WORKING PAPER 32

Water for Rural Development

Background Paper on Water for Rural Development Prepared for the World Bank

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and Intizar Hussain

IWMI
International
Water Management
Institute

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Introduction

This paper on *Water for Rural Development* is divided into two parts. The first part outlines the most important issues from IWMI's point of view on water for rural development, with a focus on developing countries. This part identifies, discusses and provides recommendations for key areas for interventions in water resources development and management in the context of rural development.

The second part of the document provides analyses of present and future water resources in the World Bank's defined regions. This part is divided into four chapters followed by a summary of the findings. The first chapter assesses global water resources and regional variations of internally renewable water resources and water withdrawals. The second chapter provides estimates of past trends in population, food production and consumption, and irrigation development, including growth in cereal yield and areas at the world and regional levels. The third chapter analyzes and discusses future water and food supply and demand scenarios (1995 to 2025) using IWMI's PODIUM model. The fourth chapter briefly outlines the importance of water for rural development. The last section summarizes the study findings and important issues.

PART I

Issues in Water Management for Agriculture for the World Bank Strategy Paper on Water for Rural Development

Introduction

With increasing water scarcity, it is essential to view water allocation and distribution in rural areas from the basin perspective. Traditionally, in the water sector, much of the focus on rural development has been aimed at individual systems or communities. This focus has to change to cope with wider issues of competition for water, particularly for water of good quality.

Looking at water from a basin perspective means that we have to look not only at water supply and demand for all users but also at institutional issues involved in the provision of services. The issue may best be exemplified by the issue of "scaling-up," whereby each separate water use, by itself, may not have a noticeable impact, but as the number of such water uses intensifies, the overall impact on water resources and other water users becomes significant.

In light of these issues, safeguarding and developing water resources for rural development require a combination of inputs or interventions in three major dimensions:

- The *upstream-downstream* dimension, which recognizes that each water use or water user potentially impacts on all the other uses and users.

- The *institutional* dimension that needs to consider how planning, policies, rights, regulations, monitoring, water user organizations, etc., need to be designed and implemented to enhance the effective functioning of organizations at basin and system levels as well as at the level of individual uses or users.

- The *provision of services* to different water uses and users so that water is delivered with a highly reliable level of service to encourage productive water use, and that this is made consistent with other service inputs such as credit, technology and marketing.

The basin perspective allows us to look with greater clarity at the importance of *upstream-downstream* issues. The most obvious element is that there is some form of equitable allocation policy maintained throughout the basin that recognizes existing uses, and yet has the ability to reallocate water amongst uses to meet emerging needs. Besides the quantity of water supply, there are other issues that emerge with increasing water scarcity:

- Deterioration of water quality, either from agricultural or urban-industrial complexes, that reduces the value and utility of water to downstream users.

- Ensuring water supplies of adequate quantity and quality for sensitive environmental areas, including such issues as wetland and wildlife protection and containment of salinity intrusion.

- Opportunities and threats posed by reuse of wastewater for irrigation or consumption.

- Meeting the water needs of the rural poor who, at present, have insufficient access to water.

- Impacts of upstream water-harvesting techniques on basin-level hydrology.
- Development and subsequent overdevelopment of groundwater resources to compensate for decreased availability of surface water.

The *institutional* dimension means that both suppliers and users of water need to be involved at the basin level for effective planning, implementation, regulation and for other water-management functions. Previous moves towards more localized participatory involvement in these tasks also need to be scaled up to the basin level to have groups dealing with basin-scale issues. A clear definition of property rights and mechanisms of enforcement of defined rights becomes more important with increasing scarcity. Single-purpose line agencies need to have greater interaction or there need to be more comprehensive management organizations at the basin level that can address the complexity of interactions between different uses and users.

Provision of services for water users needs to be viewed from a different perspective. Traditionally, service provision has been geared for a single or specific water use, dealing with such aspects as the reliability of irrigation deliveries, power, technology, credit, marketing, infrastructure, etc. While much needs to be done still to make such services more effective, they also need to be addressed from the basin perspective to ensure that improvement of services at one location or for one set of users does not impinge on the potential of other uses and users.

Different Situations, Different Needs

Through water-scarcity studies, such as those presented in this document, we see that there are different needs for different areas. Three useful categorizations help in understanding these differences:

- water-scarce areas
- high potential areas
- high need areas

Water-Scarce Areas

Areas of physical water scarcity cover much of the globe, including MENA (Middle East and North African) countries, and large parts of SA (South Asia), China, and ECA (Europe and Central Asia), i.e., those areas shown in red on IWMI's water scarcity map. These countries do not have additional water that can be tapped for more development. Water-related problems include groundwater overdraft and pollution that threaten long-term productivity of water. Challenges are reallocating water from lower-value, typically agriculture uses, to higher-value uses in industries, cities and high-value agriculture. This must be done in a manner where poor people can take advantage of the increase in the value of water, and where they do not lose out because water is taken away from them. Managing and designing for water savings in agriculture to free up water for cities, industries and environment are key challenges for many water-stressed areas.

High Potential Areas

Fortunately, water is not a limiting resource in many areas where there is much remaining scope to use water development to help poor people. The Ganges basin, home to 500 million people, many of whom are amongst the poorest in the world, is an example of a high potential area. Much of the Mekong river basin can also be classified as a high potential area. Those areas on IWMI's water scarcity map in SA, East Asia and Pacific (EAP) and Latin America and the Caribbean (LAC), classified as economically water scarce, are typically high potential areas. In the Ganges basin, there is huge scope remaining to increase production. The problem, of course, is that during a few days of the year, there is too much water, while during most of the year, water supplies are insufficient. Many argue for more large dams, while others look to groundwater and alternative means of storage to help in this area. There is scope for investment in these areas, but these should be made with an understanding of basin-wide impacts of various development alternatives.

High Need Areas

For many people in sub-Saharan Africa, water scarcity is a daily reality. But in many areas there are utilizable water resources that could be tapped. IWMI has termed these regions economically water scarce because these countries do not have the economic, financial and skilled human resources to tap this water supply. In these areas, there is a great need for water resources development but the difficulty in doing so is also quite great.

The fact that much of the water serves important ecological functions is not only a major difficulty but also a major point of conflict. Legitimate concerns over water development must deal with equally legitimate concerns over the environment. Oftentimes, those in favor of water for the environment are at loggerheads with those in favor of water for agriculture. Meanwhile, we are far from an optimal solution, and people suffer. A major question in this area is how to use water for agricultural and rural development in a way that meets ecological needs. Much more information is required, and much more dialogue between these two groups is required to meet needs in these areas.

Key Areas for Interventions in Water Resources Management for Rural Development

To address these issues, IWMI has organized its research program around five key themes. We feel that these are the most critical areas in water resources management for rural development:

- Integrated Water Management for Agriculture
- Smallholder Water and Land Management Systems
- Groundwater
- Environment and Health
- Water Resource Institutions and Policies

The following discussion is based on the experience gained from IWMI's work and involvement with other key players in developing countries including farmers, managers, researchers and policy makers. It touches on these five thematic areas, which we feel are very important for the World Bank's strategy.

Integrated Water Resources Management for Agriculture

Reinventing irrigation. There are considerable concerns about the performance of irrigated agriculture. In many cases, we know that promised goods have not been delivered—productivity remains low, the environment suffers, and issues of poverty have not been adequately addressed. We also know that food security is essential for a growing population in spite of increasing water scarcity and land degradation. And we know we have to preserve nature, and make sure our environment sustains future generations.

It is time to put the pieces together to carefully assess the benefits and costs of irrigation. IWMI, with key partners, proposes to perform a comprehensive assessment of the benefits and costs of water management for agriculture. The result will provide key insights into the most pressing question about water: How much irrigation do we really need? How much irrigation and how we do irrigated agriculture will have profound impacts on people and nature, and are some of the most pressing natural resources questions of the early twenty-first century.

The face of irrigated agriculture is changing rapidly, but the public perception of irrigation remains as one of dams and canals. Many new innovations are being realized in the areas of institutions, practices for improving the productivity of water, water-management systems for smallholders such as water-harvesting structures and low-cost drip lines, and in the ways water is managed at the basin scale. There is a need to change the public perception about this new irrigation. Yet there remain serious issues of poverty, groundwater depletion and environmental security that we will address more in this document. If these are successfully addressed, we will have reinvented both irrigation and the way we use water for agriculture.

Increasing the productivity of water. It is useful to shift thinking from increasing the productivity of land to increasing the productivity of water where water-scarce areas are concerned. For each drop of water, we should aim at increasing the value added and welfare derived from its use. In agriculture, this means promoting practices that achieve more output per unit of water consumed by agriculture. In the context of a river basin, this means ensuring clean water for drinking and industry. It means wise allocation between sectors and uses of water. It means ensuring enough water for the environment.

One of the best ways to free up water for other uses is to improve the productivity of water in agriculture. With more crop from each drop, there is a need for fewer drops. In agriculture there is considerable scope remaining to increase the productivity of water. Productivity gains can be achieved from improved agricultural practices and improved water delivery services (see box). Irrigated agriculture has received a decreasing amount of attention by the international assistance community because of disappointing performance of irrigation systems, increasing interests in the environment and the doubts about the linkage between irrigation development and poverty alleviation. But putting productivity of water in the basin perspective, we see that it has everything to do with helping the environment and helping poor people get the most out of a limited resource. Increasing agricultural productivity of water will free up more water for nature, it will reduce scarcity by giving more opportunities to poor, and with a poverty focus, it can improve their incomes and livelihoods.

A basin perspective on water savings. Essentially, the term “water savings” means freeing up water from non-beneficial uses and providing it to another more productive use. In agriculture, we would like to increase production on existing lands, and yet be able to release water for use by the environment, cities, or by more agriculture. In agriculture, it is often possible to identify means

Box 1. Means for saving water and increasing the productivity of water.

Increasing the productivity per unit of water consumed

- *Changing crop varieties* to new crop varieties that can provide increased yields for each unit of water consumed, or the same yields with fewer units of water consumed.
- *Crop substitution* by switching from high- to less-water-consuming crops, or switching to crops with higher economic or physical productivity per unit of water consumed.
- *Deficit, supplemental, or precision irrigation.* With sufficient water control, higher productivity can be achieved using irrigation strategies that increase the returns per unit of water consumed.
- *Improved water management* to provide better timing of supplies to reduce stress at critical crop-growth stages leading to increased yields or by increasing water supply reliability so that farmers invest more in other agricultural inputs leading to higher output per unit of water.
- *Optimizing non-water inputs*. In association with irrigation strategies that increase the yield per unit of water consumed, agronomic practices such as land preparation and fertilization can increase the return per unit of water.

Reducing non-beneficial depletion

- *Lessening of non-beneficial evaporation*—by reducing:
  - evaporation from water applied to irrigated fields through specific irrigation technologies such as drip irrigation, or agronomic practices such as mulching, or changing crop planting dates to match periods of less-evaporative demand.
  - evaporation from fallow land, decreasing the area of free water surfaces, decreasing non- or less-beneficial vegetation and controlling weeds.
- *Reducing water flows to sinks*—by interventions that reduce irrecoverable deep percolation and surface runoff.
- *Minimizing salinization of return flows*—by minimizing flows through saline soils or through saline groundwater to reduce pollution caused by the movement of salts into recoverable irrigation return flows.
- *Shunting polluted water to sinks*—to avoid the need to dilute with freshwater, saline or otherwise polluted water should be shunted directly to sinks.
- *Reusing return flows*.

Reallocating water among uses

- *Reallocating water from lower- to higher-value uses*. Reallocation will generally not result in any direct water savings, but it can dramatically increase the economic productivity of water. Because downstream commitments may change, reallocation of water can have serious legal, equity and other social considerations that must be addressed.

Tapping uncommitted outflows

- *Improving management of existing facilities* to obtain more beneficial use from existing water supplies. A number of policy, design, management and institutional interventions may allow for an expansion of irrigated area, increased cropping intensity or increased yields within the service areas. Possible interventions are reducing delivery requirements by improved application efficiency, water pricing, and improved allocation and distribution practices.
  - *Reusing return flows* through gravity and pump diversions to increase irrigated area.
  - *Adding storage facilities* so that more water is available for release during drier periods. Storage takes many forms including reservoir impoundments, groundwater aquifers, small tanks and ponds on farmers' fields.

to decrease nonproductive uses of water, thus releasing water for other uses. Reducing flows to sinks or non-beneficial evaporation, for example from waterlogged areas, will lead to water savings. In highly water-stressed areas, such as the Punjab in India or Pakistan, the north China Plains, and Egypt's Nile Valley, only very aggressive water-conservation practices will free up more water.

