Section 5

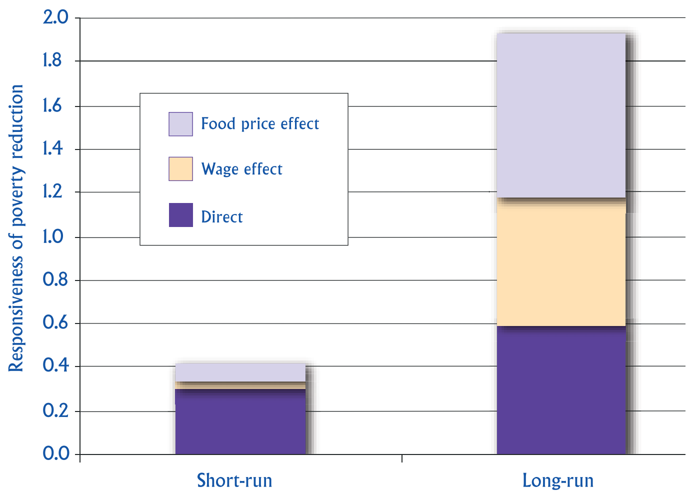
Agricultural Productivity and Competitiveness

The Green Revolution increased crop yields through research and development (R&D) in improved technology and through investments in infrastructure and agricultural services. As a result, it reduced poverty and hunger while fostering economic growth, especially in Asia and Latin America. Even beyond the Green Revolution, investment in agricultural research has had a major impact on poverty reduction through its direct effects on producer incomes, its indirect effects on consumer welfare through lower food prices, employment, and wages, and its growth-induced effects throughout the economy (Figure 5.1 and Box 5.1). Studies in India and China by the International Food Policy Research Institute have shown that investments in agricultural R&D had a higher impact on poverty reduction than most other public investments, behind only education in China and rural roads in India.

Studies consistently show high returns to investments in agricultural research in developing countries, averaging over 40 percent. Rates of return tend to be higher for research in industrial countries and for commodities with short production cycles. The paradox is that despite such evidence of high returns, agricultural research funding is stagnating in many countries. Stagnation is particularly harmful to agriculture because the returns to investment in research can take 10–30 years to be fully realized.

The impetus for the Green Revolution was to avoid the specter of mass famine and starvation, and it largely reached that goal. We now live in a world awash in food. Yet access to sufficient, safe, nutritious, and affordable food is still the primary problem for nearly 800 million chronically undernourished people. Ironically, most of the hungry live in rural areas and make a living from agriculture. Moreover, the environmental impacts of these investments and the tapering off of yield growth in recent years present new challenges to agriculture. Compounding the stresses, experts expect the demand for food to double in the next 25–50 years, primarily in developing countries, as global population reaches 8–10 billion. Further, higher incomes are leading to a shift in dietary preferences to animal products, thus triggering a shift from the Green Revolution to the Livestock Revolution.

Figure 5.1 India — Poverty reduces as yields increase



Source: Datt and Ravallion 1998.

The global community faces an enormous task in trying to enhance rural livelihoods and ensure nutritional security in a world where population is growing and consumption patterns are evolving. At the same time, countries need to reverse environmental degradation, redress social and gender inequality, and ensure human health

Box 5.1 Impact of the Consultative Group on International Agricultural Research on prices, production, land use, and trade

- World food production would have been 4–5 percent lower and developing countries would have produced 7–8 percent less—exacerbating hunger, malnutrition, and poverty.
- World food and feed grain prices would have been 18–21 percent higher—adversely affecting poor consumers.
- The area planted to crops would have been significantly higher for all food crops, as cultivated area in developing countries would have expanded by 11–13 million hectares (and by 5–6 million in industrial countries) at the expense of primary forests and fragile lands with high biodiversity.
- In developing countries, per capita food consumption would have declined by 5 percent on average and by up to 7 percent in the poorest regions—causing food, income, and nutrition insecurity.
- Some 13–15 million more children would have been malnourished, predominantly in South Asia, where the incidence of hunger is highest.

and well-being. These problems and demands require fundamental changes in the culture and business of the sector. The agricultural sector once relied on formal, supply-driven R&D systems to ensure ample food supplies. It now must draw from policy and management reforms, market forces, empowered farmers and other stakeholders, and a broader spectrum of science and technology solutions to meet growing and diversifying demands.

A New System for Productivity and Competitiveness

A number of forces, including shifting demand patterns, improved technology, integrating trade, and market pressures, are shaping the evolution of the agriculture sector. Strengthened research systems will increase the availability of new knowledge and new technologies, but not necessarily the number of innovations that will be implemented by agricultural producers. Several interrelated developments have led to this conclusion.

Agricultural development is increasingly market-oriented rather than production-driven, for example. While for most of the last century major progress in agricultural development was made by improving the productivity of staple food crops, the situation is now changing. With falling staple food prices and rising urban incomes, the goal has shifted to diversifying agricultural production to livestock and higher-value crops. But it has often been difficult for centralized public research or knowledge systems to cater to this trend.

The private sector is becoming a more prominent player as the source of knowledge generation, diffusion, and application. A substantial part of the technology package that farmers use—fertilizers, machinery, pesticides, and seeds—has been designed by and supplied through private businesses. With increasing intensification, the role of the private sector as technology supplier will increase. While the trend is global, available statistics on agricultural research show that the role of the private sector today is clearly more prominent in industrial than in developing countries.

