives in Africa is drawn from the draft report of the Africa regional meeting held at the 35th Annual Session of the Standing Committee on Nutrition of the U.N. System, Hanoi, Vietnam, March 3–6, 2008; see SCN (2008).

this chapter will examine promising policies and programmes to reduce food insecurity and malnutrition, both in general and in light of the likely impacts of climate change and bioenergy demand.

Policies and Programmes

There is broad consensus on the strategies for ending hunger. These have emerged from a number of international conferences and summits referred to above. The Millennium Summit processes, FAO's Anti-Hunger Programme, the report of the UN Millennium Project Hunger Task Force (2005) and NEPAD's CAADP all point in the same direction. Harmonised, large-scale, multi-component programmes are required if we are to make a difference. Harmonisation means that aid agencies and donors must work together to reinforce national programmes built around PRSPs, national Alliance Against Hunger and Malnutrition (AAHM) programmes or equivalent national MDG programmes. The key elements of such programmes are:

- create an enabling environment to promote peace, eradicate poverty and remove gender inequality;
- promote a fair and market-oriented world trade system;
- increase investments in human resources, sustainable food production systems and rural development;
- implement policies to improve physical and economic access by all to sufficient, nutritionally adequate, wholesome and safe food and its effective utilization;
- focus on participatory and sustainable agriculture, recognising the multifunctional nature of agriculture;
- use a "nutrition lens" to direct multi-sectoral actions to improve household food security; improve food quality and safety; prevent, control and manage infectious diseases and micronutrient deficiencies; promote appropriate diets, including breast-feeding and healthy lifestyles; provide care for the vulnerable, including people living with HIV/AIDS; introduce productive safety nets and provide direct assistance;
- prevent and prepare for emergencies; and
- build anti-hunger alliances.

Governance Issues

A number of governance issues have a considerable bearing on food and nutrition security. First, in many developing countries, there is a serious problem of institutional design. Both food security and nutrition are multi-sectoral issues, but developing country governments are almost always composed of sectoral ministries that frequently view budgetary allocation as a zero-sum game. In such an environment, it is difficult to achieve cross-sectoral collaboration. In the case of nutrition, whether

responsibility falls to an inter-ministerial committee or a single ministry, it is seldom the top priority at the ministerial level. Nor do senior policy-makers tend to recognize the costs of undernutrition. In many developing countries, a lack of adequate human resources and "nutrition champions" complicates these problems (Benson 2008). Furthermore, some have argued that "fragmentation" of the international nutrition system (UN and bilateral donor agencies, academic institutions, civil society organizations and private firms) impedes progress, as guidance can be incoherent and programme evaluation weak (Morris et al. 2008: 608).

Second, given these institutional issues, donors and developing-country governments have failed to make food and nutrition security a high policy priority, despite repeated pledges to do so. Annual donor funding for basic nutrition projects and programmes in low- and middle-income countries has run at less than US$300 million during the 2000s, compared to US$2.2 billion per year for HIV/AIDS and several billion dollars annually in food aid (Morris et al. 2008). In real terms, aid to agriculture is about half the level of 25 years ago (FAO 2006a). Governments of low-income countries devote an average of 19% of their budgets to military expenditures, compared to less than 5% for agriculture. Military expenditures account for 2.6% of GDP in low-income countries, compared to 1% for public health spending (World Bank 2007a; FAO 2001).

However, there are some indications that priorities are changing. CAADP seeks to boost African government expenditures on agriculture to 10% of their budgets, and to increase agricultural growth rates to 6% per year. In addition, the World Bank is putting renewed stress on agriculture as a development priority after years of relative neglect and has also put greater emphasis on nutrition in recent years (World Bank 2006, 2007b). Box 6.1 illustrates the difference it makes when a government puts food and nutrition security high on its policy agenda.

Third, current food price volatility offers an important rationale for developed-country governments to eliminate trade barriers and domestic farm subsidies that depress world market prices. A fair global trading system can help advance food and nutrition security (Von Braun 2007a).

Finally, there is an urgent need to reform global humanitarian response. Addressing hunger crises depends in part on more effective global peace-making and conflict resolution, as well as more timely response to early warnings of natural disasters. The current system depends on the *ad hoc* willingness of donors to meet appeals for assistance. Moving towards a more insurance-oriented approach that guarantees a response to emergency needs would protect the right to food in emergency situations (Hopkins 2009).

A Revitalised Twin-Track Approach

At the International Conference on Financing for Development held in Monterrey, Mexico, in 2002, FAO, the International Fund for Agricultural Development (IFAD) and the World Food Programme (WFP) agreed upon a practical and affordable

Box 6.1 Cutting Hunger in Brazil

Nearly one of every five Brazilians lives in poverty and 8% of the population (14 million people) is undernourished. Between 2003 and 2009, 7% of Brazilian children were stunted (down from 11% in 1996), but the figure remained significantly higher in the north-east and among indigenous children. High rates of micronutrient malnutrition are found among children in the north and north-east and among indigenous children.

Beginning in the early 1990s, Brazilian civil society and the Catholic Church (to which 75% of Brazilians belong) began to engage in a combination of hunger relief activities and food security advocacy. Civil society remains actively engaged in food security policy. Furthermore, since the election of President Luiz Inácio Lula da Silva in 2002, the Brazilian government has made its *Fome Zero* (Zero Hunger) programme a top policy priority and has emphasized achieving the progressive realization of the right to adequate food. The government has taken many of the steps recommended in the Right to Food Guidelines (FAO 2005b). The centrepiece of *Fome Zero* is *Bolsa Familia*, a conditional cash transfer programme that benefits 42 million low-income Brazilians. It provides cash to poor and extremely poor families throughout Brazil on the condition that children attend school and receive routine vaccinations, and that pregnant women receive pre-natal care. In addition to these conditional grants, unconditional "base" cash transfers are made to all families in extreme poverty. *Bolsa Familia* attempts to (1) reduce immediate poverty through the cash transfers, (2) break the inter-generational transmission of poverty with the transfer conditionalities, which are designed to increase human capital via improved health and education outcomes and (3) empower beneficiary families by linking them to complementary services.

Thus *Fome Zero* includes both direct assistance and long-term poverty alleviation. It requires coordinated action by all areas of government at federal, state and municipal levels as well as extensive participation of civil society. The programme is considered a model of success and has been shown to have improved outcomes for a variety of basic needs indicators, including education. In terms of food and nutrition security, recipient families report access to increased quantities of food and more diverse diets.

In addition to *Fome Zero,* Brazil has one of the largest school feeding programmes in the world and provides free meals in all public schools. The programme emphasizes the use of locally produced fruits and vegetables and tries as much as possible to purchase food from local smallholders, in order to bolster small farmers' incomes as well as school enrolments and the nutrition of school-aged children.