A common mistake is to justify projects on the claim of water savings. This is because project planners use a narrow point of view of efficiency at the farm or irrigation-system level that ignores water recycling and reuse, phenomena that are prevalent in many systems. Oftentimes, by increasing efficiency at the farm level the amount of water for downstream uses is reduced because additional water gained by the farm-level efficiency increases is used upstream. As discussed below, seepage from canals and fields is often a major source of domestic water, and increasing efficiency by reducing seepage can have negative health impacts. The major recommendation then is to be wary of claims for water savings based only on irrigation-system or field-level studies. Only a basin analysis will reveal whether water savings are really possible.

Improving irrigation services. Providing reliable irrigation services is the key to improving the performance of irrigation. With a reliable service, farmers invest more in improved technologies and practices, and are thus able to produce more. With unreliable services, farmers choose strategies that minimize risks, and are thus not necessarily profitable or productive. And farmers are rightfully not willing to pay for poor services.

Many past efforts in irrigation have focused on rehabilitation and modernization, or providing infrastructure to make sure that there is sufficient capacity to control water to provide more flexibility in supply to the farmers. We feel that in many poorly performing irrigation systems, providing a stable, predictable water environment is a first priority, far above providing the capacity for flexible services. This may initially translate into relatively simple operating procedures and structures. When communities get irrigation water under control, the next payoff will come in terms of the demand and implementation of more flexible systems.

How can reliable services be realized? Building accountability mechanisms between service providers and users is a first key step. This requires clear rules for the provision of services at delivery points between providers and users, and mechanisms for recourse in case services are not provided per agreements. Many levels of service, from delivering water at a fixed amount of water on a rotational basis, to providing water on demand, are capable of supporting productive agriculture. When moving to more on-demand systems, costs and complexity of operations and maintenance typically increase. With the participation of service providers and users, it is important to develop clear definitions on the desired level of service. In previously dysfunctional areas, targeting for simple, low-cost service specifications is a good strategy for achieving reliable services. Infrastructure design follows the service specifications. It should not dictate the type of service provision. In the design of new and modernized systems, many mistakes are made in design and construction that cause irrigation systems to be unmanageable.

In summary, bank assistance should target reliable delivery services by building accountability mechanisms, clarifying the level of services to be provided with the participation of service providers and users, and by supporting acceptable designs that will support the level of services desired.

It is commonly noted that farmers with access to pumping technology are more productive with water. The explanation is that when farmers own pumps they are both the service providers and the users. The service is reliable and farmers can get water when they want. Because pumping of groundwater is so important in irrigated agriculture, it will be discussed in more detail below.

Rain-fed agriculture. A popular idea is to concentrate food production in rain-fed, rather than in irrigated areas. The total cultivated area of the world is about one billion hectares, of which only about one-third is irrigated. Thus, a 10-percent increase in the productivity of rain-fed agriculture would have twice the impact as the same increase in irrigated agriculture. As the beneficial impact would be largely on poor farmers in marginal areas, this is an enormously attractive idea.

It should be recognized that this is by no means a new idea. The goal of increasing productivity of marginal rain-fed areas has been energetically pursued, using all the tools of agronomic science, for at least a century, with highly disappointing results. We believe that the sciences and technologies of agronomy and water management have now advanced to the point where there are grounds for optimism in this field—and, indeed, there are notable cases of success on the ground.

However, under specific agroclimatic conditions, small-scale farming can be productive in marginal rain-fed areas through supplemental irrigation. Of course, all irrigation is supplemental irrigation because it is designed only to "top up" effective precipitation on the crops. But supplemental irrigation is a technique specifically designed for water-scarce regions, where scarce water is stored and used only in limited quantities at the critical growth stages of crops. In many areas, for example, there is sufficient *average* rainfall over the crop season to obtain good yields, but yields are greatly reduced by short-term, 15- to 30-day, droughts at critical growth stages of the plant. Water stress at the flowering stage of maize, for example, will reduce yields by 60 percent, even if water is adequate during all the rest of the crop season. If there is a way to store *surplus water* before these critical stages and apply it in these stages if the rain fails, crop production would increase dramatically. This is such an important area that IWMI has devoted the entire theme of smallholder water and land management systems, discussed more below, to address this issue.

Smallholder Water and Land Management Systems

Where other conditions are favorable, smallholders have shown themselves to be willing to adopt new technologies that can help them increase production even when water is scarce. In recent years, there has been an upsurge in adoption of technologies such as treadle pumps, low-cost bucket and drop lines, small portable pump sets, supplemental irrigation, sustainable land management practices in rain-fed areas, recharge and use of groundwater and water-harvesting systems. This wide range of technologies, collectively referred to as smallholder water and land management systems, enable producers to access hitherto unusable water supplies and to compensate for poor levels of service in large-scale irrigation systems.

Clearly, this is an area where targeted support can be invaluable in the fight against poverty. These systems give the chance for poor people to gain access to water to gain more income. There are many indications that, by gaining access to water through these approaches, women have greatly benefited. There are possibilities to benefit the poor by designing interventions that recognize the interwoven nature of water and land rights in smallholder irrigation systems. Typically, landownership is a prerequisite for water rights. There may be opportunities to help those with limited access by swapping land and water rights: landowners with limited water rights, and landless with water rights.

But it has always been difficult for large agencies to provide effective support for these fragmented and diverse production systems. In many cases, initiatives for developing and introducing these systems come from the producers themselves, often with support from NGOs, rather than through formal government channels: their success is often the direct result of their diversity and flexibility of approach. Care has to be taken in finding appropriate ways in which to foster the continued development and adoption of these locally oriented innovations and avoid the risk of too much top-down control.

Changing the technological basis of smallholder water management also carries with it risks and threats. One risk is inherent in the process of "scaling up." While each individual piece of equipment has little overall impact on basin-level water resources, widespread adoption can have unexpected consequences because water rights of downstream users may not be taken into account.

Groundwater

Realizing potential gains in productivity from groundwater use. Sustainable management of groundwater offers major opportunities for promoting food and livelihood securities in regions of the world with dense concentration of rural poverty. Groundwater is accessible to a large number of users; it can provide cheap, convenient, individual supplies; it is generally less capital-intensive to develop, and does not depend upon mega-water projects. Groundwater development is also largely self-financing; its largely private development and use ensure automatic cost recovery. Compared to surface water, which is flashy in nature, groundwater offers better insurance against drought because of the long lag between changes in recharge and responses in groundwater levels and well yields.

Irrigation with groundwater is also generally more productive compared to much surface irrigation; groundwater is produced at the point of use, needing little transport; it offers individual farmers irrigation "on demand" that few surface systems can offer; and because its use entails significant incremental cost of lift, farmers tend to economize on its use and maximize application efficiency. Evidence in India suggests that productivity per cubic meter of water supplied to farms irrigated with groundwater tends to be 1.2 to 3 times higher than those irrigated with surface water. Similar evidence is available from other parts of the world as well.

Finally, compared to large surface systems whose design is driven by topography and hydraulics, groundwater development is often much more amenable to poverty targeting. No wonder, then, that in developing countries of Asia and Africa, groundwater development has become the central element of livelihood creation programs for the poor.

There is enormous room for institutional and technological innovations that can put groundwater irrigation at the service of the poor. In South Asia, emergence and spread of water markets have helped improve poor people's access to groundwater. Tube wells owned and operated by groups of poor farmers also offer possibilities. Micro-diesel pumps made in China have become extremely popular with smallholders in Bangladesh because they cost less to buy as well as to run compared to 5-hp diesel pumps that have become industry-standard in India. Among the most exciting are innovations in manual irrigation technologies; the treadle pump—selling as *Krishak Bandhu* (Farmer's Friend) in South Asia and "Money Maker" in Africa—costs US$12–25 a piece and can be operated by anyone including children. Treadle pumps have become quite popular in Bangladesh where already over a million pumps have been sold. It is spreading to eastern India and Nepal terai where water tables are in the range of 2–5 m. Treadle pumps are particularly popular with vegetable growers who combine small amounts of land with large volumes of disguisedly unemployed family labor to generate disproportionately large cash incomes. Equally popular in this segment are likely to be the new range of low-cost bucket and drum-based drip irrigation technologies that have recently begun coming into the market. Thus affordable technologies and competitive water markets are key to targeting groundwater development for the poor.

Groundwater overdraft. If underdeveloped groundwater in the Ganges basin and parts of Africa presents an opportunity for the poor, depletion and contamination of groundwater elsewhere hold out a big threat for them. Depletion has far-reaching social as well as environmental dimensions resulting in the immiserization of the people, especially of the already poor more than of the rich. In South Asia, when muscle-driven traditional water lifts went out of business with the onslaught of tube wells, it was the poor who got hit the hardest. New siting and licensing policies reinforce the rights of the early tube-well owners and exclude the late comers, who typically are the poor. One of the most serious ill effects of depletion is from seawater intrusion in coastal aquifers as in Egypt, Turkey, China and India. In the Saurashtra coast of the West Indian State of Gujarat, sustained overpumping by private farming communities during the 1960s and 70s generated previously unseen prosperity, earning the coastal strip the name of “Green Creeper.” Rapid intrusion of seawater in coastal aquifers, which extended from 1 km to 7 km inland in a decade, however, caused a similar rapid collapse of the region’s unsustainably bloated tube-well economy. Those well-off farmers who saw the writing on the wall early used their resources to make a careful and planned transition from farming to off-farm occupation in nearby towns. The less foresighted and/or the less resourceful stayed behind and took the full brunt of the fall of the socio-ecology. Many kept eking out a living by selling tender coconuts; but this too became difficult as the coconuts shrank in size and contained saline water. In recent years, tens of villages got depopulated every year, as those left behind proceeded towards the towns to join the ranks of the wage laborers.

We have only rough estimates of the contribution of groundwater irrigation to agriculture, and the amount of unsustainable groundwater use. Sandra Postel estimated that the annual overdraft is around 200 km^3 per year, the equivalent of approximately three and a half years of water supply released from Egypt’s High Aswan Dam. Even if this is a gross overestimate, clearly there is still a problem. In many of the most pump-intensive areas of India and China, water tables are falling at rates of 1 to 3 meters per year.

It is no exaggeration to say that the food security of India, Pakistan, China and many other countries will largely depend on how they manage this groundwater problem. Reducing the amount of pump irrigation is no answer; this simply reduces the most productive agriculture. Groundwater recharge is one solution, but it is not easy, and in some areas there is no water remaining to recharge. A second answer is to increase water productivity to achieve the same production but with less water.

Regulating groundwater overdraft is a far more complex and tricky issue compared to stimulating groundwater use where it is abundant. The crucial issue here is not so much of resource mobilization but of catalyzing appropriate legal and institutional changes. Regrettably, much work in these directions is deeply influenced by European and North American experience, which does not fit very well with the peculiar conditions in some of the poor regions. For example, groundwater law is widely prescribed as an effective remedy for the problem of overexploitation; however, in regions like South Asia and North China, effective enforcement of such regulatory frameworks presents insurmountable problems because of the sheer numbers involved. In South Asia, for example, the total stock of private tube wells probably exceeds 20 million and is growing at the rate of 1 million year. These are not even registered, leave alone licensed; in such a situation, regulating groundwater use through a law is likely to be difficult when not counterproductive. A more careful learning-process approach is needed to tackle the problem of groundwater overdraft.

Environment and Health

Comanagement of water for food and nature. Sectoral interests have dominated water resources development in most developing countries. Drinking water, hydropower and irrigation facilities are planned and constructed, commonly without regard to other needs. When water is plentiful, this approach can deliver quick results with unnoticed impact.

By building infrastructure to tap water for human purposes, we take water from nature. Now of course, environmental impact statements are required before development efforts. But how water is managed in agriculture has influence on downstream natural uses. Similarly, management of upstream catchment areas influences water use in agriculture, and in cities. It is rarely that management of water in developing countries has considered upstream and downstream needs of human and natural uses. As a result, there are too many confrontational situations resulting in win-lose situations.

We feel there are many situations where, with comanagement of water for food and nature, we can have win-win situations, and increase the overall productivity of basin-wide water resources. There are some prerequisites to comanagement. First, we have to know what the requirements of nature are. Second, we have to have resources management that integrates concerns across sectors. Third, there must be an institutional allocation mechanism that ensures water for environmental needs. For example, an environmentally sensitive area could obtain a right to water and an associated allocation of water.

