Executive Summary

In recent years, agricultural water has helped meet rapidly rising demand for food, and has contributed to the growth of farm profitability and poverty reduction as well as to regional development and environmental protection.

After several decades of publicly funded surface irrigation, and more recently of privately developed groundwater irrigation, remaining opportunities to harness new resources for agriculture are fewer and more expensive. Investment is increasingly focused on rehabilitating and improving the existing systems. However, water productivity remains generally low, and returns to public investment generally disappointing, especially in large-scale irrigation. New solutions are needed, based on new management options and widely available technologies. The role of government is changing, responsibility is being decentralized, farmers are playing an increasingly important role in decisions and investment, and more and more, markets are driving growth. How to meet ever rising demand for food while at the same time increasing farmer incomes, reducing poverty, and protecting the environment, all from an increasingly constrained water resource base, is the main challenge facing agricultural water management (AWM).

The Bank's recent corporate strategies for Rural Development, Water, and Environment, edited by the Environmentally and Socially Sustainable Development Network, call for a reengagement in AWM, and provide general principles on how that could happen. Most growth should come from improvements in water productivity; sustainable increases in farmer incomes are essential, with a focus on the poor; institutional improvements are needed to increase efficiency of resource use; and water for agriculture has to be used sustainably within an integrated approach.

The overall goal of this report is to give strategic focus to implementation of the AWM components of the corporate strategies. Its specific objectives are to set out the changing context of demand and supply for agricultural water; to identify the policy, institutional, and incentive reform options that will accelerate productivity improvements and pro-poor growth; and to articulate priorities for investment in AWM. It is also intended

to define the role of the public sector and other stakeholders, and to set out how AWM can be best integrated upstream into water resources management, and downstream as an input provider into the agricultural economy.

The primary audiences for the paper are policy makers and project managers in our partner countries and development organizations, as well as World Bank country and sector managers and task team leaders. There is broad interest among these partners in collaborating with the Bank on developing a new AWM agenda. The implications of this report are many and far-reaching. It will be used (a) as a platform for a wide global dissemination and consultation with our partners on the best policy, institutional, and investment options to reengage in AWM; and (b) as the strategic framework for the preparation by the Bank of its action plan in the sector.

THE ACHIEVEMENTS AND CHALLENGES OF AGRICULTURAL WATER MANAGEMENT

AWM is diverse and has strong links to other sectors and to the broader economy. AWM is not a goal in itself but part of a process of resource management that provides a key input to agricultural production and farmer incomes. It includes irrigation and drainage, water management in rainfed agriculture, recycled water reuse, water and land conservation, and watershed management. It covers all irrigated agriculture, whether fed by surface water or groundwater, including both public schemes and millions of private individually irrigated farms, in a wide range of agro-climatic conditions, and in a broad set of production systems and water management contexts. AWM is at the crossroads between four areas of public policy for sustainable growth: water resource management, agriculture, rural development, and the environment. AWM also interacts closely with broader aspects of macroeconomic policy for growth.

Irrigated agriculture has been vital to meeting quickly rising food demand. In the last 40 years, developing country demand for food has tripled, increasing much faster than population growth rates, as nutrition has improved. Food production in the developing world has almost kept pace, with an enormous rise in production (up two-and-a-half times during this period). Crops that are mostly irrigated—such as rice, wheat, maize, and cotton—saw production increasing since the early 1960s two- to fourfold. The production of irrigated fresh fruit and vegetables increased particularly quickly over the period—by four to six times, and these crops now account for over one-fifth of all developing country agricultural exports. Two-thirds of the increase in crop production has come from yield increases, rather than from expansion of the cropped area (except in Sub-Saharan Africa). Average yields of rice and maize more than doubled, and wheat yields went up threefold.

Irrigation continues to expand but now the pace is slowing. For developing countries as a whole, the irrigated area more than doubled over the last 40 years, and by 2000 covered 234 million hectares (ha) (representing 85 percent of the world's total irrigated area of 276 million ha in 2000), about half the land estimated by FAO to be potentially irrigable. However, the pace of development has now slowed significantly: annual rates of expansion of around 2 percent a year in the 1960s and 1970s slowed to hardly 1 percent in the 1990s. Many countries now face constraints to expansion, particularly from social and environmental concerns. The low productivity of many existing schemes has prompted a change in investment policy in the sector, away from new infrastructure and toward programs that improve the performance of existing schemes.