The government has also set ambitious anaemia control targets. Since April 2004, all wheat and corn flour in Brazil is by law fortified with iron and folic acid.

The combination of this high-priority targeted effort to reduce poverty and hunger and strong economic growth has paid dividends in Brazil. Inequality and poverty have declined, while food security has increased.

"twin-track approach" for combating hunger and poverty and for reaching the World Food Summit goals and the MDG targets. Track one is to strengthen the productivity and incomes of hungry and poor people, targeting the rural areas where the vast majority of them live and the agriculture sector on which their livelihoods depend. Track one involves improving agricultural productivity through investing in agriculture and encouraging the expansion of domestic agricultural production, improving infrastructure, distribution, preservation, processing and storage systems. It includes:

- simple, inexpensive technology packages (water management, soil fertility management, use of green and animal manures, cover crops, crop rotation including legumes, agroforestry and conservation tillage);
- rural infrastructure (roads, water provision);
- improved small-scale irrigation and soil quality;
- sustainable natural resource use and management (including forestry and fisheries);
- market and private sector development;
- food safety and quality; and
- Farmer Field Schools to provide participatory farmer "training of trainers".

Track two involves ensuring that vulnerable population groups – the hungry and malnourished, the landless, marginalised people, smallholders, fishermen and urban poor people – are protected from falling further into poverty and food insecurity. Reducing risk to these groups can be accomplished via a variety of mechanisms, namely:

- unemployment and pension benefits;
- targeted conditional cash transfers or food voucher programmes for the most vulnerable, perhaps in exchange for a socially desirable activity such as children attending school or visiting health centres and receiving vaccinations (see Box 6.1);
- food-for-work or food-for-education using locally sourced food where possible;
- mother-and-infant feeding programmes (including nutritional supplements) using locally sourced food where possible;
- school gardens and school meals, ensuring school attendance with a focus on female students;
- feeding and other support programmes for people living with HIV/AIDS, their families and orphans; and
- timely provision of emergency rations.

Although the twin-track approach was proposed primarily as a way to combat hunger, many of its key elements contribute to several MDGs simultaneously. For example, introducing improved water management, use of green manures, agroforestry and other low-cost, simple technologies not only increases the productivity and incomes of small farmers, but also enhances their role as custodians of land, water, forests and biodiversity. Similarly, investing in rural infrastructure such as roads and improved water facilities can reduce the lethal impact of water-borne illnesses, improve access to health care, prevent thousands of needless child and maternal

deaths and open links to markets where farmers can sell surplus produce and acquire fertilizer and other inputs at reasonable prices. Measures to provide direct access to food for the neediest families such as feeding programmes for mothers and infants target the hub of the vicious cycle that perpetuates hunger and malnutrition from one generation to the next, undermining maternal health, stunting children's physical and cognitive growth, impairing school attendance and performance and impeding progress towards gender equality and the empowerment of women.

However given the unacceptably slow progress in reducing hunger and malnutrition (see Chap. 3) and the recent unprecedented volatility in staple food prices, unless targeted direct action is taken to ease the constraint of low purchasing power of consumers and improve diets, malnutrition levels are unlikely to fall and may even rise in some regions.

High food prices exacerbate food insecurity and create social tensions, but high agricultural commodity prices also present a potential opportunity for re-financing agriculture, especially for developing countries. To ensure that small farmers and rural households benefit from higher food prices, a favourable policy environment is needed that relaxes the constraints facing the private sector, farmers and traders. This means reversing the decline in the level of public resources spent on agriculture and rural development and investing more in agriculture. Investments by the private sector in agriculture and related sectors would be forthcoming if appropriate investments in public goods are put in place. With the rise in food prices, now is the time to invest in irrigation and agricultural research and set the stage for rapid productivity growth targeted to lift millions out of poverty and hunger, particularly in Sub-Saharan Africa.

Improving and Increasing Investments in Agriculture

At the national and regional level, policies should consider the rebuilding of foodstocks, especially in light of the alarming decline in stocks of cereals and other staples. Such food security stocks can not only help manage price volatility, but can help address humanitarian emergencies. Governments could consider holding a mix of cash and commodities in reserves. In addition, the development of commodity exchanges and futures markets, as in Ethiopia, may likewise offer a means to moderate price volatility. It is important to note that establishing such exchanges requires a transparent system of accounting, and highlights again the need for government buy-in regarding its responsibility to create and sustain food security.

The development of well-functioning and well-integrated markets for agricultural inputs, commodities and processed goods, especially in rural areas, will contribute enormously to poverty alleviation, food security and the overall quality of life in developing countries. Market performance improves and marketing costs fall when the government no longer monopolizes trade and a competitive private sector emerges. Yet, as mentioned above, even as the government reduces its role, competent and honest 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; and
- public health and safety are maintained.

If developing-country governments implement credible and sustainable macroeconomic policies, these will provide a favourable environment for savings and investment and accurate and transparent incentives for consumers and producers alike (Kherallah et al. 2002).

The international community needs to take immediate action to defuse the current world food emergency and re-invest in nutrition-sensitive agriculture, thereby preventing similar dramatic situations from occurring in the future. More food needs to be produced where it is urgently needed to contain the impact of volatile prices on poor consumers and simultaneously boost productivity and expand production to create more income and employment opportunities for rural poor people. Smallholder farmers need to be specifically targeted as beneficiaries to ensure they have proper access to land, water resources, credit, essential inputs such as seeds and fertilizers and services such as research, extension and training. In some instances, subsidies targeted to poor farmers may be a cost-effective way to assure access to inputs. In many developing countries, access to land and other productive resources is extremely disparate. In such countries, agrarian reforms will not only boost food production, but can help reduce poverty by expanding livelihood options for landless rural people. Strategic land use planning could help ensure that adequate land and water resources are available for food and feed crop production, as well as that adequate water is allocated for household use. When smallholders have access to resources, services and infrastructure, they are better able to increase their supply response to higher prices, boosting their incomes and improving their livelihoods.

Broad-based, sustainable agricultural development requires public investment in agricultural research aimed at enhancing smallholder productivity. Such research can generate scale-neutral technologies that smallholders can readily adapt to address their current constraints. Developing-country governments and donors both need to increase investment in public agricultural research beyond current stagnant levels (Von Braun 2007a). Agricultural research also needs to enhance its focus on mitigation of and adaptation to climate change and on pro-poor biofuel development.