One of the critical issues for water management in the twenty-first century is to understand the water requirements of ecosystems. We need to know much more than we do now about these water requirements in terms of minimum flows, maximum flows and peak flows, and water quality can be maintained in river basins where human water needs also have to be satisfied. While significant progress has been made in the developed world, this type of analysis is often of low priority in many developing countries. Clearly, this is an area requiring support.

Health. A large part of the disease burden in developing countries is associated with inadequate quantities of safe water for domestic use, lack of facilities to dispose of human feces in a sanitary way and poor hygienic standards. The most important of the water-associated diseases is diarrhea, which causes high child mortality in many developing countries. For low-income communities the conventional approach to improve water supply has been the exploitation of shallow groundwater with low-cost technologies. The problem of falling groundwater levels is now widely recognized as a threat to food security. The wealthier farmers can continue to drill deeper tube wells with larger, more expensive pumps, but poor farmers will not be able to do so. Less obvious and less talked-about is that groundwater depletion also causes the shallow drinking water wells of poor communities to run dry. Deepening these wells is very costly and beyond the resources of the poor.

While the exploitation of groundwater through pumping is largely unregulated, other deliberate attempts to make irrigation more efficient influence this water resource as well. These measures include the lining of canals with concrete to reduce seepage losses and diversification of crops from rice to less-water-demanding crops. However, seepage water from canals and high percolation rates from paddy fields recharge the groundwater and thereby improve the availability of shallow groundwater sources for domestic use. At policy level there is an urgent need to address the impact of the falling groundwater levels on both future agricultural output and supply of water for households. The government institutions and the donor organization have to review their practices when promoting groundwater irrigation or implementing irrigation rehabilitation with potential impacts on the local household water supply.

The prevailing opinion has long been that groundwater is safe for drinking whereas surface water is not. This approach is not appropriate for all areas of the world. In South Asia there are important regions where groundwater cannot be utilized for drinking because of its chemical composition. The most dramatic example is from Bangladesh and West Bengal, India, where thousands of recently constructed drinking water wells are producing water with very high arsenic levels. In other areas, fluoride and salt levels of groundwater are too high to make it suitable for drinking. If rainfall is very low, people often have to use surface water from natural courses and canal irrigation systems in these areas.

Faced with water scarcity, the agricultural and nonagricultural uses of water are increasingly interdependent. To translate this into appropriate policy, the use of surface water for domestic purposes should be reevaluated. There is an urgent need to bridge the gap between the irrigation and domestic water-supply sectors. Institutional and technical solutions are needed to provide safe drinking water from surface-water sources, including irrigation canals and reservoirs. The internationally accepted concept of integrated water resources management could be very useful if elaborated and applied in rural areas and at local levels.

Water Resources Institutions and Policies

Water management institutions require radical reform if they are to meet the challenges facing them during the next few decades. The challenges include increasing food production from irrigated agriculture to meet growing demand, coping with escalating water demands in other sectors and sustaining the quality of soils and water, and improving the equity of water distribution. The five most important institutional changes required are: replacement of administrative with financially self-reliant service delivery organizations; conversion of irrigation systems into multiuse water service systems; transcending the infrastructure dependency-deterioration trap; establishing legal and regulatory frameworks for sustainable water management; and implementing integrated water-basin management. The central challenge will be to design institutions that ensure accountability of water-service providers to users. These institutions need to be adaptable to meet the changing needs of water management that come about with increasing scarcity. Effective, sustainable and integrated water management in the future requires adaptive, new or revitalized institutions to ensure that the world can meet the twin imperatives of dramatically increasing the productivity of water and halting water-related environmental degradation.

Sound water laws and policies are necessary for integrated water resources management. There are many areas where these are deficient. In many countries, groundwater legislation is nonexistent, inappropriate or outdated. Also, water laws can be very sector-specific and do not integrate the concerns of many sectors very well. Protecting the rights or allocating new rights to very poor water users is often not very well developed. Clearly, in these cases there is a need for changes in water laws.

In other cases though, there are relevant laws, but the implementation is very poor because the organizational capacity to do so is nonexistent, or because the laws are just not well thought out or they are inappropriate. It is important when thinking about water rights and water laws to make sure that relevant laws exist, and in addition that there are organizations that can do something with the laws, and that they do support operational functions.

In IWMI's analysis, institutional reforms must create the right combination of incentives to induce an optimal mix of state and local private investment to achieve sustainable infrastructure maintenance. The following is a list of hypothesized essential incentives, which should be inherent in such reform. The reform should:

1. Integrate decision making about both short- and long-term investments in irrigation infrastructure so that trade-offs between the two can be optimized.

2. Give users the incentive to maximize efficiency of the total investment in infrastructure.

3. Give the government the incentive to maximize the efficiency of its investment in infrastructure.

4. Ensure that government interventions stimulate, rather than discourage, private investment in infrastructure.

5. Give users the incentive and confidence to make long-term investments.

We are unaware of any developing country with a major irrigation sector where all five essential incentives are present in the formal sector. In contrast, in the informal irrigation sector dominated by groundwater irrigation in India for example, all these incentives are fully operational; in fact, private incentives in groundwater irrigation are so strong that overexploitation of groundwater resources and all its attendant dysfunctions have emerged as a big policy challenge in Asia. To a somewhat lesser extent, indigenous farmer-managed systems in developing countries included some of these incentives until a few decades ago when governments played a minor role. However, government interventions in recent years have, in many cases, undermined these incentives, leading to deterioration of infrastructure. In many developed countries, the incentives were, and largely remain, present. But as the beneficiaries of "environmental" investments, to preserve wetlands for example, are also increasingly seen as the general public and not the water user association members alone, doubts have arisen about the long-term sustainability of the infrastructure currently financed entirely by association members.

It must be emphasized that any approach that involves realization of the five types of incentives mentioned above will require a relatively radical reform, i.e., relative to the institutional framework existing today in most developing countries. The persistent problem of non-sustainable water service infrastructure will not go away with mere enhancements of business-as-usual. A f undamental problem requires a fundamental solution.

Recommendations

We recommend that the following issues be taken into serious consideration when developing a strategy on rural development:

1. There is a need to take a basin perspective when designing programs for development and management of water resources.

2. In water-scarce areas of MENA and SA, key water issues are water scarcity and competition, pollution, protecting nature, preventing groundwater depletion, protecting access of water by the poor, increasing productivity of water, and developing basin-level institutions to deal with these issues.

3. In high potential areas of EAP, LAC and SA, key issues are tapping the potential of groundwater, providing appropriate smallholder water management systems to poor women and men, improving water delivery services and improving productivity.

4. In high need areas, particularly in sub-Saharan Africa (SSA), there are additional requirements beyond those of high potential areas including infrastructure development to provide access to water, and developing capacity to construct, maintain, operate and manage infrastructure.

5. There is a need to focus on productivity of water, particularly in agriculture, as this will relieve scarcity, help the poor, and free up water for the environment and cities.

6. A basin perspective should be taken when assessing the potential of water savings. Increasing local farm and irrigation efficiency does not necessarily lead to water savings, and can result in fewer benefits.

7. Within irrigation systems, promote a service focus and promote reliability. Do this by building accountability mechanisms, clarifying the level of service to be provided with the participation of service providers and users, and by supporting acceptable designs that will support the level of services desired.

8. Supplemental irrigation in dominantly rain-fed areas shows great potential for increasing the productivity of water and addressing poverty and local food-security issues.

9. Encourage appropriate smallholder land and water management systems. Water harvesting, treadle pumps, and bucket and drip sets provide tremendous opportunity to help the poor, and to increase the productivity of water. Some caution is required in developing programs of widespread support. Success has come because of private and community development efforts, and inappropriate support may lead to a counterproductive top-down means of implementation.

10. A huge potential exists for groundwater exploitation in high potential and high need areas. There is enormous room for institutional and technological innovations that can put groundwater irrigation at the service of the poor.

11. In water-scarce areas such as northwest India and the North China Plains there is a serious threat of groundwater overdraft. Unfortunately, it is not easy to translate institutional solutions from developed to developing countries, so we are still searching for solutions to this problem.

12. In situations of scarcity and competition, there is a need to comanage water for agriculture and water for nature. One critical concern is that while we have a good understanding of agricultural water needs, there is little knowledge of the water requirements for nature.

13. Faced with water scarcity, agricultural and nonagricultural uses of water are increasingly interdependent in rural areas. There is an urgent need to bridge the gap between the irrigation and domestic water supply sectors to ensure water for food and water for drinking and health.

14. Water scarcity in rural areas has important implications for health. In addition to threatening food security, groundwater overdraft has health consequences when people lose their access to water due to falling water tables.

15. In areas where the same source of water is used for food production as well as drinking, bathing, and for livestock, there is a need to manage water for multiple uses, and a need to assess interventions in light of human-health consequences.

16. Building institutions remains a priority. We understand now that for productive water management in agriculture, there is a need for a more comprehensive institutional framework that provides for input and output services. With increasing scarcity, there is a need for this framework to evolve to address important issues that arise including: protecting access of water by the poor, reducing pollution and groundwater overdraft, and allocating water between competing sectors.

17. The five most important institutional changes required are: replacement of administrative with service delivery organizations; conversion of irrigation systems into multiuse water service systems; transcending the infrastructure dependency-deterioration trap; establishing legal and regulatory frameworks for sustainable water management; and implementing integrated water-basin management. The central challenge will be to design institutions that ensure accountability of water-service providers to users.

18. There is a need for a comprehensive assessment of the benefits and costs of irrigation in order to clarify the future directions for irrigated agriculture. We feel that there is a need to address concerns about irrigation brought about by several nonagricultural stakeholders, especially those representing environmental interests, and better address these in our interventions to improve water management. We feel that if we put our knowledge together, and address the issues outlined above as well as other key issues, we can reinvent the way we manage water for food and environmental security.

The issues discussed in this part are based on the findings of research conducted by IWMI over the last few years. The following IWMI publications are recommended for further reading.

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PART II

Background Paper on Water for Rural Development

Global Water Resources

General

Most of the world's total water resources are too salty to be used for beneficial uses, including direct human use and agriculture. Only less than 3 percent of the total water resources is available as freshwater resources (figure 1), of which over 70 percent is locked in the ice caps. Of the remainder, most are in deep aquifers, which are not accessible for humans, or stay as soil moisture. It is estimated that only less than 1 percent of the freshwater resources in the world (UN 1998) is available for direct human use (figure 1), which on average constitute about 43,000 km^3. This is available year in year out as flows in the rivers, and is called the world's *internally renewable freshwater resources* (IRWR) (Shiklomonav 1999).

Not all of the IRWR can be controlled by humans. It is estimated that even with most feasible technical, social, environmental and economic means, only about one-third of the IRWR can be potentially controlled (figure 1). The *potentially utilizable water resources* (PUWR) of the IRWR are estimated to be around 9,000 km^3 to 14,000 km^3 (UN 1999; Seckler 1993).

At present, about 2,370 km^3 of the PUWR are developed and are being diverted as the *primary water supply* (PWS) or the "*virgin*" or the *first* water supply for human use (IWMI 2000). A part of the PWS is evaporated in its first use. The other part returns to rivers or streams as *return flows* (RF) and in many instances this part is again withdrawn for human use. This is known as the recycled portion of PWS.

The PWS and the recycled water supply, about 3,300 km^3, constitute the water diverted for use in the different sectors. At present, three-quarters of the TWS in the world are diverted to agriculture, with only one-quarter being used for domestic and industrial sectors (figure 1).

Regional Variations

If distributed evenly, the total IRWR is translated to about 7,500 m^3 per person in 1995 (figure 2). This is a drop of 41 percent from the 1965 level of per capita IRWR. If the growth of the world's population follows the United Nations (UN) medium projection path, this will further decrease by 28 percent, i.e., to about 5,500 m^3 in 2025. This is still a substantial amount to meet water needs of each person in the world.

While the total available water resources at the global level are sufficient to fulfill human needs, their distribution across countries and regions is very uneven. Water resources vary from little or no rains in extreme arid agro-climatic regions to abundant rainfall in the humid agro-climatic regions.

For the purpose of this study, to understand the implications of regional variations in water resources endowments, we classify the countries into the following regions as specified by the World Bank: Africa (AFR), Middle East and North Africa (MENA), South Asia (SA), East Asia and Pacific (EAP), Europe and Central Asia (ECA) and Latin America and the Caribbean (LAC). North America (NAME), European Union (EU), and also Australia and New Zealand (AUNZ) are classified into one category.