Water availability for irrigation is increasingly constrained. Irrigation accounts for 85 percent of water withdrawals in developing countries, and the rapid growth of the sector has been based on the availability of these huge quantities of low-cost water. Now rising demand for agricultural water faces increased demand from domestic and industrial uses. Many areas are already enduring competition for water and rising marginal costs. For years, groundwater provided a profitable new resource, but in many basins groundwater is now being mined rapidly.

Governments have led the expansion of large-scale irrigation but performance has been suboptimal. With strong investment and management input from governments, large-scale irrigation has contributed to rapid increases in food production, the major public policy goal. However, the supply-led approaches and large-scale irrigation infrastructure that were to fuel growth have resulted in bureaucratic institutions that lack the structure and incentives for efficient management, and in inflexible water delivery systems not capable of responding to farmer needs.

Water productivity has shot up but there is massive room for improvement. The increase in water productivity in recent years has been spectacular: over the period 1961–2003 the water needed to produce food for one person halved from six cubic meters a day to less than three cubic meters a day. Over the same period, the production of rice and wheat went up by 100 percent and 160 percent, respectively, but with no increase in water use. However, in many basins, water productivity remains startlingly low and takeup of modern technology is slow: drip technology has been adopted on less than 1 per cent of irrigated lands worldwide.

AWM has contributed to poverty reduction in irrigated agriculture, but improvements have largely bypassed farmers in the rainfed areas. AWM has made a sub-

stantial contribution to poverty reduction, although irrigation development has not often targeted the poor specifically. The groundwater revolution also has a significant poverty-reduction impact, bringing a reliable water source right onto the farms of poor people. However, the rainfed areas where most poor people live have been largely bypassed by the Green Revolution and by public investment in enhanced water management.

Environmental and social impacts of irrigation have been positive and negative, but stresses are growing. As water and land managers, farmers are also stewards of the environment, and they provide many environmental services and amenities to society. AWM and its infrastructure help mitigate the impacts of drought and floods, stabilize river flows, and reduce erosion and silt loads. They have contributed to shaping the countryside and to social and cultural values. However, tension between agricultural production and protection of natural resources is growing. Farmers face increasing difficulty in fulfilling their trusteeship role as many countries approach the limits of water and land resources. Much irrigated land suffers from drainage problems—about half a million ha go out of production each year. The third-party environmental costs and risks of irrigated agriculture have grown: loss of environmental water flows; groundwater overexploitation; pollution; destruction of natural habitats and livelihoods through drainage of wetlands; and waterborne diseases.

Overall, there have been significant advances in AWM but challenges are great, especially in Sub-Saharan Africa. Overall, the pattern of recent years has been of significant advances in AWM and in productivity, making a major contribution to farmers' incomes, poverty reduction, and regional and national development. The challenges ahead are, however, enormous, and nowhere more so than in Sub-Saharan Africa, where per capita cereals consumption is only half that of East Asia and where one-third of farmers remain hungry.

More details are included in chapters 1 and 2.

THE CHANGING GLOBAL AND NATIONAL CONTEXTS FOR AWM

The global debate on water resources management and food security is sharpening the agenda for AWM. Water resources and food production are increasingly global issues, and now debate is beginning to focus attention on key AWM questions, such as the potential conflicts between water for food and water for nature; the environmental impacts of irrigation intensification; and the trade-offs between low food prices and producer incentives and incomes. Pioneering work by the International Food Policy Research Institute (IFPRI), the Interna-

tional Water Management Institute (IWMI), and the Food and Agriculture Organization (FAO) has started to bring the issues to the fore, with major recent publications by these agencies exploring the water-for-food challenge. International research is now starting to reflect the growing emphasis on water productivity.