Increased agricultural productivity can improve food availability, rural employment and access to food by reducing prices, which will benefit consumers. Even if farm-gate prices fall, farmers may still enjoy increased incomes (which will allow them to diversify their own diets beyond subsistence staples) if productivity enhancements lower production costs. In low-income countries, where agriculture and related activities account for a high percentage of the overall economy and employment, agricultural growth will stimulate growth in other sectors (Adato and Meinzen-Dick 2007). If policies ensure that growth is broad-based, incomes are likely to rise

for poor people, allowing them to invest in improved nutrition, health and other aspects of wellbeing. Policies can also encourage diversification of production, to increase availability of non-staple foods, both for farmers' own consumption and as an income-earning strategy (Hawkes and Ruel 2006a). Policies should ensure that smallholders are able to participate in new agricultural opportunities, including production of biofuel crops.

A number of policies and institutions can help facilitate smallholder participation in value chains on a fair basis. For example, promoting organization and collective action by encouraging farmers to form co-operatives and associations can improve access to inputs, credit, services and markets. Smallholders in parts of East Africa, Southeast Asia and Central America have succeeded in getting a foothold in export markets for fresh fruits and vegetables. In Uganda and Vietnam, this had important poverty-reducing effects and has gone hand-in-hand with increased production of staples for local consumption. In Guatemala, cooperatives have enabled small farmers to gain income from the global value chain, improve their access to healthcare and enhance the nutritional status of their children (Watkins and Von Braun 2003; Von Braun et al. 1989). Other mechanisms that facilitate participation in value chains include improved access to weather information, price risk management and contract farming (Minot and Hill 2007).

Agricultural and rural development strategies must recognize the important roles that women play in food and nutrition security, as farmers, marketing agents, stewards of natural resources, providers of childcare and chief preparers of meals within the household. In Kenya, for example, a programme to promote production of orange-flesh sweet potatoes (a good source of pro-vitamin A) among women farmers had a substantial impact on nutrition because it also included strategies to promote appropriate child feeding and caring practices (Hawkes and Ruel 2006a).

Attention to sustainability is important not only for sound management of the natural resource base upon which agriculture depends, but also to maintain human health and nutrition. Agricultural practices, such as poor irrigation management and inappropriate use of synthetic pesticides, can have adverse effects on human health (e.g. by expanding malarial mosquito habitat or poisoning water with pesticides) (Hawkes and Ruel 2006b).

Member governments, FAO and other development agencies need to retain their focus on the twin-track approach, where improving agricultural productivity and promoting better nutritional practices at all levels take place concomitant to promotion of programmes that enhance direct and immediate access to food by the neediest. Specifically, policies and programmes that aim to boost supply should target smallholders in addition to (or more than, depending on circumstances) larger commercial farmers. Social protection and safety nets that protect vulnerable people should be an integral part of these strategies. Indeed the inclusion of vulnerable people in policies and support programmes for agricultural development acts as an effective safety net assisting millions of poor people whose livelihoods are at risk.

Improvements in the productivity of agriculture and related sectors directly increase farm and rural incomes and household food security. At the same time, targeted agricultural growth focused on small farmers promotes overall rural and

non-farm employment and has a strong poverty-reducing effect (World Bank 2007b). Emergency relief and rehabilitation operations aim to reduce the vulnerability of those affected by natural and human-induced disasters. By facilitating better access to the skills, tools, services and rights that help the rural poor make lasting improvements in their own livelihoods, programmes addressing this overarching goal increase the impact of work directly targeted to other goals.

Pro-poor agricultural growth alone will not eliminate malnutrition and its negative impact on public health. Some of the additional, sector-specific policies that can also play a role in reducing malnutrition are discussed below. Unless direct action is taken across sectors to improve nutrition, the MDG targets for halving the proportion of undernourished people by the year 2015 will not be achieved.

Income and Employment Generation for Nutritional Improvement

In low-income developing countries, landless rural dwellers and most urban poor people rely on income from employment or business ownership to access food, health care and other necessities. Policies and programmes, therefore, need to create employment and microenterprise opportunities. Policies that support agricultural productivity should provide incentives for uptake of technologies that will create jobs for landless people rather than those that reduce employment. Likewise policies aimed at stimulating private investment – both foreign and domestic – should provide incentives for investment in labour-intensive ventures rather than capital-intensive projects.

Safety Net Programmes

"Safety nets" are government programmes aimed at transferring resources to poor and food-insecure people or people who are vulnerable to poverty, food insecurity and shocks. In addition to providing immediate resources that boost purchasing power, these programmes help poor people to manage risk, cope with shocks resulting from policy reforms such as structural adjustment or trade liberalization, boost livelihoods (for example by providing public works employment or microcredit) and invest in the next generation's human capital, thereby breaking the inter-generational transmission of poverty.[2] Some common forms of safety net programmes are food transfer programmes, unconditional or conditional cash transfers (CCTs) and public works employment. Programmes may be targeted on the basis of such criteria as geographic location, occupation (e.g. targeting smallholders, artisanal fisherfolk, landless rural labourers and unemployed and underemployed people in both the countryside and cities), income, assets, nutritional status, gender or membership in a socially excluded group; or they may be universal. In a rights-based approach to

[2]For more detail, see www.worldbank.org/safetynets

development, the state has a duty to protect the vulnerable, who in turn, have a right to social security. For example, government subsidies to powerful urban elites should not be at the expense of low-income and food-insecure citizens.

Universal programmes such as untargeted food subsidies or controls on the price of food may prove extremely costly to governments, but they also tend to enjoy a much more powerful political constituency than targeted programmes, as wealthier citizens may resent having to pay taxes to support programmes that exclusively benefit poorer demographics (Pinstrup-Andersen 1993). However, even targeted income or food transfers may place a substantial drain on a government's treasury. Mexico's *Oportunidades* CCT,[3] for example, benefits five million families (one of every four Mexican households) at a cost of nearly $4 billion annually. Nevertheless, targeted safety net programmes may be one of the most cost-effective interventions to improve nutrition. Moreover, the conditionalities in targeted CCT programmes have increased safety net popularity and political support among non-poor citizens, since conditionalities increase accountability of beneficiaries.

Oportunidades (previously known as *PROGRESA*, or the Programme for Education, Health, and Nutrition) is the oldest CCT programme in the developing world and the template for many others; numerous governments in the Western hemisphere and beyond have adopted similar schemes. The programme transfers funds to female caregivers in low-income households with children, based on research findings that women are more likely than men to invest in the wellbeing of their children. In exchange for the funds (which they may use as they please), families are expected to regularly send their children to health clinics and enrol them in school. The programme also includes mandatory nutrition and hygiene education for recipient parents and provides supplemental food to malnourished beneficiary children. The Mexican government strictly enforces the conditions, although such enforcement is more lax in some other countries. Evaluations have shown that *Oportunidades* has boosted schooling and improved health and nutrition in Mexico (Skoufias 2005).