Figure 1. World's water supply.

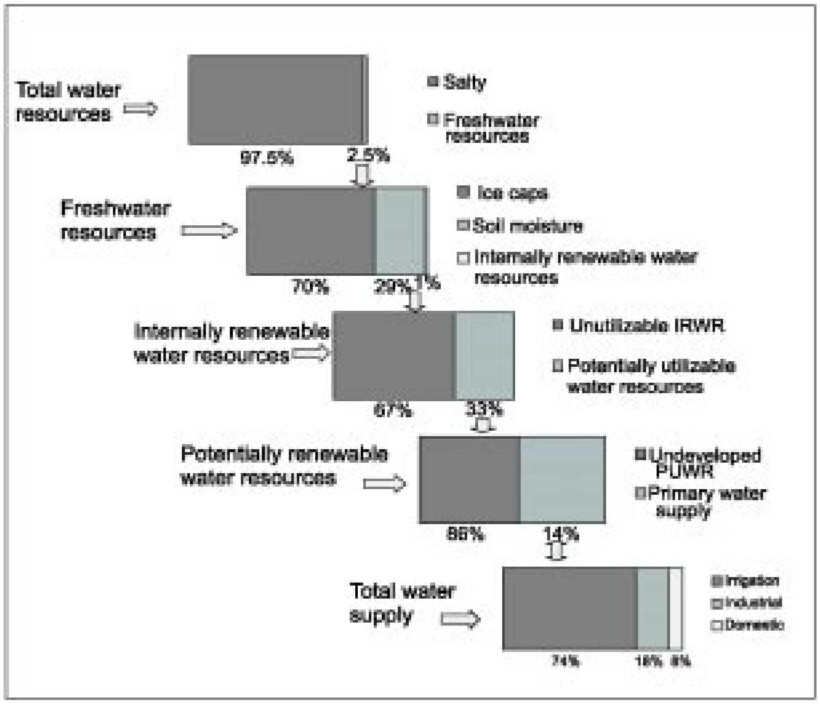
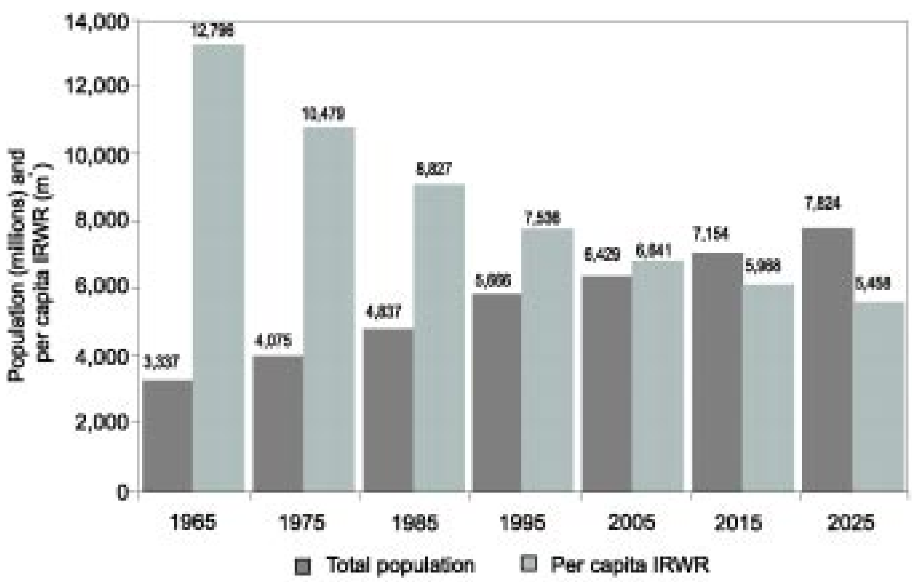


Figure 2. World's population and per capita internally renewable water resources.



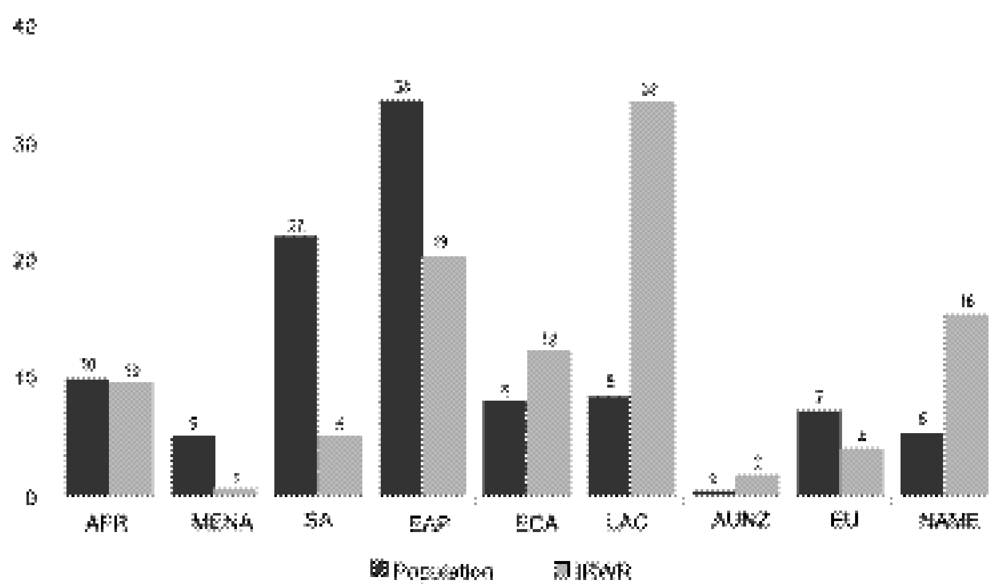
Internally Renewable Water Resources

Figure 3 shows the regional variations of the IRWR. The EAP region, with more than one-third of the world's population, has about 19 percent of the IRWR. The SA region with 22 percent of the world's total population is endowed with only 5 percent of the renewable water resources. On the other extreme, the LAC countries with 8 percent of the world's total population are endowed with 34 percent of the world's IRWR. The North American region, with only 5 percent of the world's population, has 16 percent of the total IRWR.

While regional aggregates provide an overall picture of regional water endowments, substantial variations could exist within regions. For example, almost half of the IRWR in the LAC region is generated in the Amazon basin in Brazil where only one-third of the LAC people live. The per capita IRWR in Brazil is about 29,000 m^3. The Central American and Caribbean countries, with one-third of the LAC region's population and 9 percent of the IRWR, had less than 5,000 m^3 of the per capita IRWR in 1995. Also, the central African countries, with only 12 percent of the total population, generate more than 40 percent of the IRWR of the African region. The southern African countries, with 15 percent of the total African population, generate only 8 percent of the IRWR.

The regional IRWR variations along with the capacity to control them give rise to substantial variations in PUWR. The level of inter- and intra-annual variations of rainfall and the economic, technical and social feasibility of water resources development are determining factors for PUWR. In India, most of the annual rainfall falls within 100 hours spanning over a few months (Agarwal 1998). It is estimated that only 38 percent of the IRWR can be potentially controlled for human use (CWC 1998). Most of the rains in China are received in the monsoonal months, mainly in the Yangtze river basin in the south. Since a large part of it cannot be controlled, it flows to the sea without being used for urban or agricultural purposes. A similar situation prevails elsewhere including the Congo basin in the African region, and in the Amazon basin in Brazil in the LAC region.

Figure 3. Distribution of population and internally renewable water resources (in %).



Total Water Withdrawals

The estimates of total water supply to various regions and the diversions to major water-using sectors are given in table 1. At present, about 3,400 km^3 of water are diverted to the agriculture, domestic and the industrial sectors of the world. The African countries have the smallest share of total water withdrawals. This is reflected in their very low per capita water supply of 119 m^3, constituting only one-fifth of the world average.

The world's agriculture sector accounts for the largest share of total water diversions. On average, over 85 percent of the total water supply in the developing regions is diverted to the agriculture sector. The agriculture sector of the South Asian region receives about 96 percent of the total diversions. The agriculture sectors of MENA and African regions follow closely with 90 and 84 percent of total diversions, respectively.

Irrigation development in the past has played a significant role in enhancing national food productions, increasing food security, alleviating poverty, and contributing to overall rural development of many countries in most regions. However, while the agriculture sector remains the largest user of the developed water resources, there is evidence that water use in other sectors is growing rapidly—due mainly to population growth, expansion in urbanization and industrialization in the developing world. These trends are expected to continue in the future.

Table 1. Water withdrawals and distribution between different sectors.

Region	TWS[1] (1995) km^3	Per Capita TWS (1995) m^3	Distribution of TWS between Sectors		
			Agriculture %	Domestic %	Industrial %
World	3,371	596	74	8	18
Developing countries	73%	517	85	6	9
Developed countries	27%	1,001	42	14	44
AFR	2%	119	84	11	5
MENA	7%	851	90	6	4
SA	26%	701	96	2	2
EAP	26%	466	83	7	10
ECA	11%	790	61	10	29
LAC	6%	413	73	16	11
Other countries[2]	22%	1,034	36	14	50

[1]Total water resources for different regions are given as a percent of the world's TWS.
[2]Other countries include North America, European Union, Japan, Australia and New Zealand.
Sources: IWMI 2000; Gleick 1998.

Past Developments and Trends

Food Consumption

As a result of agricultural and rural development efforts over the past three decades the world has been able to produce more food than required. The world's average per capita calorie supply from cereal products, animal-based products and non-cereal crop products (such as tubers, fruits, vegetables, etc.) has increased by 16 percent—from 2,356 kcal in 1965 to 2,733 kcal in 1995 (table 2). With an increase in population of 70 percent from 3.3 billion in 1965 to 5.7 billion in 1995, the world's total cereal consumption over this period has increased by 92 percent—from 942 million metric tons (M mt) in 1965 to 1,811 M mt in 1995.

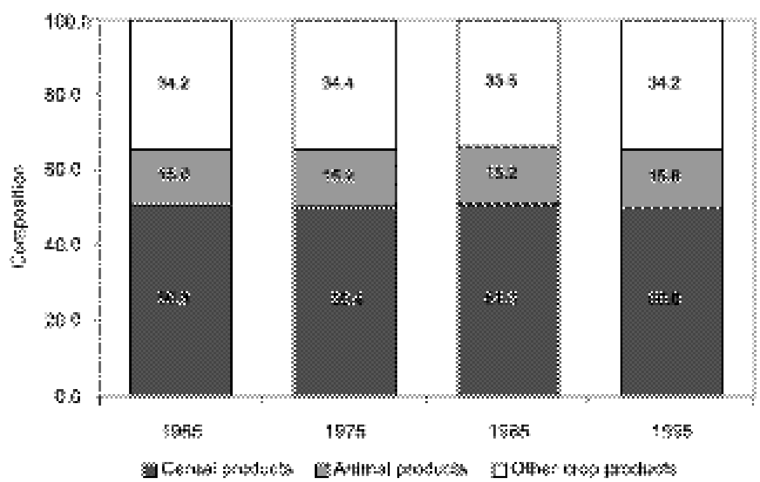
Table 2. Total population, per capita calorie supply and total cereal consumption of the world.

Year	Population		Per Capita Calorie Supply		Total Cereal Consumption	
	Total	Annual growth[1]	Total	Annual growth[1]	Total	Annual growth[1]
	Million	%	Kcal	%	M mt	%
1965	3,337	-	2,356	-	942	-
1975	4,075	2.0	2,428	0.3	1,234	2.7
1985	4,837	1.8	2,642	0.9	1,605	2.7
1995	5,666	1.6	2,733	0.3	1,811	1.2
Growth[2]						
1965–95	-	1.8	-	0.5	-	2.2

[1]Entries in the first three rows of this column indicate the total growth from the previous year.
[2]Entries in this row indicate the total growth between 1965 and 1995.
Source: FAO 1998.

On average, two-thirds of the total calorie supply in the daily diet come from food cereal and animal products (figure 4). Since feed cereals (such as maize and barley) contribute a major part of feed rations, especially in the commercial production of animal products, changes in cereal consumption constitute a good indicator of the changes in total calorie supply and vice versa. The calorie supply from food cereal products and animal products in the three decades has increased by 15 and 22 percent, respectively. A higher growth in animal product consumption means even a higher growth in feed cereal consumption and an overall higher growth in the total cereal consumption. Indeed, the world's total cereal consumption has increased at an annual rate of 2.2 percent, overall 92 percent over the 30-year period (table 2). Despite these increases, the world, as a whole, was able to increase production to stay ahead of consumption growth.