Degradation of natural resources and public concern over environmental issues are shifting research priorities and funding toward broader issues, many of them global in nature: sustainable use of land, water, forests, and biodiversity; mitigation of and adaptation to climate change; pesticide residue minimization; livestock waste management; water quality preservation; and watershed protection, to name a few. There are also increasing opportunities for agriculture to provide environmental services through carbon farming and biodiversity conservation. Success in meeting these challenges requires sharply increased skills in research on natural resources management, social sciences, and environmental issues.

Future increases in agricultural productivity must come from intensification rather than exploitation of additional natural resources. Agricultural systems must use natural resources more efficiently and repair past damage to ecosystems. This depends on the application of scientific knowledge, development of farmers' skills, and a policy framework to improve resource use and conservation.

The public sector still produces much of the agricultural research relevant to the poor. Small farmers have limited purchasing power and cannot finance research. Private firms see limited opportunity for profits from providing technologies to small farmers, so they do not invest sufficiently in this type of research. Moreover, much of the knowledge that the private sector develops builds on information developed in publicly funded research.

With the private sector increasingly serving the commercial farming sector, public funding must focus more sharply on the poor, giving priority to the commodities, regions, and technologies that are important to this group. For this to work, the public sector has to use bottom-up, participatory processes to identify, execute, and evaluate research. And these processes must be sure to address gender, since women are responsible for 60–80 percent of food production in developing countries.

From Research and Development to Innovation Systems

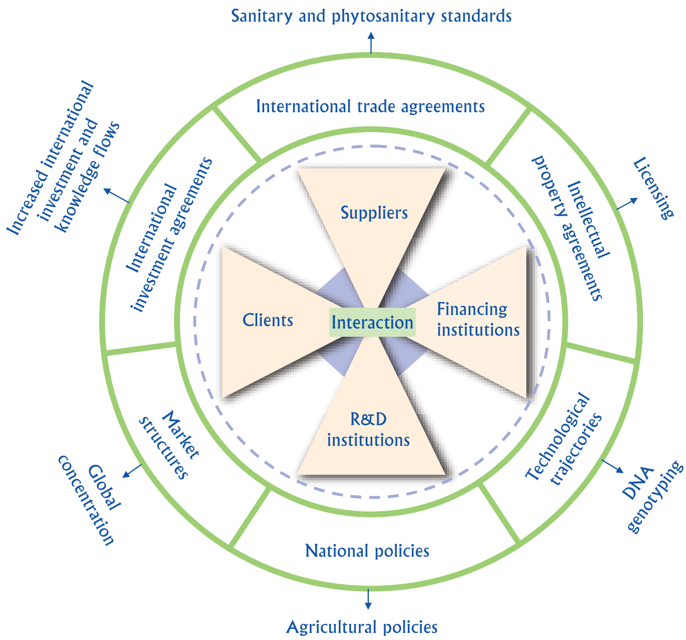
Development depends on knowledge, much of which needs to be generated in or adapted to the national context. A strong science and technology system can make important contributions to sustainable and equitable agricultural development, but it is not sufficient to ensure a productive and competitive agricultural sector.

The conditions must be put in place to ensure that this knowledge actually leads to accelerated development. This realization has led to extensive changes in rural development strategies and agricultural research systems in the industrial world. In particular, agriculture has borrowed the concept of national innovation systems from the industrial sector. This ensures that new knowledge is relevant in the market context and that the role of the private sector in the development and diffusion of new knowledge is explicitly recognized. Innovation systems consist of the institutions, enterprises, and individuals that demand and supply knowledge and technologies and the rules and mechanisms by which these different agents are interacting.

In this concept, the focus is not on the science suppliers but on the totality of actors who are involved in innovation. Private sector investment, the financial system, the policy and regulatory environment, and stakeholder participation are more explicitly recognized. End-market demands are more integrated, and the conditions that need to be fulfilled for innovations to become successful are spelled out more clearly (Figure 5.2).

The effectiveness of the agricultural innovation system depends on three main elements:

Figure 5.2 Overview of agriculture innovation systems



- An institutional environment that is conducive to the flow of knowledge, collaboration, experimentation, and the implementation of innovations
- A well-articulated demand for new knowledge and technology—producers, traders, and others must be able to express their demands and must have the capacity to adapt and adopt new knowledge and technology
- The effective supply of new knowledge and technology from the public research system but also from other sources, such as indigenous knowledge, private sector research, and transfers from abroad.

The agricultural innovation system will be effective to the extent that the different elements work in harmony. If research produces a great deal of new knowledge but results are not used by producers in the marketplace, the investments in the research system have a low payoff in the economy. If demands for new technologies are not recognized by the research system, it is hard to see how the right type of innovations can be generated.

To realize the potential gains from innovation systems, it will be important for countries to:

- Establish an environment conducive to business development by putting in place key national trade and investment policies and an intellectual property rights (IPR) regime and by establishing unambiguous measures, standards, testing, and quality systems
- Put in place a framework for the generation of new ideas, their subsequent commercialization, and the establishment of new businesses through tax incentives, IPR protection, competitive research programs, technology financing programs, venture capital, and start-up funds
- Support the establishment of new knowledge-based companies and carry out R&D activities through incubators, technology centers, technology parks, and other means.

Realigning International Agricultural Research to Meet New Challenges

The changing food security challenge, urbanization and globalization, increased private sector involvement in agricultural research, and global concerns about the sustainable management of resources have all prompted the

Consultative Group on International Agricultural Research (CGIAR) to develop a new set of system priorities. Developed in close consultation with its stakeholders and led by the CGIAR Science Council, the vision for the longer term is one in which the CGIAR provides international public goods through agricultural research aimed at the alleviation of poverty. The five priority areas are:

- Sustaining biodiversity for current and future generations
- Producing more and better food at lower cost through genetic improvements
- Reducing rural poverty through agricultural diversification and emerging opportunities for high-value commodities and products
- Promoting poverty alleviation and sustainable management of water, land, and forest resources
- Improving policies and facilitating institutional innovation to support sustainable reduction of poverty and hunger.