Changes in the global trade environment and national marketing strategies are of critical importance. The irrigation sector depends on market-derived incentives for its future, and some countries—with rapidly growing economies—have begun to move from a supply-driven food production strategy toward market-driven policies for AWM that focus on productivity and incomes. However, constraints to market-driven approaches persist: remaining trade barriers are predominantly on irrigated agricultural products (such as rice, wheat, cotton, and sugar), and access to national and international markets for smallholders is constrained by domestic restrictions on market development and by the lack of organized smallholder supply chains. Where access does exist, as for horticultural products, the dynamic impact of market-driven growth on irrigation development and productivity has been great.

Water resources management is changing, and environmental and social concerns are growing. Responses to growing scarcity, to increased competition among sectors, and to growing environmental and social concerns include integrated and basin management approaches and demand management measures. On the supply side, there are fewer new diversion and storage projects, and more consideration of reuse of wastewater and drainage water. Climate change is increasing the existing vulnerability of farmers. Investment policies are starting to move toward upgrading and management improvements, although very slowly. Consideration of the environmental and social impacts is becoming an important factor in AWM, with broader understanding of the multifunctionality of water and of human and ecosystem interactions. Environmental and social concerns are increasingly mainstreamed.

The roles of the respective stakeholders are changing. The role of government in AWM has begun to change, with tentative moves toward a greater role for users. There has been some decentralization, and the participatory irrigation management movement has caught on in more than 50 countries. However, few public irrigation schemes have become financially self-sustaining, and cost recovery generally remains low. Investment by farmers and other private sector investment is substantial, particularly in small-scale irrigation and private groundwater irrigation, which alone account for over half of the irrigated area worldwide. There are some initiatives in

public-private partnership (PPP) or large-scale irrigation, but they remain very timid.

More details are included in chapter 3.

THE FUTURE STRESSES AND RISKS CAUSED BY RISING FOOD DEMAND AND INTENSIFICATION OF IRRIGATED AGRICULTURE

The strong demographic push to food demand is expected to continue. For the developing world as a whole, population is projected to increase by half over the period 1999–2030. Developing countries' food self-sufficiency ratio is expected to decline from 91 percent to 86 percent, and their food trade balance is expected to turn sharply negative (US$50 billion annually by 2030). Nations with fast-growing economies will be able to import an increasing share of their basic food needs, which will stimulate investment in higher-value irrigated agriculture where markets exist. The poorer nations, particularly in Sub-Saharan Africa, are likely to focus on strategies to develop irrigated agriculture where investment costs are not too high, and to improve food crop production in currently subsistence agriculture environments. AWM will be an essential element in both strategies.

Intensified irrigated agriculture will provide more than half of the extra food. FAO has estimated that crop production in developing countries needs to increase at about 1.6 percent per year over the next three decades—a demanding challenge, although only half the rate of growth recorded in the last 10 years. Projections by FAO and IFPRI/IWMI are that irrigated areas are likely to have to provide more than half of this increased production. As water and land resources are constrained, further water productivity improvements will be essential. Water productivity improvements in large-scale irrigation are possible, but require major programs of "modernization"—a combination of institutional change and investment in system improvement. There is scope, too, for groundwater productivity to improve. In addition to technical choices, farmers have multiple choices to increase income from their production, particularly through diversification into production of fruits and vegetables and other higher-value irrigated crops.

However, over 40 percent of the extra food will have to come from intensified rainfed farming in coming years, for which improved water management is essential. Rainfed cereals yields would need to increase—IFPRI/IWMI (2002) estimates by more than 40 percent by 2025. The water productivity challenge in rainfed farming is how to introduce accessible technical solutions without increasing risks. Known techniques for soil moisture con-

servation and water harvesting—and some technologies for rainfed areas such as low-cost supplemental irrigation—can have high returns.

Growing water scarcity will have to be managed. In most parts of the world, the water available to irrigation will be constrained further, and irrigation consumption will grow much more slowly than consumption in municipal and industrial uses. In Asia overall, IFPRI/IWMI (2002) projects that water consumption by all users will increase by 14 percent by 2025, but irrigation consumption will go up by only 1 percent—and in water-constrained China, irrigation consumption is even projected to decline. Water stress will create a strong push to improve water productivity and to strengthen the use of demand management approaches. In many river basins, intersectoral competition will be a critical problem. Increased withdrawals for irrigation will be limited, and mechanisms for allocating water equitably between sectors will be needed. Groundwater depletion from increased irrigation will continue and may accelerate. Governments and users will have strong incentives to work on reducing rates of depletion.