CCTs are just one example of safety net programmes, and (like the vast majority of development programmes) their success depends on a number of context-specific variables including rural infrastructure and access to care. If low-income people do not have ready access to health and education, then *Oportunidades*-type conditions make little sense. Some developing-country governments, particularly in Sub-Saharan Africa, have implemented unconditional cash transfers. In general, these are much less complex to administer and focus on improving food and nutrition security rather than investment in human capital. Evaluations have found South Africa's unconditional child support grant programme to be effective in improving child nutrition (Agüero et al. 2007).

Food transfer programmes include food aid (drawing on either local supplies or external, in-kind resources; Fig. 6.1 indicates some of the many possible uses of food aid), supplementary feeding, targeted subsidies for the most vulnerable

[3] Unless otherwise noted, the discussion of cash transfers which follows is drawn from Cohen et al. (2008).

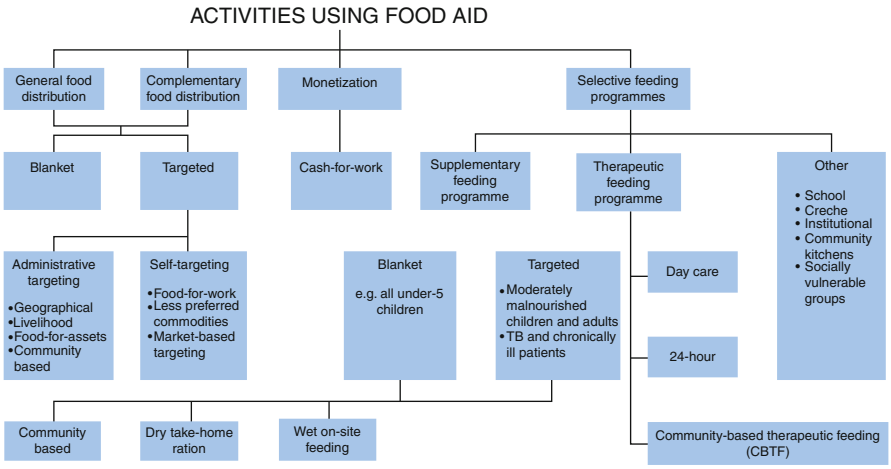

Fig. 6.1 Activities using food aid (Source: FAO/AGN 2005)

households, food stamps or coupons (or, where feasible, electronic benefit transfer cards similar to a debit card). For example, India's main Public Distribution System in theory makes subsidized food available to all citizens, but in effect targets the food to lower-income and disadvantaged Indians by offering less preferred commodities and grades of commodities. In addition, the Targeted Public Distribution System offers additional subsidised cereal grains only to low-income families (Viswanathan 2006). Food stamps and vouchers are easier to administer and less expensive than subsidies.

Public works programmes offer citizens who have lost their jobs or suffered a crop failure government-paid employment, usually for a limited period of time. Such schemes help people affected by shocks to maintain their purchasing power while developing publicly funded infrastructure, such as roads, or common pool assets, such as replanted forests, rehabilitated rangeland or water harvesting structures. Public works employees may receive wages in the form of food, cash, vouchers (for acquiring food or farm inputs) or a combination. A large-scale example of such a programme is Ethiopia's Productive Safety Net Programme (PSNP) which utilizes substantial locally generated resources as well as donor funds and emphasises the use of cash payments (although payment is sometimes in food as well) as part of an effort to move the country away from dependence on external food aid (UNDP 2007).

Insurance to Preserve Assets Against Shocks

Agriculture is a risky business, due to variable weather and fluctuating prices. Whereas farmers in developed countries can rely on well-established crop insurance mechanisms, as well as government subsidies in many countries, to insulate them

from the catastrophic effects of shocks, smallholders in developing countries usually lack such protections, as insurance markets are largely missing, especially in rural areas. A shock may result from extreme weather, such as drought or flooding, another natural disaster, such as an earthquake or tsunami or human-induced events, such as war. Because of high levels of risk and lack of insurance, poor farmers are often reluctant to adopt innovative technologies. Risk management and mitigation can help reduce this aversion (Dercon 2004).

In order to maintain minimal levels of consumption of food and other necessities, poor people often respond by selling off their productive assets, such as land, tools and implements, livestock, labour, children and property (jewellery, homes, building materials), or by consuming seeds, the migration of some family members for remittances or even prostitution. Such coping behaviours frequently make it much more difficult to resume previous livelihoods once the shock has passed. As a result, such shocks often create a vicious circle leading to increased malnutrition and vulnerability, with long-lasting impacts on children. In the absence of established insurance markets, governments and aid agencies should work to implement simple, informal alternatives that are appropriate to poor rural areas of developing countries. For example, joint liability saving schemes permit poor people to engage in a certain measure of self-insurance. Another example is rainfall insurance (often in the form of lottery tickets), which requires only a minimal premium and pays out if rainfall is below "normal" levels (Dercon 2004). The World Food Programme piloted a more elaborate version of this model with a drought insurance scheme in Ethiopia in 2006. The WFP served as the insurer, backed up by commercial reinsurance (WFP 2007). These approaches overcome some of the deficiencies of the current humanitarian response system by reducing the post-shock need to appeal to donors and speeding up provision of aid. Enhanced response to shocks will be especially important in the future, given the likelihood that climate change will lead to more frequent and severe extreme weather events. Since 2007, Oxfam America has worked with a consortium of partners to provide micro-drought insurance, credit and risk reduction to poor farmers in Adi Ha, Ethiopia. Partners include commercial insurers, the Relief Society of Tigray, the International Research Institute for Climate and Society and the federal Ministry of Agriculture and Rural Development. Low-income farmers pay their premiums through participation in PSNP, which WFP supports. Since late 2010, Oxfam and WFP have collaborated on a 5-year, $28 million partnership to scale this model up in other developing countries (Cohen et al. 2011).