Figure 4. Composition of the world's per capita per day calorie supply (in %).



Food production. Figure 5 shows the trends in crop production.[1] The total world crop production has almost doubled since 1965. While the total crop area in the 30-year period has increased at an annual rate of 0.33 percent, crop yields have increased at 1.9 percent per annum (table 3). It is very clear that productivity growth has been a major driving force for increased overall food production in the world.

Figure 5. Trends of world's crop area, yield and production and net irrigated area indices.

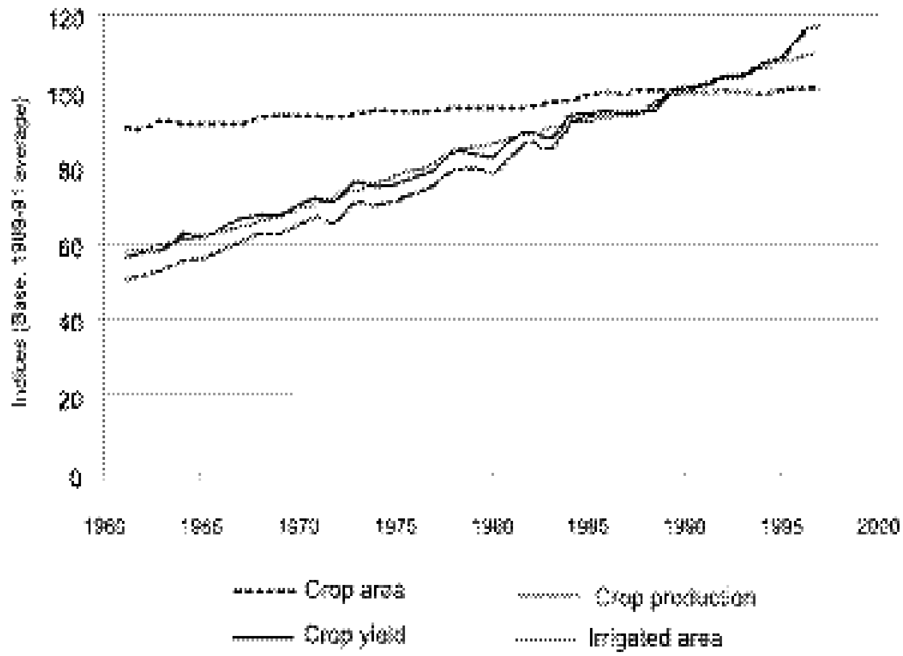


Table 3. Annual growth of the world's crop production, area and yield and the irrigated area.

Period	Annual Growth (%)			
	Crop production	Crop area	Crop yield	Irrigated area
1965–1975	2.4	0.3	2.0	2.3
1975–1985	2.6	0.5	2.2	1.8
1985–1995	1.8	0.2	1.6	1.5
1965–1995	2.3	0.3	1.9	1.9

Source: FAO 1998.

Irrigation development. Several factors have contributed to the growth in crop productivity in the last three decades. Foremost among them are expansion in irrigation, adoption of high-yielding varieties and better agronomic practices. While the exact contribution of these factors to the growth of productivity is difficult to quantify, it is well recognized that growth in irrigation has played a major role.[2] Over the last three decades, the world's net irrigated area[3] has increased by 73 percent, from 150 million ha in 1965 to 260 million ha in 1995 (FAO 1998).

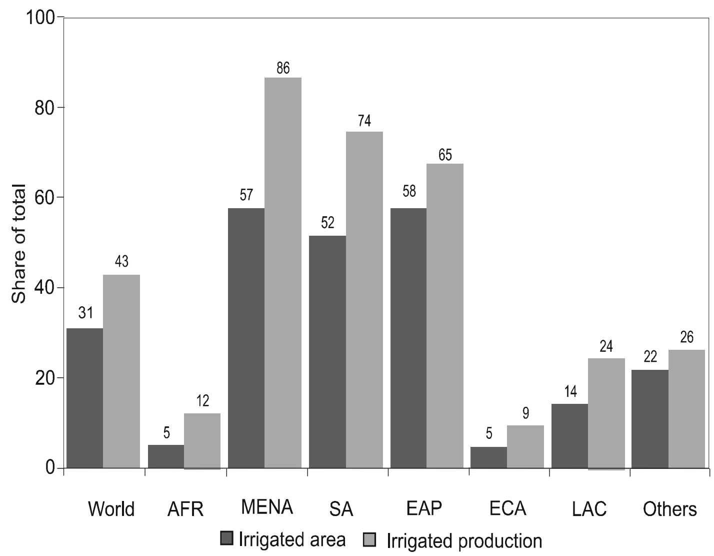
[1]These are crop production indices with 1989–1991 average as the base derived from FAO data.

[2]In the next few years, IWMI will be conducting a comprehensive assessment of the cost and benefits of irrigation, to food, environment, social and rural livelihood security. Within these activities, IWMI hopes to quantify the contribution of irrigation to the growth in crop yields in different regions of the world.

[3]The net irrigated area is defined as the area irrigated at least once during the calendar year (FAO 1998).

The world's irrigated cereal area at present accounts for 31 percent of the total harvested area, but accounts for 43 percent of the total production (figure 6). This indicates that the productivity in irrigated cereal lands is 60 percent higher than that in rain-fed cereal lands. In South Asia and EAP regions, productivity in irrigated cereal lands is 172 and 100 percent, respectively, higher than the respective productivities in the rain-fed cereals lands.

Figure 6. Irrigated cereal area and production; total harvested area and production (in %).



The irrigation water supply at present accounts for 74 percent of the total water withdrawals. Much of the growth in irrigation withdrawals in the last three decades was achieved through a combination of large- to medium-scale water-development projects. These included multipurpose large reservoir storages to extensive tube-well extractions.

Benefits of irrigation development, whether surface water or groundwater are many, foremost among them being the food security. This is especially true for most developing countries. According to the World Bank, the irrigation development projects that the bank was associated with in the last decades have brought direct benefits, in terms of improved food security and increased incomes, to more than 46 million farming families (World Bank 1997). Also, new irrigation development was strongly associated with creating on-farm and off-farm employment opportunities for large masses. In addition, indirect links of irrigation development with infrastructure developments including roads, schools and markets have contributed to the development of rural areas.

The majority of the world's population is still rural and depends on agriculture. About 55 percent of the total population in 1995 was estimated to be rural (table 4). In 1995, 45 percent of the total population (more than 2.5 billion people) was estimated to depend directly or indirectly on agriculture for its livelihood. Half of this population is the economically active labor force, and 43 percent of it constitutes the female labor force.

Table 4. Total, rural and agricultural population of the world.

Year	Population Distribution								
	Total	Rural		Agriculture		Labor Force[1]		Female Labor Force[2]	
			% of total		% of total		% of agriculture		% of total labor force
	Million	Million	%	Million	%	Million	%	Million	%
1965	3,337	2,157	65	1,889	57	887	47	359	41
1975	4,075	2,538	62	2,117	52	1,000	47	418	42
1985	4,837	2,850	59	2,348	49	1,148	49	489	43
1995	5,666	3,113	55	2,533	45	1,279	50	552	43

[1]This is the economically active population in agriculture.
[2]This is the economically active female population in agriculture.
Sources: FAO 1998; UN 1999.

Trends

South Asia. Over the period 1965 to 1995, total per capita calorie supply in South Asia (SA) has increased by 17 percent, from 2,020 kcal in 1965 to 2,369 kcal in 1995 (table 5). The near doubling of the population in the same period from 645 million in 1965 to 1,249 million in 1995, and increases in animal products in the diets have resulted in a substantial growth in total cereal consumption. Cereal products, which comprise 65 percent of the per capita calorie supply, dominate the South Asian's daily diets (figure 7). The total cereal consumption in the regions has increased substantially by about 118 percent. The contributions to the daily diet from cereal and animal products have increased by 13 and 48 percent, respectively.

Table 5. Total population, per capita calorie supply and total cereal consumption.

Year	Population		Per Capita Calorie Supply		Total Cereal Consumption	
	Total	Annual growth[1]	Total	Annual growth[1]	Total	Annual growth[1]
	Million	%	kcal	%	M mt	%
1965	645	-	2,020	-	106	-
1975	815	2.3	1,984	-0.2	133	2.3
1985	1,017	2.3	2,182	1.0	176	2.9
1995	1,249	2.1	2,369	0.9	231	2.7
Growth[2] 1965–95	-	2.2	-	0.5	-	2.6

[1]Entries in the first three rows of this column indicate the total growth from the previous year.
[2]Entries in this row indicate the total growth between 1965 and 1995.
Source: FAO 1998.

The total cereal production in South Asia has grown by 146 percent, from 92 M mt in 1965 to 226 M mt in 1995 (table 6). The growth from 1965 to 1995 was so impressive that the region as a whole was able to wipe out regular cereal production deficits that were recorded before the mid-seventies (figure 8). After the 1980s, the region was able to keep its production surpluses or deficits within 5 percent of the consumption needs even under extreme climatic conditions. Production surpluses in good climatic years have helped replenish year-ending stocks for the use in bad years. As a result, the region was able to achieve trend self-sufficiency in cereals over the last one and a half decades.

Figure 7. Composition of per capita per day calorie supply, South Asian region (in %).

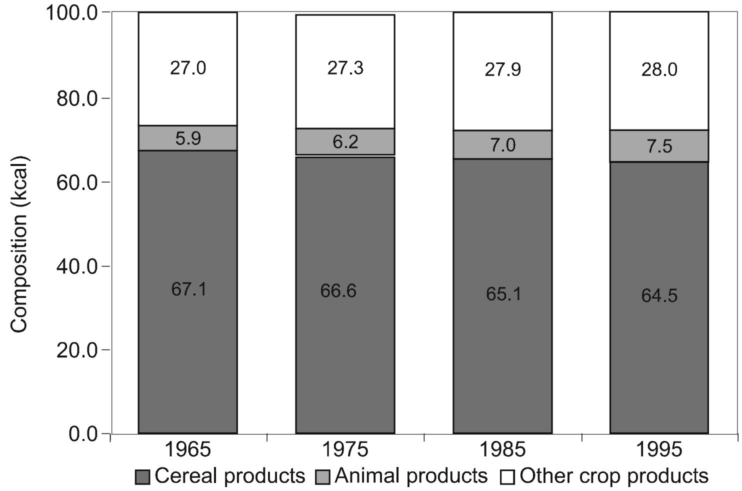
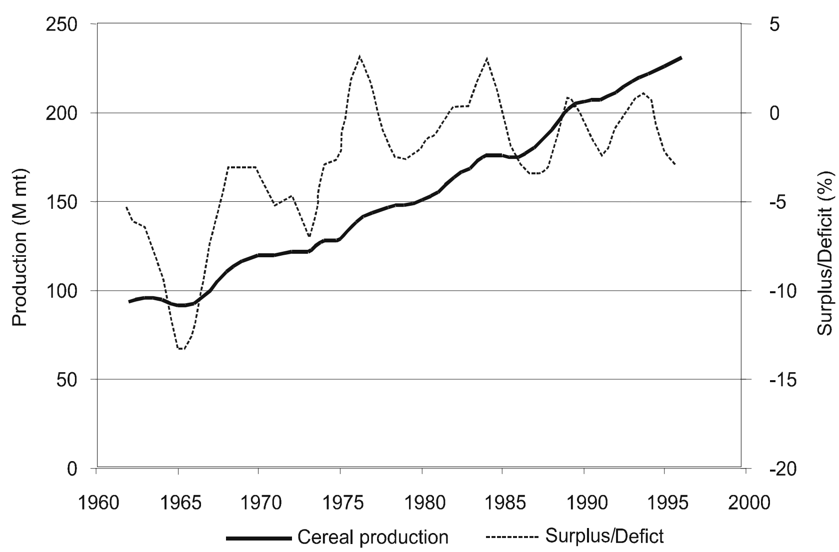


Table 6. Cereal production, area, yield and the net irrigated area.