There is some potential for expansion of the irrigated area. FAO estimates that the irrigated area in developing countries could increase by almost 20 percent (40 million ha) in the period 1997–9 to 2030. Some increase in the irrigated area will be supplied by diversion from structures already in place. Elsewhere, some new water withdrawal projects for irrigation would be undertaken. In Sub-Saharan Africa and Latin America in particular, there is technically scope for expansion of irrigation.

Risks for the environment and society will increase. As irrigated agriculture is intensified and as additional irrigation capacity is developed and drawdown of groundwater continues, environmental risks will increase. It will be essential to manage these risks using the technical, managerial, and economic instruments that have been developed progressively in recent years.

More details are included in chapter 4.

POLICIES, INSTITUTIONS, AND INVESTMENTS TO PROMOTE AGRICULTURAL WATER IN DEVELOPMENT

This section summarizes the options and trade-offs for improving AWM, beginning with the farmer's perspective and then treating in turn options at the system or area level, at the sectoral level, at the level of the nation and the macroeconomy, and finally in the global context. These reform options are described in detail in chapters 5 and 6 of the report. Relevant sections of those chapters are noted by section number.

The farmer's perspective

The farmer's main objectives are to increase his or her income and assets sustainably and to reduce vulnerability. Water security—access to assured water supplies—is an essential prerequisite. The farmer thus needs to have a say in the management of the irrigation system, which will provide a water service of quality as well as a secure water entitlement. These interests set the AWM reform priorities: irrigation modernization, user participation, water rights, and demand-driven investment. For profitable farming, the farmer also requires access to efficient input and output markets, and to cost-effective technology. These needs set the priorities for agricultural policy: market development, and research and technology transfer. How the farmer's interests and needs in AWM can be met is described in detail in the report and summarized below.

Options at the system or area level

"Modernizing" large-scale irrigation. In large-scale irrigation (LSI), the objective is to improve farming profitability sustainably through improved service at the least public cost. The inflexible water delivery systems and bureaucratic institutional design that characterize much LSI make response to changing markets and profit opportunities difficult. Further improvements in profitability have to be made through integrated system modernization, that is, by turning both the irrigation delivery system and the institutional structure around to focus on delivering a sustainable, efficient, and demand-responsive water delivery service. LSI modernization thus requires an integrated package of physical improvements and institutional change in addition to agronomic improvements.

Physical improvements will include a broad range of "hardware" investments and related management practices to assure an efficient, least-cost water service delivery that meets farmer needs. Optimization tools have been developed that allow the most cost-effective investments to be selected. (Section 6.1)

The parallel *institutional changes* to create a demand-responsive water service delivery typically include a reduction in the role of governments in management and financing, and promotion of decentralization, agency accountability, and scheme financial autonomy as an interim milestone toward full scheme management transfer. Efficiency improvements should be introduced to reduce costs and expand the revenue base: in the irrigation reform in Victoria, Australia, 80 percent of the improvement in financial performance came from system efficiency gains and an expanded revenue base, and only 20 percent from increased water charges. Water user associations have proved effective in modernization programs, and user participation should be included at each step of the decisionmaking process. Scaling up to water boards or user federations should be encour-

aged. Irrigation management transfer should be undertaken when the conditions are right and should generally be a carefully designed and implemented, medium- to long-term process. A possible complement is to involve the private sector through public-private partnerships (PPP). PPP brings in a "third professional party" that can be the catalyst for improved management and the genesis of a corporate culture. (5.5)

A vital component of institutional change—scheme financial autonomy—depends on cost recovery. Low cost recovery leads inexorably to poor service, and covering scheme costs is a mandatory objective: if systems are to deliver quality service, somebody has to pay for it. If irrigators cannot pay, then government must. Globally, this is an area where scant progress has been made to date, and more work is needed. There should be global dialogue to establish internationally valid benchmarks and targets. Within a scheme, it has to be clear what investment, operations and maintenance, and other costs should be recovered from whom, and how—for example, the costs of upstream works could be financed by government, downstream works at the tertiary and quaternary level by the irrigators, with cost sharing for the secondary canal level. (5.4)