Direct Nutrition Interventions

Direct nutrition interventions play a key role in improving nutrition as part of the comprehensive, cross-sectoral approach outlined above. With regard to malnutrition among preschool children, a strong consensus has emerged that there is a crucial and narrow "window of opportunity" for action: from conception through the first

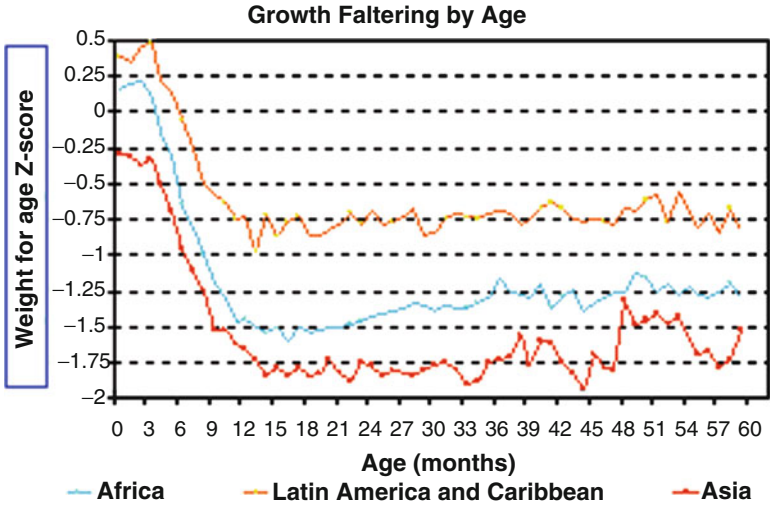

Fig. 6.2 Growth faltering by age (Source: Shrimpton et al. (2001))

18–24 months of a child's life (Fig. 6.2). The damage that malnutrition causes to a child's physical and mental development during this time is likely to be considerable, irreversible and possibly fatal.

There is now a credible evidence base supporting direct investments in early childhood nutrition as an excellent use of scarce public resources in developing countries. For example, a recent study in Guatemala offers the first unambiguous evidence that providing infants and very young children with foods in adequate quantity and quality, in terms of variety, diversity, nutrient content and safety, enhances their productivity and incomes as adults. Previous studies provided substantial, but indirect evidence of this. The study in Guatemala tracked children who received food supplements fortified with micronutrients between 1969 and 1977. Follow-up research during 2002–2004 found that boys who received the supplements between 6 and 24 months of age on average earned wages 46% higher than those of non-recipients. For girls, the supplement seems to have improved school performance, although not adult incomes, probably because of gender differences in labour force participation and work activities. Significantly, children who first received the supplement after age three did not experience any economic gain (Hoddinott et al. 2008; see also Victora et al. 2008).

While a strong focus on the critical period from the first 18–24 months of life is crucial (World Bank 2006), direct interventions can also have high returns for other age groups and population groups including low-income childless households who may be in need of support. In particular, the care of adolescent girls and pregnant women is vital for protecting their own health and that of their future children.

Especially because of the importance of good maternal nutrition in achieving normal birthweights and good child health and nutrition, nutrition interventions should adopt a life-cycle approach (Fig. 3.4). For example, there is growing evidence

Table 6.1 Some cost-effective interventions to reduce maternal and child undernutrition

Behaviour change interventions
Breastfeeding promotion
Promotion of appropriate and timely complementary feeding
Promotion of handwashing
Micronutrients and deworming interventions
Vitamin A supplements
Therapeutic zinc supplements for management of diarrhoea
Preventive zinc supplements[a]
Provision of micronutrient powders to children under 2 years of age
Deworming
Iron-folic acid supplements for pregnant women
Iron fortification of staple foods
Salt iodization
Iodized oil capsules
Maternal calcium supplements[a]
Complementary and therapeutic feeding interventions
Prevention or treatment for moderately malnourished children 6–23 months of age using complementary foods
Treatment of severe acute malnutrition[b] using a community-based approach
Maternal supplements of balanced energy and protein

Source: Authors, adapted from Horton et al. (2010)
[a]Cost estimates for full coverage have not been calculated
[b]Weight-for-height of −3 z-scores (standard deviation scores) or more below the median of the WHO child growth standards

that improving the quality of the diet of the mother during the first half of pregnancy can have at least as strong an effect on birthweight as providing food supplements later in pregnancy (SCN 2010a). Other studies have shown that weight and height gains of children receiving complementary foods during early childhood are greater in children whose mothers also received food supplements during pregnancy (Mora et al. 1981). It is now recognized that the causes of stunting are rooted in inadequate foetal growth and include poor maternal nutrition, and that about half of the growth failure accrued by 2 years of age occurs *in utero* (SCN 2010a).

Currently, there is a lack of comprehension of the enormous potential impact that small changes during the period in utero can have later in the life course. These effects seem to be greater if the mother is reached either during or preferably *before* the first semester of pregnancy. If countries were to direct more effort and resources to this area, the potential for breaking the cycle of growth failure would greatly increase (SCN 2010a).

In addition to ensuring good nutrition before and during pregnancy, preventing and/or delaying teenage pregnancy is important to a life-cycle approach. Adolescent growth ceases at pregnancy, increasing risk of low birth weight for the baby and poor health outcomes for the mother. Far greater priority is needed for this area including sexual education and family planning services for adolescents in order to reduce teenage pregnancy rates (SCN 2010a). Table 6.1 lists a series of preventive

and curative interventions known to improve maternal and child nutrition (Bhutta et al. 2008; Horton et al. 2010). For the majority, cost estimates for full coverage of target populations have been calculated. These strategies fall under three broad categories – behaviour change, provision of micronutrients and deworming treatments and complementary and therapeutic feeding – and are discussed below, along with other types of direct nutrition interventions.

Promotion of exclusive breastfeeding is crucial to improving infant nutrition. A series of initiatives have helped to promote exclusive breastfeeding during the first 6 months of life and continued breastfeeding with complementary foods through age 1–2 years. The International Code of Marketing of Breast-milk Substitutes, which includes voluntary industry cooperation with global norms and binding national legislation, is of particular importance in this regard. This legal instrument supports the realisation of the right to food through the promotion and protection of breastfeeding and the informed use of breast milk substitutes (where necessary). UNICEF has also worked to encourage hospitals to promote breastfeeding to new mothers through its baby-friendly hospital initiative.[4]

Community-based maternal and child health programmes have also proved cost-effective. These programmes play a role in increasing access to technology and resources, and are also important in fostering behaviour change and generally supporting caring practices. They often provide vitamin A and iron supplements along with immunizations, growth monitoring and, frequently, supplemental feeding (World Bank 2006). Research in Haiti found that such programmes are more effective if they target children between 6 and 24 months of age and provide health and nutrition services to all low-income children in the community, not just those whose growth has faltered. Such a preventive approach results in greater reductions of stunting, underweight and wasting than the more commonly used recuperative approach, which targets children up to 5 years of age (Ruel et al. 2008).

In order to assure that working mothers in urban settings are able to provide care to their children, policies and programmes need to facilitate the availability of low-cost amenities for the care of preschool children. These could be community-based (Ruel and Quisumbing 2006) or based at workplaces, although the latter approach is less common in the urban areas of most developing countries.