Year	Production		Area		Yield		Irrigated Area	
	Total	Growth[1]	Total	Growth[1]	Average	Growth[1]	Total	Growth[1]
	M mt	%	M ha	%	Tons/ha	%	M ha	%
1965	92	-	117	-	0.8	-	41	
1975	130	3.5	127	0.8	1.0	2.7	52	2.3
1985	176	3.1	133	0.5	1.3	2.7	64	2.1
1995	226	2.5	130	-0.2	1.7	2.7	78	2.1
Growth[2] 1965–95	-	3.0	-	0.3	-	2.7	-	2.2

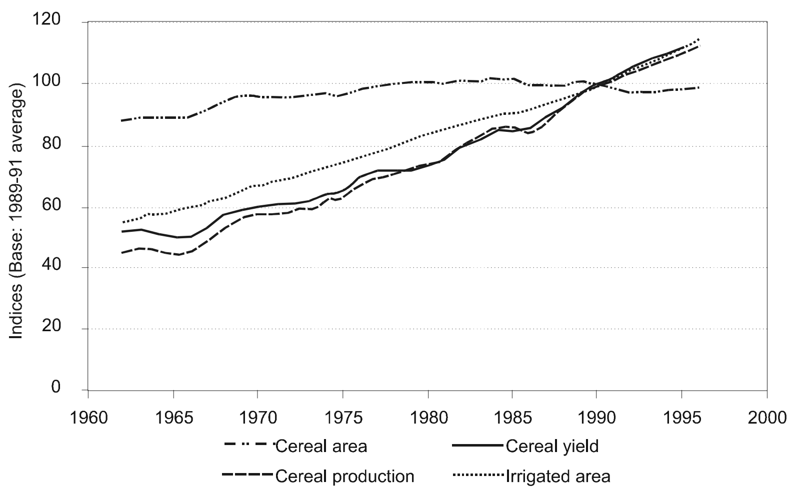
[1]Entries in the first three rows of these columns indicate the growth from the previous season.
[2]Entries in this row indicate the growth between 1965 and 1995.
Source: FAO 1998.

Figure 8. Cereal production and production surplus/deficit, South Asian region.



The growth in total cereal area in the region has more or less flattened out since the mid-eighties (table 6; figure 9). The growth in productivity was the major contributing factor to increased production. In the 30-year period, the total cereal area increased only at an annual rate of 0.3 percent while the average yield increased at an annual rate of 2.7 percent. With extreme fluctuations of rainfall under monsoonal climatic conditions, South Asia would not have realized such yield increases without irrigation. The net irrigated area in the region increased at an annual rate of 2.2 percent in the 30-year period (table 6). About half of the total cereal area is irrigated at present, and contributes to three-fourths of the total cereal production (IWMI 2000).

Figure 9. Cereal area, yield, production and net irrigated area indices, South Asian region.



More than 70 percent of South Asia's present population, i.e., more than 900 million people, live in rural areas (table 7). This is equivalent to 30 percent of the world's rural population. Almost the whole of this population depends for its livelihood on agriculture. New irrigation development in this region has had substantial benefits to its rural agricultural population. Productivity growth, associated with irrigation development, has brought not only food security to rural households but also increased incomes, employment opportunities and, hence, increased stability to their livelihoods.

Table 7. Total, rural and agriculture population.

Year	Population Distribution								
	Total	Rural		Agriculture		Labor Force[1]		Fem. Labor Force[2]	
			% of total		% of total		% of agriculture		% of total labor force
	Million	Million	%	Million	%	Million	%	Million	%
1965	645	531	82	456	71	215	47	84	39
1975	815	650	80	551	68	252	46	100	40
1985	1,017	780	77	641	63	288	45	112	39
1995	1,249	917	73	719	58	328	46	126	38

[1]This is the economically active population in agriculture.
[2]This is the economically active female population in agriculture.
Sources: FAO 1998; UN 1999.

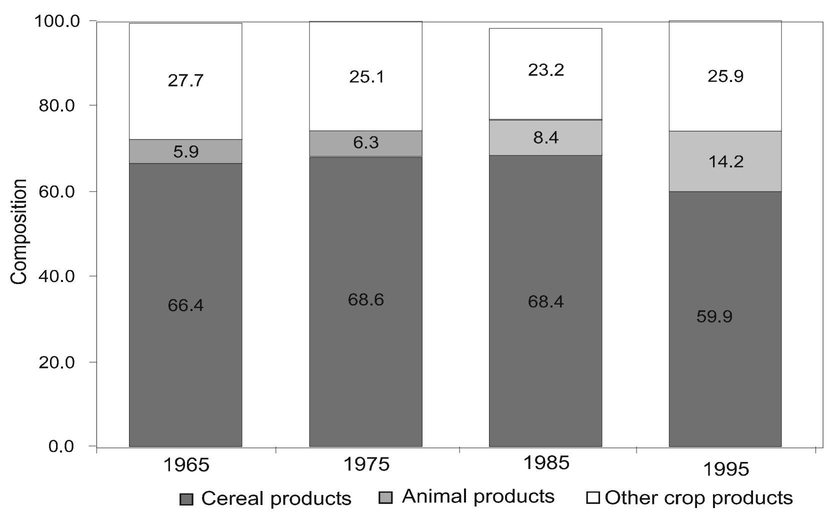
East Asia and Pacific. The average per capita calorie supply in East Asia and Pacific (EAP) has substantially increased by 37 percent, from 1,950 kcal in 1965 to 2,735 kcal in 1995 (table 8). Composition of the animal products in the daily calorie supply alone has increased by 238 percent, from 5.9 percent (about 115 kcal) in 1965 to 14.2 percent (about 389 kcal) in 1995 (figure 10). Increased consumption of animal products combined with 73 percent growth in population has resulted in a substantial growth in cereal consumption.

Table 8. Total population, per capita calorie supply and total cereal consumption.

Year	Population		Per Capita Calorie Supply		Total Cereal Consumption	
	Total	Annual growth[1]	Total	Annual growth[1]	Total	Annual growth[1]
	Million	%	kcal	%	M mt	%
1965	1,025	-	1,950		186	
1975	1,307	2.4	2,091	0.7	274	3.9
1985	1,535	1.6	2,543	1.8	403	3.9
1995	1,773	1.5	2,735	0.7	507	2.3
Growth[2] 1965–95	-	1.8		1.1		3.4

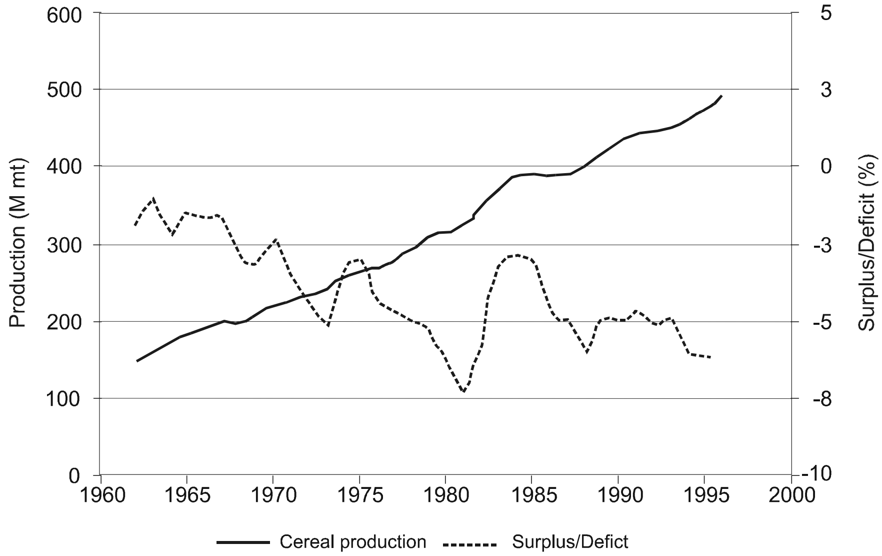
[1]Entries in the first three rows of this column indicate the total growth from the previous year.
[2]Entries in this row indicate the total growth between 1965 and 1995.
Source: FAO 1998.

Figure 10. Composition (%) of per capita per day calorie supply, EAP region.



Total cereal consumption in the EAP region has increased from 186 M mt in 1965 to 507 M mt in 1995 at an annual rate of 3.4 percent. However, total cereal production in the 30-year period has increased from 183 M mt in 1965 to 476 M mt in 1995, at an annual rate of 3.2 percent. Production growth was not fast enough to keep pace with consumption growth, resulting in significant production deficits over time (figure 11).

Figure 11. Cereal production and production surplus/deficit, EAP region.



It should also be noted that industrial and service sectors of some countries in the EAP region such as Malaysia, Indonesia and Philippines were growing rapidly during the 1980s and the 1990s. These countries have been net cereal importers.

The total cereal area in the 30-year period has increased only at an annual rate of 0.2 percent (table 9; figure 12). Virtually all of the increase in production in the region was due to productivity growth. The average cereal productivity has increased at an annual rate of 3.0 percent since 1965. Much of the productivity growth in the region has been associated with increase in irrigated area, which has grown at an annual rate of 2.2 percent over this period. The irrigation withdrawals at present account for more than 80 percent of the total withdrawals. Irrigation development in the EAP region has not only contributed to the growth in productivity and hence to overall production but also brought significant benefits to most rural people as well.

Of the 1995 population, more than two-thirds lived in rural areas (table 10), a drop of 13 percent from the 1965 level. However, in absolute terms, the rural population has increased from 833 million in 1965 to 1,191 million in 1995.

Table 9. Cereal production, area and yield and the net irrigated area.

Year	Production		Area		Yield		Irrigated Area	
	Total	Annual growth[1]	Total	Annual growth[1]	Average	Annual growth[1]	Total	Annual growth[1]
	M mt	%	M ha	%	Tons/ha	%	M ha	%
1965	183	-	134	-	1.36	-	44	
1975	266	3.8	142	0.6	1.87	3.2	55	2.3
1985	391	3.9	140	-0.2	2.80	4.1	60	2.1
1995	476	2.0	142	0.2	3.36	1.8	68	2.1
Growth[2] 1965–95	-	3.2	-	0.2	-	3.0	-	2.2

[1]Entries in the first three rows of these columns indicate the growth from the previous season.
[2]Entries in this row indicate the growth between 1965 and 1995.
Source: FAO 1998.

Figure 12. Cereal area, yield and production and net irrigated area indices, EAP region.

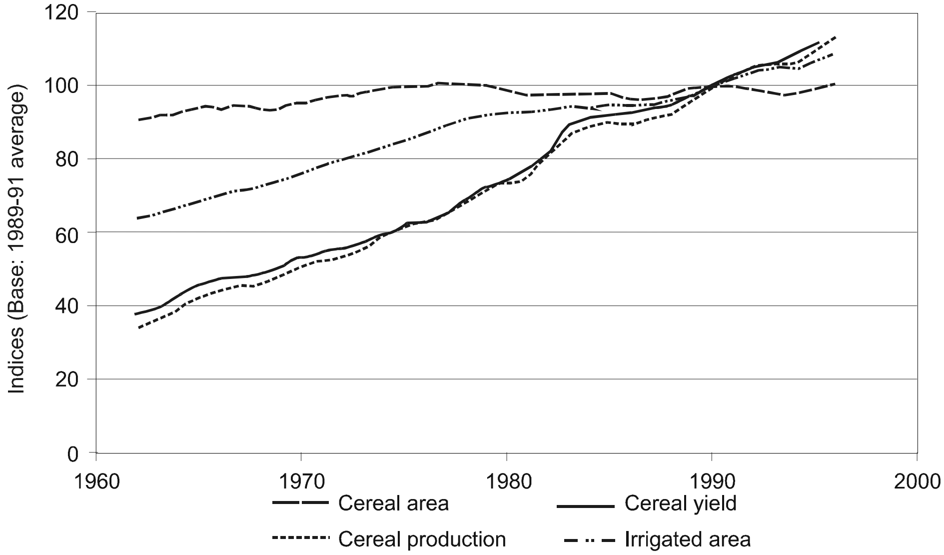


Table 10. Total, rural and agriculture population of EAP.

Year	Population Distribution								
	Total	Rural		Agriculture		Labor Force[1]		Fem. Labor Force[2]	
			% of total		% of rural		% of agriculture		% of total labor force
	Million	Million	%	Million	%	Million	%	Million	%
1965	1,025	833	81	800	78	401	50	170	42
1975	1,307	1,046	80	922	71	473	51	209	44
1985	1,535	1,145	75	1,037	68	571	55	261	46
1995	1,773	1,191	67	1,111	63	641	58	299	47

[1]This is the economically active population in agriculture.
[2]This is the economically active female population in agriculture.
Sources: FAO 1998; UN 1998.