These priorities were determined based on the need to meet expected impact, to focus on international public goods, and to recognize the existence of alternative sources of supply of research. The CGIAR aims to progressively devolve some site-specific research to National Agricultural Research Systems. Special attention will be paid to building partner capacity in Sub-Saharan Africa. Research-for-development objectives are being pursued through the CGIAR Centers' core programs, through systemwide and ecoregional programs, and through the broader partnership-based challenge programs.

Building a Foundation for Global Cooperation in Agricultural Knowledge

How can we reduce hunger and poverty, improve rural livelihoods, and facilitate equitable, environmentally, socially, and economically sustainable development through the generation, access to, and use of agricultural knowledge, science, and technology? This is the core question of the International Assessment of Agricultural Science and Technology for Development (IAASTD). This unique international effort will evaluate:

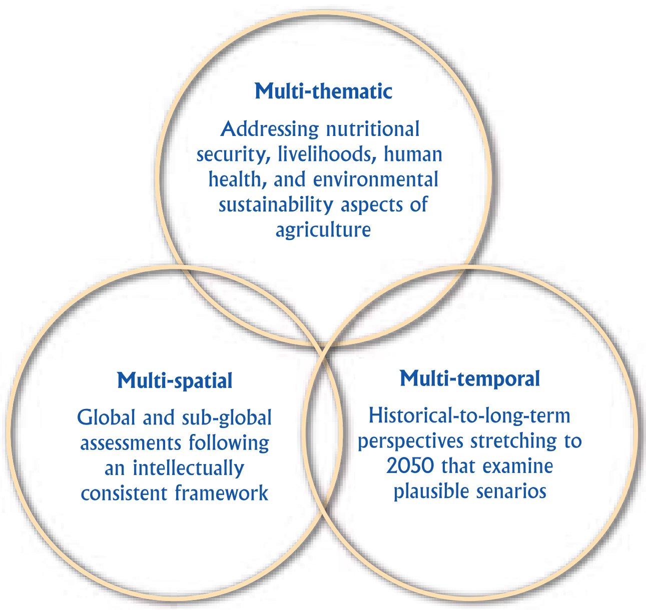
- The relevance, quality, and effectiveness of agricultural knowledge, science, and technology (AKST)
- The effectiveness of public and private sector policies as well as institutional arrangements in relation to AKST to meet the development goals of environmental sustainability, improved rural livelihoods, nutritional security, and human health.

IAASTD is co-sponsored by FAO, UNEP, UNESCO, GEF, UNDP, WHO, and the World Bank. It brings together governments, NGOs, the private sector, producers, consumers, the scientific community, and signatories of multilateral environment agreements to share views and gain common understanding and a vision for the future. The main output of the assessment to be completed in September 2007 is a series of critical, in-depth global and subglobal assessment reports.

The IAASTD does not aim to predict the future; however, it will create "plausible scenarios" based on knowledge from past events and existing trends such as population growth, rural/urban food and poverty dynamics, loss of agricultural land, water availability, and climate change effects. Based on these issues, "What if?" questions can be formulated that allow the implications of different technological options and institutional arrangements to be explored and understood (Figure 5.3).

The assessment will not dictate what countries or stakeholders should do; rather, it aims to inform processes of future planning and thinking as to what may happen over the next 30–50 years and therefore what different AKST options, scenarios, and policies may yield if the world follows different pathways to address these challenges.

Figure 5.3 Scope of the International Assessment of Agricultural Science and Technology for Development



Section 6

The Challenge of Addressing Climate Change

Governments today face one of the greatest challenges of the new millennium: how to achieve prosperity for all while preventing economic growth from irreversibly changing the planet's climate. Sustaining global prosperity becomes increasingly difficult with a climate that continually becomes warmer and more unstable. But economies cannot grow without increasing energy consumption. And today's energy generation depends primarily on carbon-emitting fuels that result in human-induced climate change. There is general agreement that the way that energy and environmental challenges are addressed in the next two decades will to a large degree determine whether growth is sustainable. Unfortunately, new, cleaner, and more efficient technologies remain underutilized, while carbon-intensive energy infrastructure and inefficient cities are being rapidly built and expanded—setting the capital stock for decades.

Scientific Understanding of Climate Change

There is wide recognition that human-induced climate change is a serious environment and development issue. The Earth is warming—with most of the warming of the last 50 years attributable to human activities, predominantly in the energy and agricultural sectors.