Micronutrient deficiencies may be tackled through improving dietary diversity, supplementation or food fortification, as well as public health measures. Supplementation and food fortification approaches are frequently implemented through public-private partnerships including “biofortification”, which involves the use of conventional plant breeding or agricultural biotechnology to develop crops high in nutrients such as iron, zinc and beta-carotene. Farmers have not yet widely planted such crops in their fields, but breeding efforts also aim to develop varieties with desirable traits, such as higher yield. Biofortification may be more sustainable than supplementation or fortification, as it has lower recurrent costs.[5] Deployment

[4] See http://www.unicef.org/nutrition/index_24806.html

[5] See http://www.harvestplus.org for more information.

of genetically modified crops in developing countries requires the establishment of sound biosafety systems, including the capacity to assess environmental risks that may indirectly affect human health and development (WHO 2005b).

In the case of children who are severely wasted, if there are no medical complications, community-based therapeutic care is preferable to treatment in a hospital or clinic. Low-income families often cannot readily reach such in-patient facilities. Ready-to-use therapeutic foods (RUTFs) can play an important role in community-based treatment. Children with moderate acute malnutrition may be provided with traditional blended and fortified food aid, such as corn-soya blend (Bhutta et al. 2008; Wiesmann et al. 2007).

Nutrition education can promote nutritional knowledge and appropriate attitudes of caregivers about foods, social and dietary customs, family/child care and feeding practices, household hygiene and the competing demands on women's and other caregivers' time that may constrain their ability to secure, prepare and serve food. Even though poor households may not be able to afford to increase the amount of food they consume, with enhanced nutritional knowledge they may be able to change the way it is allocated among household members, the selection of the type of food that is consumed, giving particular attention to inhibitors and enhancers of passage of essential micronutrients across the gut wall, or the way that it is prepared and served, so as to enhance nutrition.

Access to clean water and safe sanitation is crucial for both good health and good nutrition. Rapid urbanization in developing countries presents new challenges to governments to assure clean and safe environments, particularly in low-income communities. Climate change stiffens this challenge as it contributes to water scarcity and also will lead to more frequent flooding and therefore increased risk of contaminated urban water sources.

For those living with the disease, better nutrition can postpone HIV/AIDS-related illnesses, such as diarrhoea, pneumonia and tuberculosis, and prolong life. Nutrition components in HIV/AIDS treatment programmes can provide incentives for improving diets, for strengthening the nutrition focus of health services (particularly in the context of anti-retroviral therapy and home-based care) and for ensuring nutritionally balanced food aid as a safety net for the acutely food-insecure or those at risk of becoming so, such as households hosting AIDS orphans (Gillespie and Kadiyala 2005). There is evidence that community-based therapeutic care, using RUTFs, may be helpful in the treatment of HIV/AIDS in both children and adults (Wiesmann et al. 2007).

To address the problems of overweight and obesity, WHO (2008) has devised a *Global Strategy on Diet, Physical Activity, and Health.* It calls for international, national and local policies and plans to encourage healthier diets and increased physical activity (WHO 2008). The marketing practices of private firms with respect to energy-dense, nutrient-poor foods are also relevant to this problem.

In sum, nutrition interventions should encourage health-seeking and health-promoting behaviours through policy support, capacity building, advocacy and information, education and communication. Efforts to improve access to health services should include support for the production and use of acceptable traditional medicines and practices and indigenous health knowledge.

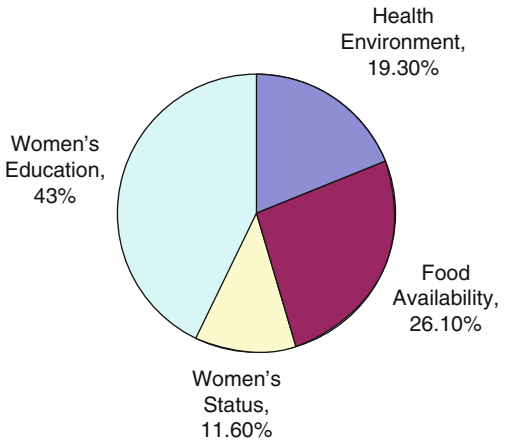

Fig. 6.3 Sources of reduction in developing-country child malnutrition, 1970–1995 (Source: Smith and Haddad (2000))

Education for All

IFPRI research has shown that there were four drivers of the reductions in child malnutrition achieved in developing countries during 1970–1995 (Fig. 6.3). Improvements in female education had the biggest impact, followed by increases in food availability, improvements in the health environment and improvements in women's social status relative to that of men. This means that accelerating progress in reducing child malnutrition will require changes in policy and practices that discriminate against women, as well as increased public expenditures to assure access to health services and universal primary education.

Educating girls has beneficial effects on family size, birth spacing, child care practices and household income, as well as child nutrition, particularly when education promotes good nutrition, use of preventive health care facilities and other caring practices. Yet the international community has failed to deliver on its commitment to universal primary education first made at the 1990 World Conference on Education for All and more recently included in the MDGs. Currently 100 million primary school-aged children are not enrolled in schools which accounts for 13% of the children in that age group. A sizeable majority, 57%, of the primary level out-of-school children, are girls, and the proportion becomes even greater for secondary school (UNESCO 2008). The gender gap in education may also be seen in adult literacy rates: for all low- and middle-income countries the rates are 85% for men and 72% for women; in Sub-Saharan Africa, the figures are 70% and 53% and in South Asia, 70% and 45% (World Bank 2007a). School meals and food-for-education programmes can help achieve full enrolments, increase educational gender equity and improve food and nutrition security.

Priorities and Approaches for Responding to Threats to Nutrition from Climate Change and Biofuel Demand

Need for Serious Global Governance with Regard to Climate Change

A combination of adaptation and mitigation measures, sustainable development and research to enhance both adaptation and mitigation can diminish the threats to nutrition from climate change. The human-rights framework offers the means to explicitly link environmental concerns to good governance and the inherent emphasis of human rights. The rights-based approach to climate change can trigger the development of national normative frameworks and tools.

Changes in policies and institutions will be needed to facilitate adaptation for food and nutrition security to climate change. There are multiple adaptation options that imply different costs, ranging from changing practices in place to changing locations of food, fibre, forestry and fishery activities. The potential effectiveness of the adaptations varies from only marginally reducing negative impacts to, in some cases, changing a negative impact into a positive impact. Adaptation measures should be integrated with development strategies and programmes, country programmes and Poverty Reduction Strategies. Moreover, adaptation is a shared responsibility and stakeholders represent a variety of sectoral interests, including agriculture, health, water supply, coastal management, urban planning and nature conservation.