Europe and Central Asia. Europe and Central Asia (ECA) have the highest per capita per day calorie supply in the developing world. The average per capita calorie supply in 1995 was 3,349 kcal. This is an increment of only 6 percent from the 1965 level (table 11). However, the composition of cereals, animal and other crop products in the daily diet shows drastic changes during this period. There was a tendency to shift from more animal products in the daily diet to a more vegetarian diet. The contribution of cereal products in the daily calorie supply in this period has increased by 13 percent (figure 13), while the contribution of animal products in the daily calorie supply has decreased by 46 percent. The contribution from other crop products to daily calorie supply has increased by 55 percent. These shifts are reflected in changes in the total crop consumption.

The growth of total cereal consumption in the region stayed barely above the population growth. The cereal production deficits have widened and the region became a net importer of cereals after the early 1970s (figure 14). However, more drastic changes observed after 1985 were associated with the collapse of the former Soviet Union.

Table 11. Total population, per capita calorie supply and total cereal consumption.

Year	Population		Per Capita Calorie Supply		Total Cereal Consumption	
	Total	Annual growth[1]	Total	Annual growth[1]	Total	Annual growth[1]
	Million	%	Kcal	%	M mt	%
1965	347	-	3,159	-	176	-
1975	387	1.1	3,366	0.7	248	3.4
1985	428	1.0	3,384	0.1	290	1.6
1995	455	0.6	3,349	-0.1	252	-1.4
Growth[2] 1965–95	-	0.9	-	0.2	-	1.2

[1]Entries in the first three rows of this column indicate the total growth from the previous year.
[2]Entries in this row indicate the total growth between 1965 and 1995.
Source: FAO 1998.

Figure 13. Composition (%) of per capita per day calorie supply, ECA region.

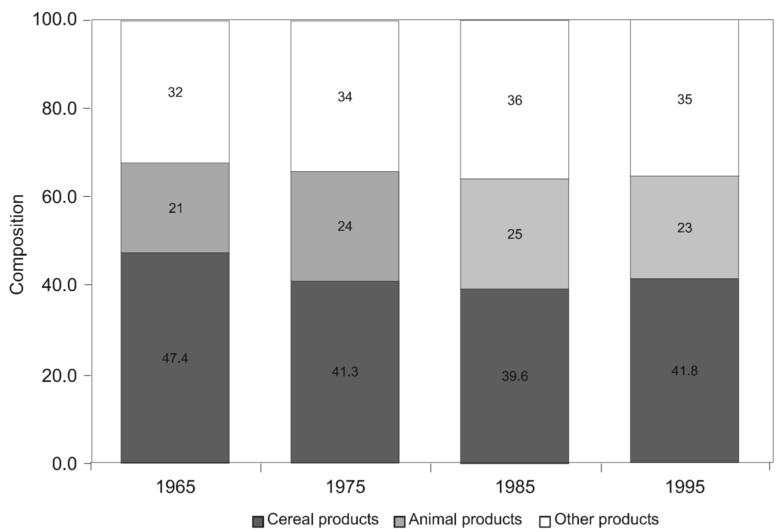


Figure 14. Cereal production and production surplus/deficit, ECA region.

The decrease in total cereal area indicates that productivity growth has been the sole contributor for production growth in this region (table 12; figure 15). The productivity in the region has increased by 45 percent. The contribution of irrigation to the total cereal production is very low, and rain-fed farming accounts for over 75 percent.

The rural population in the ECA region (34% in 1995; table 13) is smaller than in most other regions. Thus irrigation development in this region may have brought direct benefits to a smaller portion of the total population.

Table 12. Cereal area, yield and production and the net irrigated area.

Year	Production		Area		Yield		Irrigated Area	
	Total	Annual growth[1]	Total	Annual growth[1]	Average	Annual growth[1]	Total	Annual growth[1]
	M mt	%	M ha	%	Tons/ha	%	M ha	%
1965	180	-	152	-	1.18	-	13	-
1975	233	2.7	152	0.0	1.53	2.6	20	4.4
1985	249	0.7	142	-0.7	1.76	1.4	28	3.3
1995	222	-1.2	129	-0.9	1.72	-0.2	29	0.5
Growth[2] 1965-95	-	0.7	-	-0.5	-	1.2	-	2.7

[1]Entries in the first three rows of these columns indicate the growth from the previous season.
[2]Entries in this row indicate the growth between 1965 and 1995.
Source: FAO 1998.

Figure 15. Cereal area, yield and production and net irrigated area indices, ECA region.

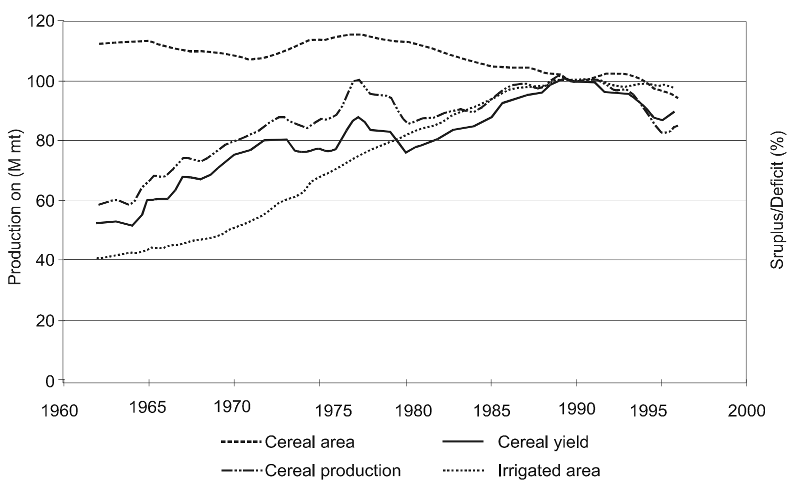


Table 13. Population distribution.

Year	Population Distribution								
	Total	Rural		Agriculture		Labor Force[1]		Female Labor Force[2]	
			% of total		% of rural		% of agriculture		% of total labor force
	Million	Million	%	Million	%	Million	%	Million	%
1965	347	176	51	132	38	65	49	34	52
1975	387	170	44	115	30	57	50	28	49
1985	428	165	39	105	25	53	50	25	46
1995	455	155	34	92	20	48	52	21	44

[1]This is the economically active population in agriculture.
[2]This is the economically active female population in agriculture.
Sources: FAO 1998; UN 1998.

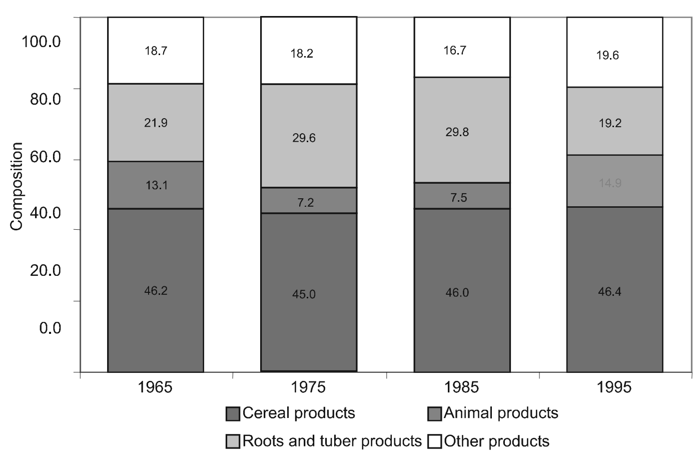
Africa. Over the period 1965 to 1995, the African population is estimated to have grown at an annual rate of 2.8 percent, which is much higher than growth rates experienced in most other regions (table 14). However, average per capita calorie supply over the same period is estimated to have grown only by an annual rate of 0.2 percent, which is much lower than in the other regions. Cereals, and roots and tubers contribute 46 percent and 19 percent, respectively, to daily diets (figure 16). The calorie supply from cereal products has increased by 13 percent while that from roots and tubers show only a 7-percent growth. The contribution of animal products to daily calorie supply has decreased from 13 percent (about 281 kcal) in 1965 to 11 percent (about 172 kcal) in 1995.

Table 14. Total population, per capita calorie supply and total cereal consumption.

Year	Population		Per Capita Calorie Supply		Total Cereal Consumption	
	Total	Annual growth[1]	Total	Annual growth[1]	Total	Annual growth[1]
	Million	%	kcal	%	M mt	%
1965	249	-	2,144	-	39	-
1975	323	2.7	2,155	0.1	52	2.9
1985	432	2.9	2,101	-0.3	66	2.5
1995	566	2.7	2,298	0.9	91	3.1
Growth[2] 1965–95	-	2.8	-	0.2	-	2.9

[1]Entries in the first three rows of this column indicate the total growth from the previous year.
[2]Entries in this row indicate the total growth between 1965 and 1995.
Source: FAO 1998.

Figure 16. Composition (%) of per capita per day calorie supply, African region.



The growth of cereal production in Africa has not kept pace with the increasing demand resulting from high population growth. Although the cereal production over the 30-year period has more than doubled, the production deficit has increased over time and is estimated to be 15 percent of the consumption in the mid-nineties (figure 17).

Unlike in most other regions, the productivity growth in Africa has been very low, with only a little contribution to overall production growth (figure 18; table 15). The production growth mainly resulted from expansion in cereal area, which is estimated to have grown at an annual rate of 1.6 percent over the 30-year period. The total irrigated area, though increased at an annual rate of 1.8 percent, is only a small part of the total crop area, with rain-fed cultivation dominating the crop production. Only 5 percent of the total cereal area was irrigated in 1995, which contributed only 12 percent to the production growth.

Figure 17. Cereal production and production surplus/deficit, African region.

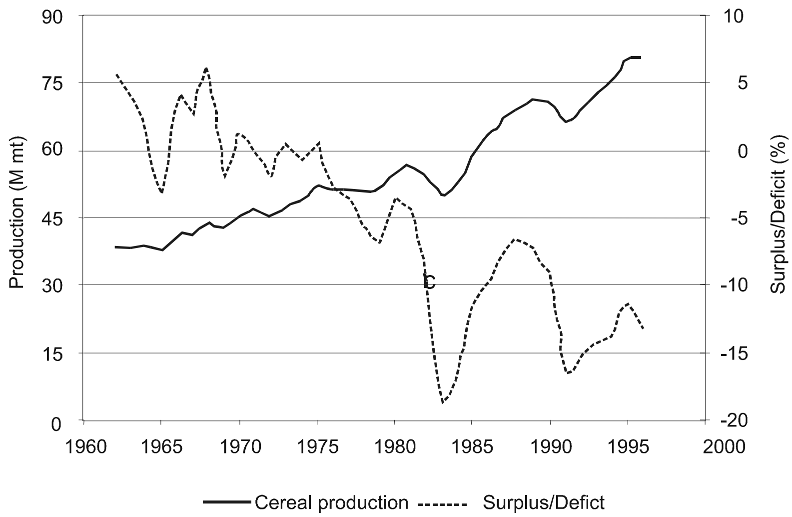


Figure 18. Cereal area, yield and production and net irrigated area indices, African region.

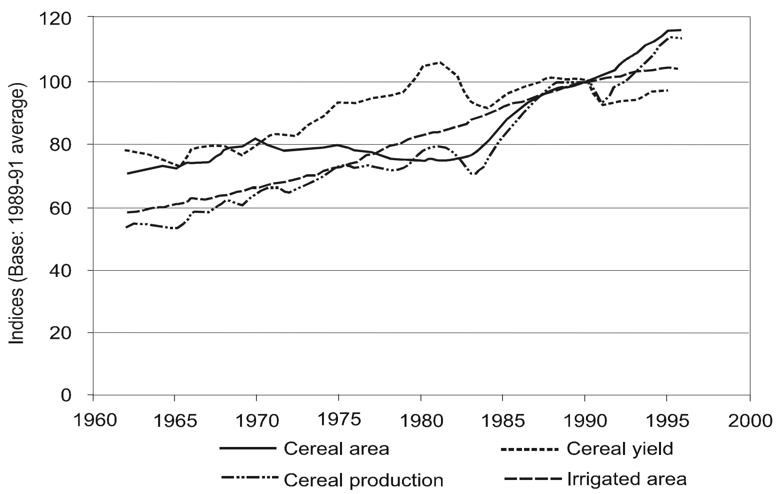


Table 15. Cereal area, yield and production and the net irrigated area.