Overall, irrigation "modernization" is a process implemented over an often lengthy period, with changes sequenced and integrated as needed. Priorities are a focus on the objective of farmer profitability through improved service delivery; a market-driven demand orientation; integration of physical investment, agronomic improvements, and institutional change including a reduced role for government; involvement of users throughout; efficiency improvements to reduce costs; and scheme financial and managerial autonomy. (6.1)

Improving the profitability of small- and medium-scale irrigation. Water productivity on traditional and small-scale AWM systems is typically low. Government support is best provided through community-driven approaches and financing mechanisms, or working through nongovernmental organizations (NGOs) as part of a broader package of rural development that ensures that rural and market infrastructure develop in step with one another. Participatory irrigation management (PIM) and irrigation management transfer (IMT) should be systematically encouraged. An element of matching grants will be necessary. The agenda should include research for the development of affordable irrigation technologies. New approaches use the market to develop appropriate technologies and to disseminate them. (6.1)

Ensuring more sustainable development of groundwater irrigation. Unplanned mining of groundwater has severe costs for the rural economy, particularly for the poor, and the challenge is to recover sufficient control to allow opti-

mum economic benefits to be achieved. First best solutions rely on a rights-and-regulation framework, but in most countries this will be a very long-term solution. The alternative is to strengthen existing rights and promote self-regulation, with supporting changes to the incentive framework. In particular, governments need to eliminate energy subsidies, which drive overdrafts everywhere. Demand-side measures to improve the efficiency of water use should be combined with supply-side measures, such as aquifer recharge enhancement, rainwater harvesting, drainage, and urban wastewater reuse. With a handful of possible exceptions, such as Jordan, no developing country has succeeded in recovering control over groundwater, and prospects for eliminating overdraft completely are limited. However, using the institutional, economic, and technical tools discussed, countries may move toward more "planned" depletion, where a slower pace of mining may allow a less water-intensive economy to develop without severe shock or negative impacts on the poor. (5.2)

Enhancing water productivity in rainfed agriculture. Improving water availability and productivity in rainfed agriculture and watersheds is essential for household food security and poverty reduction, yet solutions are much less evident than for irrigated areas. There is a significant research agenda, particularly on land and water management and agronomic practices, but priorities are the transfer of existing technology, the development of market outlets, and physical investment in rural infrastructure and in water control structures. Market-driven integrated approaches that reduce risk, and that involve community participation throughout are most likely to succeed. (6.1)

Developing and integrating sector policies for AWM

At the sectoral level, policies for water resources management, agriculture, rural development, and the environment need to mesh to support sustainable, market-driven growth in rural incomes based on improved AWM.

Water resource management policies. Critical areas where water resources management and AWM need to interact are basin planning, incentives to water productivity, nonconventional water, and water rights.

AWM has to be treated within an *integrated water resource management framework* in which basin plans aim at accommodating often conflicting objectives such as economic efficiency of water allocation, equitable water distribution, and environmental protection, including drainage needs and environmental flows. The basin approach allows the productivity of agricultural water to be managed by reducing the amount of water depleted from the water balance: measurement of returns per unit of water lost through evapotranspiration should become the yardstick of productivity. (5.2)

As water scarcity increases, the whole *incentive structure* has to promote water productivity. Demand management should combine the price signals that result from the macroeconomic, trade, and fiscal regimes and from agricultural and irrigation sector policy with nonprice factors such as rationing, asset transfer, or cost sharing on investment to create incentives to water productivity. (5.4)

Particularly in water-scarce countries, investment in *reuse of treated waste and drainage water* can offset water scarcity, but there are trade-offs that need to be managed in an overall basin context, including human health risks, pollution, and reduced environmental flows. Reuse of wastewater is a key area for investment. Governments have to determine reuse policies and establish the regulatory framework, but users should be partners in the development of programs. (6.1)

Established *water rights*—especially tradable rights—should improve water productivity and promote investment. However, on large schemes where quantities are uncertain and service delivery weak, attribution of legal rights is hard, and development of firm entitlements, often at the group level, should form part of the modernization programs. Some countries—Jordan, for example—have introduced formal rights by developing over time a flexible legal framework of entitlement and transfer, with capacity building. They have also formalized existing informal markets. (5.2)

Agricultural policies. Three areas of agricultural policy are of critical importance for AWM: market development policies, food policy, and policy for technology development and transfer.