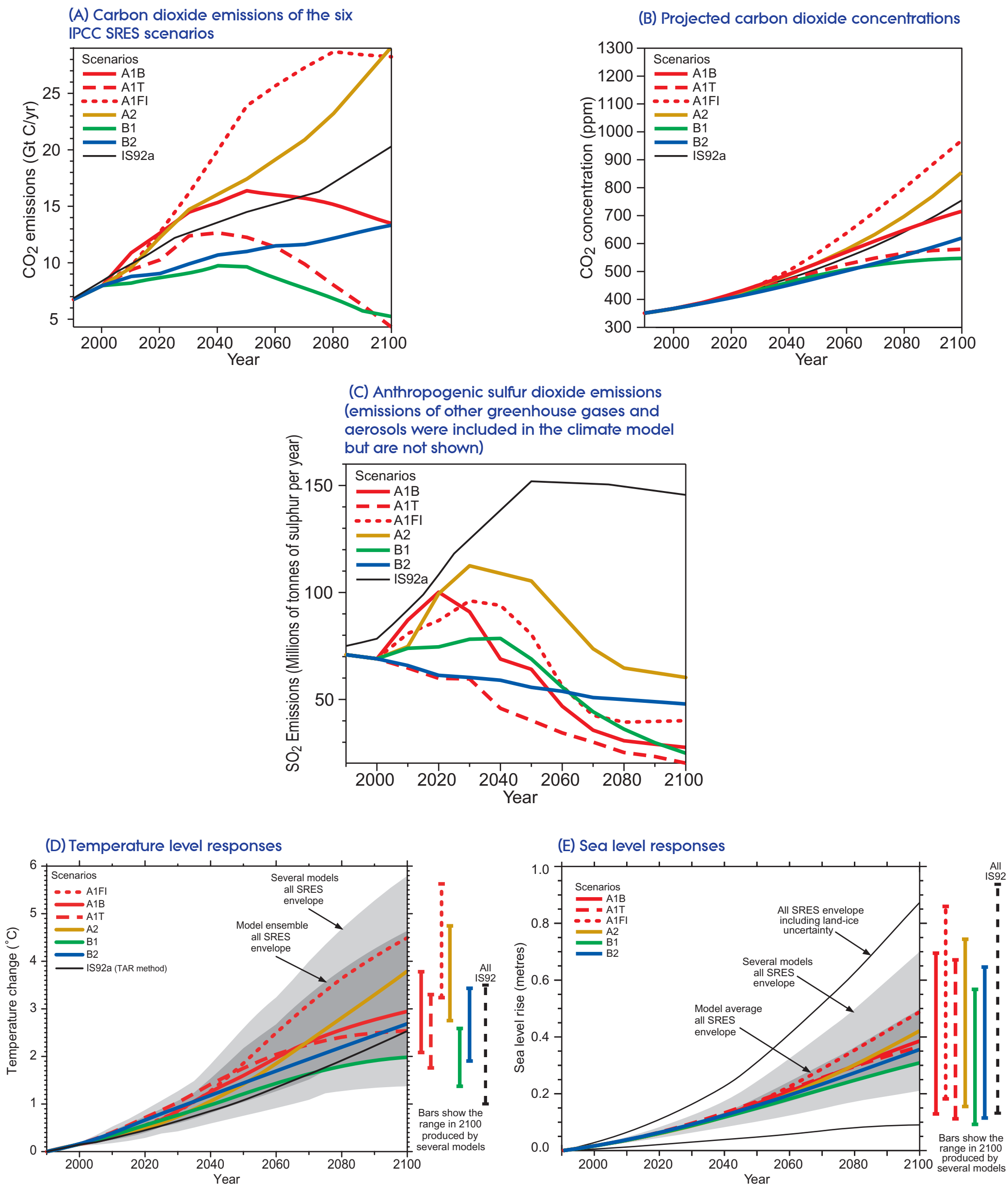
Most greenhouse gases (GHGs) are projected to increase significantly over the next 100 years—carbon dioxide (CO_2), for example, which has increased from about 280 parts per million (ppm) to 377 ppm since the pre-industrial era, is projected to reach 540–970 ppm by 2100 (Figure 6.1). The global mean surface temperature, which rose by about 0.7° Celsius over the last 100 years, is projected to increase by a further 1.4–5.8° Celsius by 2100. The spatial and temporal patterns of precipitation, which have already changed, are projected to change even more in the future. Sea levels rose 10–25 centimeters during the last 100 years and are projected to rise an additional 8–88 centimeters by 2100, and most non-polar glaciers are retreating. The frequency of extreme events, such as heat waves, droughts, and floods, is also projected to increase.

The observed changes in climate have already affected ecological, social, and economic systems, and poverty alleviation and sustainable development are threatened by projected changes in climate. Over the next 100 years, water availability and quality are expected to decrease in many arid and semiarid regions. Human health is threatened by projected increases in the incidence of vector-borne diseases such as malaria and dengue and water-borne diseases such as cholera, as well as in heat-stress mortality. Hunger alleviation is threatened by projected reductions in agricultural productivity in the tropics and subtropics for almost any amount of warming, as well as by depleted fisheries. Biodiversity and the goods and services of many ecological systems, especially coral reefs, are likely to be adversely affected. Developing countries and particularly poor people in developing countries are the most vulnerable.

Several recent scientific findings suggest there is even greater reason for concern:

- Increased oceanic acidity is likely to reduce the oceans' capacity to absorb CO_2 and affect the entire marine food chain.
- A regional increase of only 2.7° Celsius above present (associated with a globally averaged temperature rise of about 1.5° Celsius above today) could trigger a melting of the Greenland ice cap.
- An increase in ocean surface temperature of 1° Celsius is likely to lead to extensive coral bleaching.
- A reversal of the land carbon sink is possible by the end of this century.
- Destabilization of the Antarctic ice sheet becomes more likely above 3° Celsius, and the Larson B ice shelf is already showing signs of instability.
- The North Atlantic Thermohaline Circulation may slow down or even shut down within the next 100–200 years.

Figure 6.1 The global climate models for the twenty-first century



Source: Intergovernmental Panel on Climate Change.

Based on the current understanding of the climate system and the response of different ecological systems and socio-economic sectors, if significant global adverse changes are to be avoided, the best guidance today suggests limiting the increase in global mean surface temperature to less than 2° Celsius above pre-industrial levels and keeping the rate of change below 0.2° Celsius per decade. Recent probability analysis suggests that accomplishing the former with relatively high certainty will require keeping the equivalent CO_2 concentration below 400 ppm. It also suggests that stabilizing the equivalent CO_2 concentration at 450 ppm would imply a medium likelihood of staying below 2°C above pre-industrial levels. And if the equivalent CO_2 concentration were to rise to 550 ppm, this outcome would be unlikely.