Adaptation options are cited throughout this book and cover a wide variety of sectors. For example, cereal cropping system adaptations such as changing varieties and planting times enable avoidance of a 10–15% reduction in yield corresponding to a 1–2°C local temperature increase. The benefits of adaptation tend to increase with the degree of climate change up to a point; adaptive capacity in low latitudes is exceeded at 3°C local temperature increase (Easterling et al. 2007). With regard to mitigation, financial incentives can help promote improved land management, maintenance of soil carbon content and efficient use of fertilizers and irrigation. This could encourage synergy with sustainable development and reducing vulnerability to climate change. It can also help improve the health environment. Incentives to improved waste and wastewater management, as well as stronger regulation, would improve the sanitary environment (Metz et al. 2007). Both outcomes will contribute to better nutrition.

Policies for Responding to Rising Bioenergy Demand

Biofuel development in developing countries should be carefully designed, so as not to crowd out investments in infrastructure, more general agricultural development, health, nutrition and other efforts aimed at climate change mitigation and adaptation. Policies should ensure that smallholders, including women farmers, have

access to resources, infrastructure, services and organizations so that they can participate in biofuel production on a fair basis. Policies need to employ a right-to-food lens, ensuring that biofuel projects are consistent with international standards regarding the realisation of this right. Finally, policies need to examine the environmental consequences of biofuel development and avoid unsustainable practices (FAO 2008g; Eide 2008).

Increased investment in agricultural productivity for developing countries will improve food production and encourage engagement in the biofuel market. With sufficient investments in research, it may even be possible for developing country farmers to leap-frog to second generation cellulosic biofuel technologies, creating energy and emission efficiency gains on a global scale. Thus international cooperation is needed in research and development to bring new technologies on line. Of particular interest from a food-security perspective are those technologies that allow production of biofuels from non-food stocks, thereby avoiding tradeoffs among food, feed, fibre and fuel uses of staple crops.

Creating a biofuels industry that helps the neediest people improve their lives and livelihoods requires careful management at all levels. This management includes taking the necessary steps to develop a global market and trade regime with transparent standards for biofuels (Von Braun and Pachauri 2006). For example, developed-country governments should move rapidly towards market-oriented biofuel production and processing, removing subsidies and ending trade barriers to developing-country biofuels.

Participatory decision-making and cross-sectoral policy coordination should be institutionalized in the area of bioenergy. The clear allocation of the roles of duty-bearers and rights-holders may also increase government responsiveness, as well as accountability and transparency, while ensuring that biofuel programmes are consistent with human rights norms.

To protect poor and food-insecure people from adverse effects of the rapid growth of the biofuel sector there is a need to link policies for food and fuel so as to safeguard food security, to assist those negatively impacted by climate change and the expansion of biofuels production and to raise awareness among policymakers to provide for integration of local, regional or international policies that affect the agricultural sector and the rural economy (FAO 2008f).

Chapter 7
Conclusions and Recommendations

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Abstract The final chapter is divided into three sections: "Responding to Climate Change", "Assuring Pro-poor and Sustainable Biofuel Development", and "Making Nutrition a Development Priority". Each section includes specific recommendations guided by a pro-poor, rights-based, MDG-focused normative framework.

Keywords Nutrition-sensitive agriculture • Nutrition-sensitive development • Rights-based approach • Adaptation • Mitigation • Food and nutrition security • Climate change • Sustainable economic development • Poverty reduction • Sustainable biofuel development • MDGs • Participatory community nutrition programmes • Direct nutrition interventions • Making nutrition a development priority • Twin-track approach • Narrowing the nutrition gap

Efforts to assure food and nutrition security in the face of current challenges – including climate change and rising bioenergy demand – must continue to make achievement of the MDGs a central goal. It remains essential to accelerate progress

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in reducing poverty, hunger and malnutrition while mitigating risk and protecting the environment. Nutrition-sensitive development, especially in agriculture and other closely related sectors including health, social protection, employment and education, are integral to this acceleration. A rights-based approach engages affected stakeholders – particularly smallholder farmers, women and poor rural and urban consumers – as active participants in this process. Civil society organizations have a key role to play in holding governments accountable to citizens.

Responding to Climate Change

Climate change is projected to affect the health status of millions of people, particularly those with low adaptive capacity, through increases in malnutrition and consequent disorders, with implications for child growth and development, as well as through an increase in diarrhoeal disease. The IPCC AR4 has concluded that, due to the very large number of people that may be affected, malnutrition may be one of the most important health consequences linked to extreme climatic events.

Agricultural production, including access to food, is projected to be severely compromised by climate variability and change in many African countries and South Asia. This would further adversely affect food security and exacerbate malnutrition.

Agriculture, food and nutrition issues need to be placed higher on national and international climate change agendas in order to devise effective and pro-poor policies. The expiration of the Kyoto Protocol in 2012 offers an opportunity to bring these issues to the table as a new agreement is negotiated.

Sustainable economic development and poverty reduction remain top priorities for developing countries. Climate change could exacerbate climate-sensitive impediments to sustainable development faced by developing countries. To address this challenge requires integrated approaches for adaptation, mitigation and sustainable development. Strategies should include measures that would simultaneously reduce pressures on biodiversity and food security and contribute to carbon sequestration.

Adaptation is a key factor to address the impacts climate change will have on food production and food insecurity. Early impacts of climate change can be effectively addressed through adaptation; however, options for successful adaptation diminish and associated costs increase, concurrent to sustained climate change. Hence, prioritization of investment aimed at improving adaptation of agriculture to climate change for achieving food and nutrition security is crucial. The development of adaptation strategies should consider that adaptation capacity depends on geographical situation, economic development, natural resources, social context, institutions, governance and technology of the countries.

Sustainable development can reduce vulnerability to climate change by enhancing adaptive capacity and increasing resilience. Plans for sustainable development should promote adaptive and mitigation strategies, for example by including adaptation and mitigation measures in land-use planning and infrastructure design or including measures to reduce vulnerability in existing disaster risk reduction plans.

Mitigation in agriculture has significant potential and uses technologies which can be implemented immediately. Agricultural mitigation measures often have synergy with sustainable development policies and many influence social, economic and environmental aspects of sustainability. In order to improve the mitigation potential in this sector, synergies between climate change policies, sustainable development and improvement of environmental quality should be promoted.

Climate change adaptation and mitigation measures should be developed as part of overall and country-specific development programmes such as Poverty Reduction Strategy Papers, pro-poor strategies and National Food and Nutrition Action Plans. In this framework, FAO and other international organizations should assist countries in assessing capacity building needs for the design and implementation of integrated development strategies to address food and nutrition security challenges from climate change and biofuel demand.

Priority research needs for the assessment of climate change impacts on food, fibre, forestry and fisheries have been identified in the IPCC AR4. Attribution of current and future climate-change-related malnutrition burdens is problematic because the determinants of malnutrition are complex. Further research and information on the links between climate change-related food insecurity and malnutrition are called for.