Development of internal and export markets is the most important driver of farm profitability, together with efficient allocation of agricultural water, increased water use productivity, and investment and modernization in irrigated agriculture. Domestic market reforms—liberalization, privatization, subsidy removal—should complement external trade reforms and create an enabling environment for irrigated production, which encourages inward and domestic investment and provides for secure contractual arrangements. Development of exports in horticulture, for example, may require governments to take an active role in developing the behind the border agenda in trade facilitation. Government's role is best undertaken in partnership with the private sector. In addition, strategic investment to promote markets and create market and transport infrastructure can be critical to the development of irrigated agriculture. Development of markets and roads in the Nigerian *fadama* combined with access to groundwater boosted profitability by three times and more. (5.3)

Food policy has driven much public investment in irrigation, successfully supplying cheap food but often keeping irrigators poor and reducing investment returns. Food security can best be increased by channeling scarce

water to the most profitable enterprises of the poor, not by targeting food production per se. The emphasis has to be on efficient resource allocation and on the development of markets to add value to the production of the poor and to ensure that food is available. For poorer countries, escaping from the poverty trap requires taking some risks in moving toward a market-driven irrigated agriculture. Better off countries (including China) should consider moving progressively away from strict self-sufficiency goals to high-value irrigated production. Where food policy changes, support and safety net programs may be needed. (5.3)

Technology development and transfer is essential to growth—but it has to be market-driven. Considerable AWM technology is available, but farmer adoption has been slow. Currently, just 3 percent of the irrigated area worldwide uses pressurized irrigation, and the scope for expansion is enormous. Technology adoption is best promoted by encouraging the development of profitable product markets. Governments should also work with the private sector to develop technology and promote its adoption through the market. (6.1)

Rural development policies. Rural development policies target sustainable improvements in livelihoods. Irrigation helps reduce *poverty* through increased food output, higher demand for employment, and higher real incomes, and also drives a local multiplier effect to increase nonfarm rural output and employment. Irrigation also reduces vulnerability by stabilizing output, employment, and income. In general, irrigation has the most poverty-reducing impact where (a) there is equity in land distribution; (b) investments and water charges are designed with the needs of the poor in mind; (c) schemes are well managed and provide good water service; and (d) users are involved in management. There may, however, be negative impacts on the poor, and irrigation is not always the most efficient pro-poor investment available. Policy analysis and poverty-reduction strategy papers should explicitly examine poverty-reduction aspects of AWM, and poverty reduction should be built into AWM investment programs. Programs should give priority to (a) pro-poor rainfed agricultural water (and land) investment; (b) low-cost irrigation technologies, preferably through the market; (c) use of community-driven development and social fund approaches to AWM investment; (d) small-scale irrigation and water conservation investments; (e) targeting large-scale irrigation investments toward pro-poor entry points; and (f) diversification into higher-value irrigated crops. Care has to be taken to ensure that the benefits of public support go principally to the poor. (5.7, 6.4)

Women are stakeholders in AWM—and a poverty target group—yet they are widely disregarded in policy and programs. Women should be systematically involved in AWM projects, and economic and social analysis and mechanisms of participation and inclusion should be adapted to increase the effectiveness of women's participation. (5.6)

Environmental policies. The considerable global experience on *managing environmental risks* needs to be applied both to intensification and to expansion of irrigation. At the macroeconomic level, the main instrument to guide farmers to environmentally friendly practices should be the incentive structure, which should reflect the value of environmental goods, services, and costs, for example, reducing energy subsidies or making cost-sharing grants for terrace maintenance. At the sectoral level, environmental concerns need to be mainstreamed into all aspects of water management and agricultural policy, including into research and technological innovation and adoption in AWM. Expansion of irrigation should take place within basin plans, using safeguard approaches. Particular attention should be given to the protection of environmental flows and of groundwater resources. (5.8)