Instead of declining, however, global GHG emissions are increasing. Despite the Kyoto Protocol coming into force, emissions have increased in OECD countries and are growing rapidly in developing countries, especially China and India. Because of global economic growth, the world is experiencing a boom in energy use that is dominated by coal-power generation of unprecedented proportions. Unless concrete actions are taken now to provide a long-term policy and investment framework for carbon emission reductions, the largest producers of coal-fired electricity—the United States, China, and India—will remain carbon emission–intensive. Consequently, decisions taken today on technologies and policies in these countries will have irreversible consequences on GHG emissions and hence on development paths for 40–60 years.

Given that the Earth's climate has already changed and that further change is inevitable, future alterations need to be mitigated by reducing projected emissions of greenhouse emissions at the same time that countries adapt to climate change. The exact nature of the trade-off between mitigation and adaptation is veiled by uncertainty on the actual impacts and on the potential progress of research and development on lower-cost cleaner technology. But we do know this: action cannot wait.

Mitigation of Greenhouse Gas Emissions

Significant reductions in net greenhouse gas emissions are technically feasible due to an extensive array of technologies and practices in energy supply and demand, waste and land management, and industrial sectors—many at little or no cost to society. However, realizing this technical potential will involve the development and implementation of supporting policies to overcome barriers to the diffusion of these technologies into the marketplace, increased funding for R&D, and effective technology transfer.

Reducing projected GHG emissions in the energy production and supply sector will require a broad portfolio of technologies, including:

- Increased power plant efficiency, such as sub-critical to super-critical thermal power plants, and ultimately integrated gasification combined cycle (IGCC) coupled with carbon capture and storage (CCS)
- Increased use of natural gas as a bridging fuel in a transition period until renewable energy technologies become commercially available
- Reduced transmission and distribution losses
- Increased use of renewable energy technologies (biomass, solar, wind,

run-of-the-river and large hydropower, and so on)
- Nuclear power.

New efficient coal technologies and the renovation and modernization of existing inefficient thermal power plants are by far the most important priorities in the short to medium term, as coal will remain a primary energy source of many OECD and developing countries, particularly China and India. While widespread adoption of supercritical coal technologies would substantially improve efficiency in many developing countries, it would not over the long term solve the problem of carbon emissions. The real savings could come from combining IGCC with CCS, where the technology virtually eliminates carbon emissions into the atmosphere, making coal essentially a carbon-clean fuel. However, IGCC is still in its early stages and therefore is expensive. With substantial effort and lower cost manufacturing at scale, IGCC could become commercially competitive in 7–10 years.

To complement low-carbon energy supply technologies, there are numerous technologies, practices, and policies that can improve the efficient end-use of energy in the transportation, buildings, and industry sectors, thus reducing the demand for energy (Box 6.1). Improved efficiency in energy use offers one of the greatest opportunities to address energy security, price, and environmental concerns.

Finally, only with accelerated R&D will new technologies move into the realm of commercial viability and adoption. The level of investments in energy technology R&D in the public and private sectors is significantly less in real terms than historically. Promising technologies include in the near term CCS and fuel cells, as well as end-use efficiency options (zero-emission vehicles, for instance, and more efficient buildings), and over the long term hydrogen as an energy carrier and nuclear fusion. Increased OECD public sector support for energy R&D that is predictable and long-term is needed to overcome the technical challenges to commercial deployment of promising advanced clean energy technologies.

Reducing carbon emissions must be complemented by efforts to reduce emissions of the more radioactively po-

Box 6.1 End-use technologies and practices

- **Transportation**: Efficient gasoline/diesel engines, urban planning, urban mass transport systems, modal shifts to inter- and intra-city rail and water transport
- **Buildings**: Insulation, advanced windows, new lighting technology, efficient space cooling and heating, water heating, refrigeration, and other appliances
- **Industry**: Cogeneration, waste heat recovery, pre-heating, new efficient process technologies, efficient motors/drives and improved control systems, incineration of waste gases
- **Municipalities/Urban Local Bodies**: District heating systems, combined heat and power, efficient street lighting, efficient water pumping and sewage systems
- **Agricultural**: Efficient irrigation pumps, land management (such as afforestation, reforestation, reduced deforestation, and no-till agriculture).

tent greenhouse gases such as HFC-23, nitrous oxide, and methane. These are low-cost, high-impact investments, as these gases have a much greater impact than CO_2 per ton of gas. These in turn can be complemented by improved land use, land-use change, and forestry (LULUCF) activities. Afforestation, reforestation, improved land management, and agroforestry provide a wide range of opportunities to increase carbon uptake. Slowing deforestation provides another opportunity to reduce emissions. LULUCF activities have the potential to sequester up to 1–2 gigatons of carbon per year over the next 50 years, which is equivalent to 10–20 percent of projected fossil fuel emissions over the same period. The Kyoto Protocol limits the total credit that its ratifiers can claim from LULUCF activities, however, and only afforestation and reforestation activities are eligible under the Clean Development Mechanism.

Many energy-efficient technologies have not been adopted on a wide scale because of poor pricing policies and an incomplete legal and regulatory reform agenda. In addition, there are non-pricing as well as pricing bottlenecks, such as transaction costs, insufficient information availability, and institutional constraints.