Assuring Pro-poor and Sustainable Biofuel Development

A number of steps must be taken in order to assure that biofuel development is pro-poor, environmentally sustainable and supportive of food and nutrition security:

- developed-country governments should remove trade barriers to developing-country biofuel exports;
- developed-country governments and international organizations such as FAO and the international financial institutions should provide financial and technical assistance to pro-poor, sustainable biofuel projects in developing countries;
- developing-country governments need to conduct human rights, food security and nutrition impact assessments before launching biofuel development projects;
- developing-country governments should make biofuel production policies pro-poor and gender equitable (e.g. incentives to encourage outgrower schemes and labour-intensive processing plants);
- strategic land use planning could help ensure that adequate land and water resources are available for food and feed crop production, as well as that adequate water is allocated for household use;
- developing-country policies should encourage technology spillovers from biofuel production that can enhance food crop production;
- research is needed on non-food crop sources of bioenergy, e.g. cellulosic biofuels, to minimize food-feed-fuel tradeoffs; and
- policies should favour production of biofuel crops with a small environmental footprint that can contribute to climate change adaptation and mitigation strategies.

Making Nutrition a Development Priority

Good nutrition makes a vital contribution to the fight against poverty. It protects and promotes health; reduces mortality, especially among mothers and children; encourages and enables children to attend and benefit from school; and enhances productivity and incomes in adulthood. By indirectly strengthening communities and local economies, good nutrition contributes to the achievement of other development objectives which, in turn, positively impact the MDGs. For example, the increased participation of poor and vulnerable people and of women in the development process that may arise from effective community nutrition programmes will likely lead to more effective demands for improved services and to better use of existing resources. Moreover, the use of nutrition-based benchmarks and indicators and of participatory community nutrition approaches can improve the targeting, coverage and efficacy of both health and income-generating initiatives.

Direct nutrition interventions alongside nutrition-sensitive development programmes in related sectors thus have a unique role to play in efforts to reach the MDGs. Nutrition-sensitive agricultural development is particularly important, especially in countries where the majority of the population remains rural. Nutrition-sensitive agricultural development requires a move away from traditional food security models focused mainly on increased yields to a broader perspective which includes making nutrition security a primary goal. Narrowing the "nutrition gap" should be an objective for agricultural development plans in countries where undernutrition persists. Policies designed to protect and expand smallholder rights, increase incentives to produce and market micronutrient-rich foods and prioritize the needs of poor net consumers are key. Emerging themes for nutrition-friendly agriculture as part of a broader nutrition-sensitive development framework include pro-poor food production systems, social protection and assistance, livelihood diversification, environmental sustainability, capacity building and setting higher standards in agricultural trade, foreign direct investment and development.

Nutrition-sensitive development in agriculture (as well as other sectors) recognizes the importance of addressing the social, economic, cultural and political determinants of undernutrition. In addition to the policy instruments cited above, national nutrition data should be disaggregated with regard to groups presumed to be vulnerable, in order to establish whether and to what extent nutritional deprivation exists and to inform policies towards realizing the right to adequate food, the fundamental right of everyone to be free from hunger and the highest attainable standard of health.

Developing-country governments should also give high priority to implementing proven nutrition interventions on a national scale. Donors should substantially increase support for efforts to improve food safety and nutrition. Improved policy coherence and international cooperation are required to eradicate malnutrition in all its forms (Morris et al. 2008). Key strategies for making nutrition a development priority include:

- setting targets, agreeing on coordinated actions in each country and mobilizing resources;
- using participatory approaches that build local institutions and skills, strengthen legal rights and access to resources and empower women, indigenous people and other vulnerable groups;
- giving priority to "hot spots" where a high proportion of the population suffers from malnutrition, hunger and extreme poverty and often also from illiteracy, disease, social marginalization and child and maternal mortality;
- using food assistance (procured locally or externally, as appropriate to the specific circumstances) to develop and enhance skills or to create physical assets, such as food storage facilities or soil and water conservation structures that will help communities weather crises and build the foundation for longer-term development;
- focusing people-centred policies and investments in rural areas and on agriculture in ways that promote sustainable use of natural resources, improve rural infrastructure, facilitate the functioning of markets and enhance rural institutions;
- supporting dynamic rural growth by improving the productivity of smallholder agriculture and by diversifying into rural non-farm activities and strengthening micro-enterprises in which rural women play a major role;
- strengthening poor urban livelihoods with an urban twin-track approach that combines pro-poor employment and asset generation programmes with measures to help poor people meet their basic needs for food, shelter, water, health and education; and
- accelerating progress towards an open and fair international trading system, with special attention to improving market access and reducing developed countries' export subsidies and trade-distorting domestic support in agriculture (FAO 2005a).

All of these approaches are proven, practical and affordable. All can be effectively adapted and applied to meet local requirements, monitored to ensure that they are effective and scaled up as they prove successful and sufficient resources are mobilized. If developing countries gear up their efforts to revitalize agricultural and rural development and ensure that hungry people have access to food, and if donor countries fulfil their pledges to increase development assistance substantially, we can reach the WFS and MDG hunger reduction targets and by doing so, shift progress towards reaching all of the other MDGs into high gear. Moreover, since the primary goal of all of these measures is to support the resilience of food systems and improve food and nutrition security, they are crucial to meeting the challenges to nutrition posed by climate change and growing demand for biofuel.

Appendices

Appendix 1: Scenarios of the IPCC's Special Report on Emissions Scenarios (SRES)[1]

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures towards a service and information economy, with reductions in material intensity and the introduction of clean and resource efficient technologies. The emphasis is on

[1] Source: M.L. Parry et al. (2007).

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global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.

Appendix 2: IFPRI IMPACT Model[2]

IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) is designed to examine alternative futures for global food supply, demand, trade, prices, and food security. The IMPACT model allows IFPRI to provide both fundamental, global baseline projections of agricultural commodity supply, demand, trade, prices and malnutrition outcomes along with cutting-edge research results on quickly evolving topics such as bioenergy, climate change, changing diet/food preferences, and many other themes. IMPACT covers 30 commodities, which account for virtually all of world food production and consumption, including all cereals, soybeans, roots and tubers, meats, milk, eggs, oils, meals, vegetables, fruits, sugar and sweeteners, and fish in a partial equilibrium framework. It is specified as a set of 115 country-level supply and demand equations where each country model is linked to the rest of the world through trade. 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. In order to explore food-security effects, IMPACT projects the percentage and number of malnourished preschool children (0 to 5 years old) in developing countries as a function of average per capita calorie availability, the share of females with secondary schooling, the ratio of female to male life expectancy at birth, and the percentage of the population with access to safe water.

[2] Additional information about the model and its formulation can be found in Rosegrant et al. (2001) and documentation posted at http://www.ifpri.org/themes/impact.htm

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