Much of the world's irrigated lands suffer from *drainage* problems, and an estimated 20–30 million ha need improved drainage. Developing countries should allocate more resources to drainage investments within an integrated water resources management framework, using participatory approaches and planning tools to take account of the social, economic, and technological aspects. (6.1)

Policy integration. Improving the profitability of irrigated farming requires a combination of actions at the farm, scheme, and sectoral levels. The common thread at all levels is that of market-driven incentives, but a wide range of policies, institutional reforms, and investments is needed to steer irrigated agriculture onto a sustainable growth path. These measures will vary according to local conditions, and sequencing and prioritization need consideration. In the 1970s and 1980s, investment in large-scale irrigation in Morocco and Jordan created irrigation networks capable of better service, but the scheme-level improvements in institutions, the links to external markets, and the integration of scheme water use within efficient basin plans has come much more slowly, so that water productivity and farming profitability are only now improving. The integration of scheme and sectoral measures into the broader framework of national macroeconomic policy for growth is also key to driving productivity and profitability.

Macroeconomic policy and AWM

At the macroeconomic level, the objective is national economic growth through efficient resource allocation. At this level, the roles of government and other stakeholders are determined, and fiscal policies on budget support and investment are decided. The political economy of vested interests and competing objectives is also important at this level.

Governments should be responsible for *core public sector tasks* related to AWM: integrated water resources management, environmental protection,

research and technology transfer, and rural infrastructure. In addition, governments should correct market failure through interventions in poverty reduction, water pricing, and the development of product and financial markets. Beyond these functions, governments should seek broader engagement of other stakeholders—farmers, NGOs, and the private sector—in a process of decentralization and inclusion. (5.5)

Government budget support finances about half of the US$30–35 billion invested globally in irrigation each year. Past patterns of support have generally reduced the cost of water, giving little incentive for efficient use and creating distortions in the market. Budget support should be realigned with policy goals such as water use productivity, farming profitability, and poverty reduction—for example, the current generation of "smart" cost-sharing subsidies on drip irrigation. (5.4)

Public investment in AWM should be guided by the lessons of experience: integration within basin plans, decentralized management, participatory approaches, and financial sustainability at least cost to the government budget. Some irrigation expansion and new water resource withdrawals will be justified by rising demand for agricultural products in coming years. Projects will have to be justified in terms of their impacts at the overall basin hydrological and welfare level in a way that is seen to be fair to all stakeholders. Environmental and social risks will need systematic mitigation, too. That expansion of large-scale irrigation is the best investment available in AWM will need to be demonstrated, because returns to other AWM investments may be much higher. However, investment in new infrastructure is certainly justified in countries such as Ethiopia, which has abundant water and a level of storage infrastructure per capita less than 1 percent of that of North America. The private sector should be involved through PPP wherever possible. Where feasible, irrigation expansion projects should be integrated into multipurpose programs to ensure inclusion in the integrated water management framework and to improve the economics of the irrigation component. Water infrastructure should increasingly be seen as a means of increasing water security by reducing vulnerability to exogenous shocks such as floods, drought, and hydrological variability. (5.1, 5.5, 6.1)

Returns to investment in AWM are often higher than has been estimated in recent years, and this will increase the attractiveness of investment. Benefits from multifunctionality of irrigation and drainage investments and from the multiplier effect of direct and indirect job and wealth creation in the economy have been understated. One study in Pakistan found that total benefits of irrigation were 12 times the direct, on-site benefits when all quantifiable economic and social benefits were accounted for. Climate change and hydrological variability cost the Ethiopian economy over one-third of its growth potential, and returns to irrigation are correspondingly high. Where profitable markets are available, economic returns to agricultural water are competitive. (6.2)

Policies, institutions, and resource allocation are shaped in part by the *political economy* of each nation. The structure of established interests means that in any change there will be losers as well as winners, and reforms in AWM typically have high political transactions costs. Governments need to enlist support for reforms through transparent and inclusive processes. Reforms need champions, and should be piloted to show how benefits outweigh costs. Incentives need to be built in, including early benefits for "winners" and support measures for "losers." (5.5)

AWM in the global context

At the global level, three major issues will affect AWM: trade reform, climate change, and the global research agenda.