Significant restructuring of the energy system will require energy-sector reform, including:

- Removal of subsidies to reflect the true cost of energy supply
- Internalization of the costs of externalities (such as local and regional air pollution) through markets, taxes, or subsidies
- Establishment of credible legal and regulatory frameworks that provide the stability on rules and prices that will induce investments into financially viable products
- Development of enabling policy environments through regulatory interventions, such as appliance energy efficiency standards and labeling policies, mandated utility demand-side management programs, mandatory energy audits, industrial energy efficiency norms, market access for clean energy generators, carbon taxes
- Creation of market-based approaches, such as emissions trading, risk mitigation instruments, and innovative clean energy and energy efficiency funds
- Voluntary programs and education and training.

Many of these policies feed back onto each other—for example, legal and institutional responses give rise to economic incentives that in turn will push technological initiatives such as renewable energy and energy efficiency. Policy targets for renewable energy that exist in 45 countries today are one example of how to accelerate the use of energy technologies that do not emit GHGs.

Adaptation to Climate Change

Some further climate change is inevitable, and ecosystems and human societies will thus need to adapt to new conditions. These changes will expose people to the adverse effects of climate change, some of which may be countered with current coping systems while others may need radically new behaviors. Climate change needs to be factored into national and sector-wide development plans. While its adverse consequences can be reduced by adaptation measures, they cannot be completely eliminated.

Climate variability is already a major impediment to reducing poverty and will become increasingly so as the Earth's climate warms. Most of the steps needed to adapt to a future climate are compatible with those necessary to reduce vulnerabilities to current climates. Immediate attention is needed for small island states and low-lying coastal areas exposed to storms, but for most countries the longer-term challenge is in the key sectors related to agriculture and associated water resource management.

Adaptation in developing countries is more difficult than in OECD countries because of increased exposure to climate impacts, restricted human capital and technological capacities, and limited access to credit markets and international markets.

Adaptation will require the transfer of existing technologies, new technologies, and the revision of planning standards and systems. Priority funding is needed to develop typologies of country cases to better understand options and costs; to establish better planning and screening tools, especially for hydrological and biological resource management; and to "climate proof" agriculture through a new generation of drought- and water-resistant seeds and breeds. Much of the technology and knowledge needed for adaptation is either currently available or can be developed at relatively low cost. Given the probability of more extreme weather events, there is an urgent need to upscale emergency response mechanisms.

Successful adaptation will require the efforts of many—from governments that should include adaptation in sector and national development planning to communities that need to cope better with changing conditions. Adaptation activities range from economic measures such as insurance for extreme events to capacity building for alternative crop cultivation and management of the impacts of sea level rise, infrastructure and investment for water storage, groundwater recharge, storm protection, flood mitigation, shoreline stabilization, and erosion control.

Financing Needs and Sources

The incremental costs of mitigating greenhouse gas emissions is estimated to range from less than $10 billion a year to over $200 billion (in 2005 dollars), depending on the stabilization target, the pathway to stabilization, and the underlying development pathways of developing countries. The central estimate for stabilizing carbon dioxide at 550 ppm, for instance, is about $60 billion per year. The reduction in projected GDP increases moderately when passing from a 750 ppm to a 550 ppm concentration stabilization level, with a much larger increase in passing from 550 ppm to 450 ppm. The percentage reduction in global average GDP over the next 100 years for stabilization at

450 ppm is about 0.02–0.1 percent a year, compared with projected annual average GDP growth rates of 2–3 percent.

Developing countries are not expected to bear the additional costs of a low-carbon economy because of the recognition of common yet differentiated responsibilities in the United Nations Framework Convention on Climate Change and because industrial countries are responsible for most of the anthropogenic GHGs currently in the atmosphere. There are only three sources of funding for mitigating greenhouse gas emissions: voluntary actions, international grants, and trade. While all are potentially important, trade is likely to confer the biggest flow of funds—between $20 billion and $120 billion per year.

Market mechanisms and incentives can significantly reduce the costs of mitigation. International project-based and emissions-rights trading mechanisms allowed under the Kyoto Protocol, in combination with national and regional mechanisms, can reduce the costs of mitigation for OECD countries that have ratified the Kyoto Protocol. In addition, countries can reduce net costs of emissions abatement by taxing emissions (or auctioning permits) and using the revenues to cut distortionary taxes on labor and capital. Project-based carbon trading can facilitate the transfer of climate-friendly technologies and produce a revenue stream to developing countries consistent with their national sustainable development goals.

To deal with the scale of investment needed in climate change, it is therefore imperative that a long-term, stable, and predictable regulatory system be established, based on a wide variety of principles, common policies, energy efficiency improvement goals, and technology standards or targets. Ideally a framework should be established that reaches out to 2050 to produce market certainty, stimulate R&D, and allow time for appropriate policies to be enacted. Even with an improved regulatory environment and the use of policy and political risk mitigation instruments, the challenge of financing incremental costs and reducing technology risks will be significant. Financing vehicles are needed that could blend grants with carbon finance and provide funds to collateralize clean energy technologies.

The overall annual costs to adapt to projected climate change—that is, to climate-proof development—are likely to lie in the range of $10–40 billion a year, of which about a third is associated with public finance. Most of the initial funding will come from the public sector, but this needs to be integrated in national development planning and private investment plans.

Section 7

Bridging from Local to Global

Actions must be taken in this decade to lay the foundations that will carry us well into the middle of this century. Global and national policies, investment strategies, and new institutional relationships need to be developed. In today's interconnected world, the management of fragile ecosystems, transboundary water systems, communicable diseases, climate change, and scientific and technological pathways and knowledge systems all warrant attention. Management of these systems will require cooperative action. And in today's mobile world, issues of demographic change, migration, and social conflict need to be addressed. This fact suggests greater attention to promoting the long-term development of human capital and stable, inclusive societies.