Trade reform policies will strongly influence water productivity and profitability in agriculture by opening up external markets. The impacts of trade reform on irrigated agriculture should be carefully assessed before reforms are undertaken, because impacts on the irrigation economy can be negative as well as positive. A phased program including economic mechanisms and social support programs should be developed to help the adjustment toward free trade. Nations should invest in institutions and technology, because trade-driven growth requires a knowledge-intensive irrigated agriculture. (5.1)

Climate change creates greater risks and uncertainties, which should be dealt with by a risk management approach. At the strategy and policy level, adaptation to climate change needs to be factored into economy-wide modeling and poverty-reduction strategies. Increased hydrological variability will drive changes in investment programs, because investments in water storage and water productivity will become more profitable in many areas.

Research and technology transfer are vital to obtaining productivity improvements in AWM. Technical research priorities should focus increasingly on water productivity and on AWM for rainfed farming. Institutional, social, and economic research will also be vital on such aspects as large-scale irrigation management and modernization, and poverty-reduction impacts. Research institutions and governments should forge partnerships with the private sector, which is already very active in development and dissemination of irrigation technology. (5.1)

THE PRIMARY MESSAGES OF THE REPORT: TOWARD AN ACTION PLAN

The report sets AWM as an input to farming and as a key factor in farmer incomes, in agricultural growth and exports, and in poverty reduction. This economic context defines two underlying themes: an emphasis on pro-

ductivity of water use and the need for market-driven approaches. These themes have driven the key messages of the report:

- The setting of AWM within an integrated water resource management context, ensuring both efficiency in allocation of water between sectors and the integration of the productivity of agricultural water within the broader context of evapotranspiration from the hydraulic system.
- A focus on ways to increase water productivity and farming profitability through markets and the incentive structure, through investment, and through technology development and adoption.
- A move toward new institutional arrangements, which give more responsibility and say to farmers, engage the energy of the private sector, and reduce government's role.
- An emphasis on integration of policies, institutional change, and investments to achieve efficient outcomes in all aspects of AWM from modernization of large-scale integration to enhancing water management in rainfed agriculture, and on the sequencing and prioritization of change processes.
- A pragmatic approach to intensification and expansion of AWM, using participatory approaches and new methodologies to make sure that social and environmental concerns enhance the economics and sustainability of investments, and ensuring that the broader benefits of AWM are captured.
- Increased attention to the potential for reducing poverty, and the systematic factoring in of poverty and gender concerns to AWM programs.

These messages need to be adapted to regional and local situations through a process of dialogue and study that will produce action programs. At the country level, the new World Bank Country Water Assistance Strategies can act as the locus for an integrated approach to AWM within broader sectoral and macroeconomic strategies.

POSTSCRIPT ON SUB-SAHARAN AFRICA

The case of Sub-Saharan Africa is raised in many parts of the report and deserves special attention: it is the poorest region, and growing poorer, yet with a large untapped endowment of water resources, Sub-Saharan Africa is where changes in AWM could make the biggest difference.

Hitherto, agricultural growth has been largely through extension of low-yielding, rainfed cultivation. The low infrastructure base, low capitalization, scant market development, and high levels of risk combine to keep farmers locked in a poverty trap of low-yielding, self-sufficiency strategies. Yet less than 5 percent of renewable water resources is abstracted and only

4 percent of agricultural land is under irrigation. Climate change and increasing hydrological variability increase the need for AWM—and improve its economic returns.

There are constraints—high cost, low population densities, weak skills base, and so forth—but it is clear that integrated investment in AWM infrastructure, markets, technology, institutions, and human development would help increase incomes and reduce poverty, offering Sub-Saharan Africa the prospect of the path to economic takeoff that Asian countries have so successfully pursued.