We have argued that there are grounds for optimism when we take a 50-year view of the prospects for development. The optimistic vision of a wealthier, more equitable world is achievable, but we should not doubt the scale of the challenges we face. This paper has emphasized five issues that will be critical in achieving this vision:

- Sustaining natural wealth
- Improving governance
- Achieving social development
- Boosting agricultural productivity and competitiveness
- Managing climate risks

Many of these challenges are local, and local investments and institutional reforms will suffice to deal with the issues. But there is a large and growing set of challenges that are truly global in nature. Dealing with these will require increased coordination at the global level. This final section offers summary thoughts on the challenges we have highlighted and concludes with a discussion of some "issues without passports" that we foresee.

Sustaining Natural Wealth

Better management of natural resources is a particular concern in the poorest countries. These nations are the most highly dependent on natural resources as a source of income and wealth, and the policies and institutions dealing with these resource issues tend to be weakest in these countries. Two priorities stand out in low-income countries: first, boosting the profitability of natural resources, since these can be a source of development finance; second, better management of the soil resource, since fully two-thirds of the natural wealth of low-income countries consists of cropland and pasture.

We are learning how devolution of resource management to local communities can boost profits from these resources. For agricultural land, the key is clearly boosting yields while preserving soil quality, as discussed later in this section. For commercial resources, such as minerals and energy, avoiding the distorting effects of large resource rents is vital—the solutions here span macro policies and better governance in the resource sectors. Transparency in commercial natural resource management is particularly important in order to ensure that the benefits of resource abundance are not hijacked by special interests. Water will need to be managed as an economic good. We see living resources—forests and fish—in decline in most of the developing world. Better governance and the rule of law are the linchpins in transforming natural resource wealth into sustainable economic development.

Finally, the Millennium Ecosystem Assessment concluded that the majority of the environmental services provided by nature are in decline. In most cases these services are provided as "externalities," where the provider of the service is distinct from the beneficiary. Under these circumstances it is possible to make truly damaging development decisions concerning natural resources. There is an urgent need to inventory and value environmental services as a first step to designing interventions to better protect them.

Improving Governance through Increasing Transparency

Partly because there is a higher comfort level with technocratic "fixes," traditional themes such as public sector management (including civil service reforms, codes of conduct, and so on) continue to be given significant prominence in the aid community. By contrast, transparency has been an underemphasized pillar of institutional reforms. Even popular lore subscribes to the importance of transparency in the old adage "sunlight is the best disinfectant."

Transparency reforms can span political processes (publishing campaign contributions, or publishing votes and draft legislation), public procurement, enforcement of conflict-of-interest laws, and laws on access to information. Freedom of the media and transparency of public finances are also key.

Of course, transparency reforms are not the only institutional reform priorities. International financial institutions and donors can complement these reforms by continuing to support traditional core competencies, helping with capacity building, sharing knowledge, and supporting focused reforms in key institutions in developing economies, such as in the judiciary, customs, and tax and procurement. These targeted reforms supporting highly vulnerable institutions would, however, have to be adapted to specific realities, and thus might vary considerably from country to country in their priority and in specific design. In some countries the first priority might be to support procurement reforms, stronger accountability institutions in parliament, and freedom of the press; in others, it may be reforms in the judiciary, women's rights, and customs and excise.

Governance and corruption challenges are not the exclusive responsibility of developing countries, nor are public institutions the only culprits. The industrial world must not only deliver on its aid and trade liberalization promises, it must also lead by example. OECD countries, which are lagging behind, should ratify and effectively implement the 2003 UN Convention against Corruption and take concrete steps to repatriate assets looted and stashed abroad by corrupt officials.

Socially Balanced Development

We have learned that for development to be sustainable it must be accompanied by positive social change—it is not just about economic growth. This requires action at the local level to build more accountable institutions, to invest in social capital, to include the marginalized as empowered actors in the development process, and to support societies that are more cohesive. It is also clear that when societies fail, when deep divisions and exclusion are not addressed, countries erupt into violent conflict or the state gradually erodes.

As has become painfully clear, the problems of conflict-affected or fragile states do not respect borders. They provide the breeding grounds for global threats—from terrorism to the spread of HIV/AIDS and other diseases. The international community spends vast amounts of resources trying to reconstruct societies torn apart by violent conflict and to contain the spread of disease and terrorism. A more cost-effective approach is surely to support social and development processes that can produce more cohesive societies, better able to peacefully manage social tensions and nurture more accountable and effective institutions that do not provide a springboard for global threats.

Social accountability is about reforming political and institutional cultures, changing mindsets, building citizenship, strengthening civil society capacity, and above all helping to construct a new set of state-citizen relations. Both supply and demand sides matter. Social accountability is about strengthening bridging mechanisms. The demand for accountability by citizens must be matched not only by the willingness of the government and service providers, but also by their ability to respond to civic demands. Finally, access to information is vital. The quality and accessibility of public information and data are key determinants in the success of social accountability mechanisms.

Boosting Agricultural Productivity and Competitiveness

In the past, major investments in technology and infrastructure averted a global food crisis. But as demand for safe, nutritious, and affordable food increases, the challenge to countries is to increase the productivity of limited agricultural land and water without harming the natural resource base, including biodiversity. Achieving this goal will take a concerted effort by the public, private, and civic sectors acting at all levels of intervention. At the local level, we need to empower rural farmers to organize and demand services and appropriate technology from various sources. Farmers will need to work closely with other stakeholders to develop new varieties and to adapt existing or create new technologies that meet their needs. They will also need to shift their production patterns to preserve the environment.

National and subnational governments need to create an enabling environment where the private and civic sectors can operate to meet the needs of both farmers and consumers. With an average 20-year delay on returns to research, governments and the private sector need to support research systems now, so that they can reap the benefits in the future. Perhaps most important, the public sector needs to target investments carefully to complement private sector activities at the national and international level. While the private sector invests in commercially viable technology, the public sector must focus on technology to meet the needs of the poorest, where the profit margins are not guaranteed. International organizations such as the CGIAR will be central to generating the science, technology, and practices that will form the future of sustainable agriculture. Activities such as the International Assessment of Agricultural Science and Technology for Development can help build a consensus among the stakeholders in agriculture as a basis for future cooperation that will move the sector forward.

Agriculture still retains a central role in the livelihoods of rural people, especially in Africa. Higher rates of growth in agricultural productivity are essential to promote broad-based economic growth, reduce rural poverty, and conserve natural resources. Productivity growth, in turn, is based largely on the application of science, technology, and information provided through national agricultural innovation systems embracing all the stakeholders who generate, share, import, and use agricultural knowledge and information.

Managing Climate Risks

Developing countries recognize that they must accelerate access to affordable and reliable modern energy services in order to decrease poverty and increase productivity, enhance competitiveness, and improve their economic growth prospects. Transformational policies and strategies will be needed to meet national expectations of secure, safe, and clean energy and to deal with the implications of climate change. The widespread commercialization of energy efficiency technologies is an effective strategy both to reduce local and regional air pollutants and to address climate change and energy security concerns without affecting economic growth.

Unfortunately, carbon-intensive energy infrastructure and inefficient cities are being rapidly built and expanded, setting the capital stock for decades, while new, cleaner, more efficient technologies remain underutilized. Decisions taken today on technologies and policy will have profound consequences on development paths for 40–60 years. In addition to the need to transform the energy sector, there needs to be a transformation in land management, with policies, practices, and technologies that decrease net emissions of greenhouse gases.

Many developing countries are not yet willing to commit to reducing their greenhouse gas emissions because they fear it will adversely affect their ability to gain access to cheap energy for development. Yet developing countries and poor people who live there are the most vulnerable to climate change. Climate change threatens the quantity and quality of water, agricultural production, human health, human settlements, and ecological systems throughout most of the tropics and subtropics. The challenges, therefore, are to ensure access to affordable, climate-friendly energy for development and to reduce the vulnerability of socioeconomic sectors and ecological systems to climate change.

Because of the recognition of common yet differentiated responsibilities in the United Nations Framework Convention on Climate Change and because industrial countries are responsible for most of the anthropogenic greenhouse gases currently in the atmosphere, developing countries are not expected to bear the additional costs of a low-carbon economy. To deal with the scale of investment needed in climate change, it is imperative that a long-term, stable, and predictable regulatory system be established that encompasses the concept of differentiated responsibilities and that promotes cost-effective reductions in greenhouse gas emissions through an international trading system. Depending on the specific obligations negotiated, project-based carbon trading could facilitate the transfer of climate-friendly technologies and produce a revenue stream of between $20 billion and $120 billion per year to developing countries, consistent with their national sustainable development goals.

Addressing climate change will require national energy sector reform, internationally coordinated climate policies, international collaboration on technology development and diffusion, the establishment of new financing mechanisms for both mitigation and adaptation, and the integration of climate concerns in sector and national economic planning.

Issues without Passports—The Need for Global Issues Management

The Asian financial crisis of 1997/98 demonstrated in stark terms the risks of financial contagion in global capital markets. Unsound policies in individual countries led to financial crises that quickly spilled over to neighboring countries, where it was feared that similar vulnerabilities existed. Financial markets around the world felt the pain. The lessons learned from the crisis have led to better global systems, enforced by institutions such as the International Monetary Fund and the Bank for International Settlements, for tracking debt, increasing transparency, and strengthening regulation of financial institutions.

From the sustainable development perspective, we see a range of issues that are truly global, spanning:

- Emergent infectious diseases of humans, plants, and animals, such as avian influenza
- Loss of biodiversity, which imposes global costs
- Damage to the ozone layer
- Global warming and climate change
- Failed states, exporting instability to neighbors and the world.

Local actions can be important in dealing with many of these issues, whether it is adopting carbon-neutral energy technologies or eliminating substances that harm the ozone layer. But the incentives for taking these actions must lie in better systems for global coordination. For example, individual emitters of carbon dioxide have no incentive to reduce emissions because most of the damage they do is remote in space and time. The solution to the problem lies in global agreements that provide the incentives through regulatory or economic instruments. One very successful example of such a global scheme is the Montreal Protocol on Substances That Deplete the Ozone Layer.

It is increasingly apparent that these issues interact. Some chemicals that damage the ozone layer are highly effective greenhouse gases as well. Global warming and climate change will affect the incidence of disease, as well as stressing local "hotspots" of biological diversity. Failed states can harbor disease, frustrating efforts at eradication.

This long and growing list of global issues will require that the truly global institutions—the United Nations system, of which the World Bank is a part—step up to meet the challenge.

There is also a growing need for the provision of what might be termed "global technological public goods." There are problems such as tropical diseases and the vulnerabilities of tropical agriculture that do not lead to profitable investment opportunities for the private sector. Finances and the ability to pay are limiting factors. Innovations in global finance and strengthening institutions such as the Consultative Group on International Agricultural Research are key steps in solving some of the most intractable problems of developing countries.

Better means to deploy knowledge and human ingenuity must surely be part of the solution to the challenges highlighted in this paper. This will require new thinking on the modalities of international development assistance. The need for finance will not go away in developing countries, at least not in the near term. But increasingly it will be delivery of the "software" of development—creating and sharing knowledge, building capable institutions that can use this knowledge—that will define the relationship between donors and recipients.

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