Year	Production		Area		Yield		Irrigated Area	
	Total	Annual growth[1]	Total	Annual growth[1]	Average	Annual growth[1]	Total	Annual growth[1]
	M mt	%	M ha	%	Tons/ha	%	M ha	%
1965	38	-	50	-	0.75	-	4	
1975	52	3.3	55	0.8	0.96	2.4	4	1.8
1985	59	1.1	60	1.0	0.98	0.2	6	2.3
1995	80	3.2	80	2.9	1.00	0.3	6	1.2
Growth[2] 1965-95	-	2.5	-	1.6	-	1.0	-	1.8

[1]Entries in the first three rows of these columns indicate the growth from the previous season.
[2]Entries in this row indicate the growth between 1965 and 1995.
Source: FAO 1998.

This region has the highest percentage of rural population (71% in 1995), most of whom depend on agriculture (table 16). In addition, almost half of the active population in agriculture is female. Overall, it appears that most of the rural poor men and women in Africa have benefited very little from the global wave of new irrigation development in the past three decades.

Table 16. Total, rural and agriculture population distribution

Year	Population Distribution								
	Total	Rural		Agriculture		Labor force[1]		Female labor force[2]	
			% of total		% of rural		% of agriculture		% of total labor force
	Million	Million	%	Million	%	Million	%	Million	%
1965	249	215	86	203	82	97	48	44	46
1975	323	264	81	246	76	115	47	53	46
1985	432	330	76	300	70	138	46	64	47
1995	566	404	71	368	65	168	46	79	47

[1]This is economically active population in agriculture.
[2]This is economically active female population in agriculture.
Sources: FAO 1998, UN 1999.

Middle East and North Africa. The population growth in the Middle East and North Africa (MENA) was the highest among all regions. The total population of 283 million in 1995 was an increment of 135 percent from the 1965 level (table 17). Fueled by substantial increases in the consumption of food cereal products and animal products in the daily diets (30% and 39%, respectively) (figure 19), the total per capita calorie supply has increased by 4.3 percent annually. Increases in food cereals and animal products in the diet have resulted in the increase of the total cereal consumption at a substantially higher rate than that of the total population.

However, the growth in food production was not large enough to keep pace with increasing food demand. The cereal production deficit has increased over time and stood around 40 percent of the cereal consumption in the nineties (figure 20). As in most other regions, the productivity growth is the major driving force behind substantial growth in production (table 18; figure 21)

Table 17. Total population, per capita calorie supply and total cereal consumption.

Year	Population		Per Capita Calorie Supply		Total Cereal Consumption	
	Total	Annual growth[1]	Total	Annual growth[1]	Total	Annual growth[1]
	Million	%	kcal	%	M mt	%
1965	249	-	2,144	-	39	-
1965	121	-	2102	-	26	-
1975	159	2.8	2451	1.6	40	4.1
1985	218	3.2	2870	1.6	69	5.8
1995	283	2.7	2951	0.3	93	2.9
Growth[2] 1965–95	-	2.9	-	1.1	-	4.3

[1]Entries in the first three rows of this column indicate the total growth from the previous year.
2Entries in this row indicate the total growth between 1965 and 1995.
Source: FAO 1998.

Figure 19. Composition (%) of per capita per day calorie supply, MENA region.

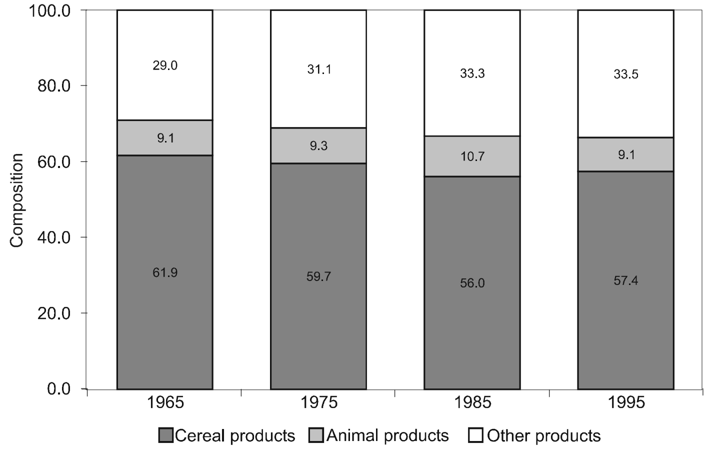


Figure 20. Cereal production and production surplus/deficit, MENA region.

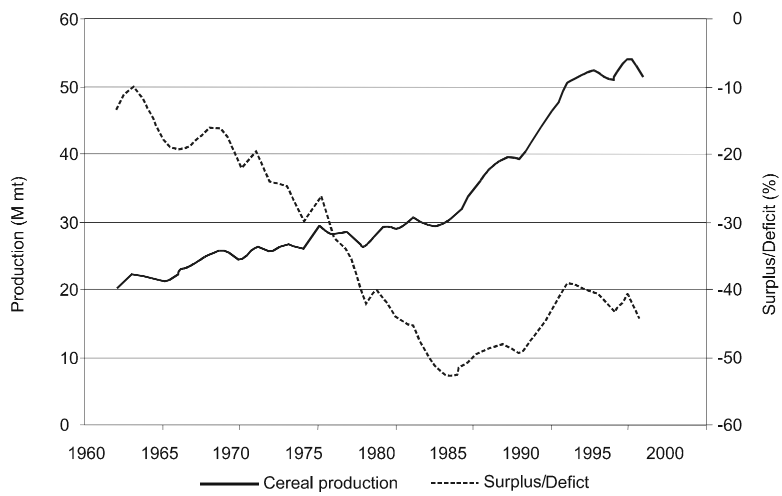
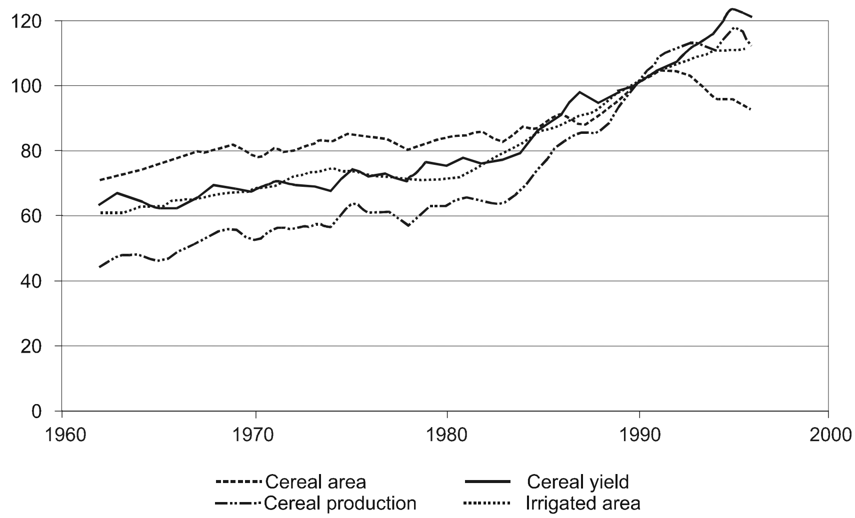


Table 18. Cereal production, area, yield and production and net irrigated area.

Year	Production		Area		Yield		Irrigated Area	
	Total	Annual growth[1]	Total	Annual growth[1]	Average	Annual growth[1]	Total	Annual growth[1]
	M mt	%	M ha	%	Tons/ha	%	M ha	
1965	21	-	23	-	0.93	-	12	-
1975	29	3.1	26	1.3	1.12	1.8	14	1.6
1985	35	1.8	27	0.2	1.30	1.6	16	1.5
1995	54	4.5	30	1.0	1.84	3.5	20	2.7
Growth[2] 1965-95	-	3.1	-	0.8	-	2.3	-	1.9

[1]Entries in the first three rows of these columns indicate the growth from the previous season.
[2]Entries in this row indicate the growth between 1965 and 1995.
Source: FAO 1998.

Figure 21. Cereal area, yield and production and net irrigated area indices, MENA region.



Rural population of the MENA region (table 19) is comparatively smaller than that of South Asia, EAP or the African region. However, as irrigation is essential for agriculture in most countries in the region, the rural population may have benefited substantially from increased irrigation development.

Table 19. Total, rural and agriculture population.

Year	Population Distribution								
	Total	Rural		Agriculture		Labor Force[1]		Female Labor Force[2]	
			% of total		% of rural		% of agriculture		% of total labor force
	Million	Million	%	Million	%	Million	%	Million	%
1965	121	73	61	72	59	23	32	6	28
1975	159	85	54	79	50	25	31	8	33
1985	218	103	47	83	38	26	31	10	37
1995	283	120	42	85	30	28	32	12	42

[1]This is the economically active population in agriculture.
[2]This is the economically active female population in agriculture.
Sources: FAO 1998; UN 1999.

Latin America and the Caribbean. The total population in the Latin American and the Caribbean countries has increased more than 90 percent from the 1965 level (table 20). The growth in consumption of food cereals (9%) and the substantial growth in the consumption of animal products (36%) have resulted in a total cereal consumption growth of 162 percent (figure 22; table 21).

The growth of cereal production in the region, however, has not kept pace with the consumption growth. The region as a whole has recorded substantial production deficits in the 1990s (figure 23), which is a significant change from the situation that prevailed until the mid-1970s when the region achieved production surpluses. While there was a turnaround in the production situations, the total cereal production has more than doubled during the 30-year period (figure 24; table 21). The major factor contributing to production growth was the productivity growth. The total cereal area increased only by 16 percent while the productivity grew by 82 percent. As in Asia, the growth in irrigation in this region has made a significant contribution to the average yield growth.

Table 20. Total population, per capita calorie supply and total cereal consumption

Year	Population		Per Capita Calorie Supply		Total Cereal Consumption	
	Total	Annual growth[1]	Total	Annual growth[1]	Total	Annual growth[1]
	Million	%	kcal	%	M mt	%
1965	250	-	2,394	-	51	-
1975	322	2.6	2,545	0.6	76	4.1
1985	401	2.3	2,687	0.6	106	3.3
1995	480	1.8	2,774	0.3	134	2.4
Growth[2] 1965–95	-	2.2	-	0.5	-	3.3

[1]Entries in the first three rows of this column indicate the total growth from the previous year.
[2]Entries in this row indicate the total growth between 1965 and 1995.
Source: FAO 1998.

Figure 22. Composition (%) of per capita per day calorie supply, LAC region.

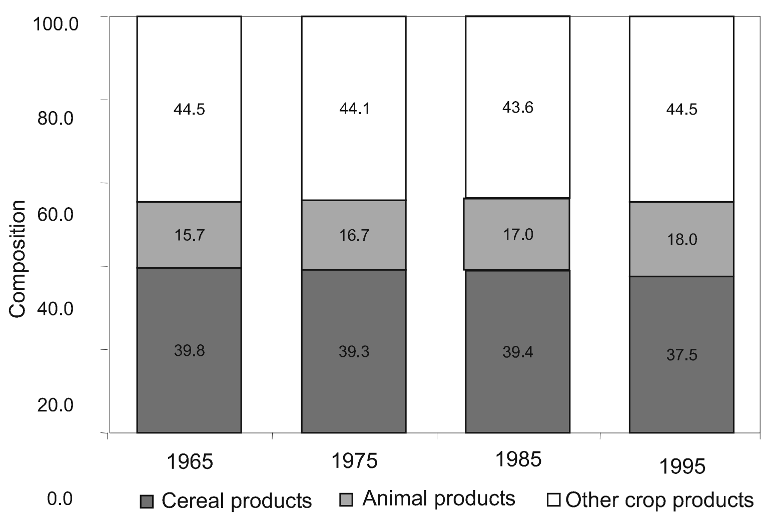


Table 21. Cereal production, area, yield and net irrigated area.

Year	Production		Area		Yield		Irrigated Area	
	Total	Annual growth[1]	Total	Annual growth[1]	Average	Annual growth[1]	Total	Annual growth[1]
	M mt	%	M ha	%	Tons/ha	%	M ha	
1965	56		43	-	1.30	-	9	-
1975	77	3.3	50	1.5	1.55	1.8	12	3.0
1985	102	2.8	52	0.3	1.98	2.5	15	1.9
1995	117	1.4	50	-0.3	2.36	1.8	18	2.1
Growth[2] 1965–95	-	2.5	-	0.5	-	2.0		2.4

[1]Entries in the first three rows of these columns indicate the growth from the previous season.
[2]Entries in this row indicate the growth between 1965 and 1995.
Source: FAO 1998.

Figure 23. Cereal production and production surplus/deficit, LAC region.

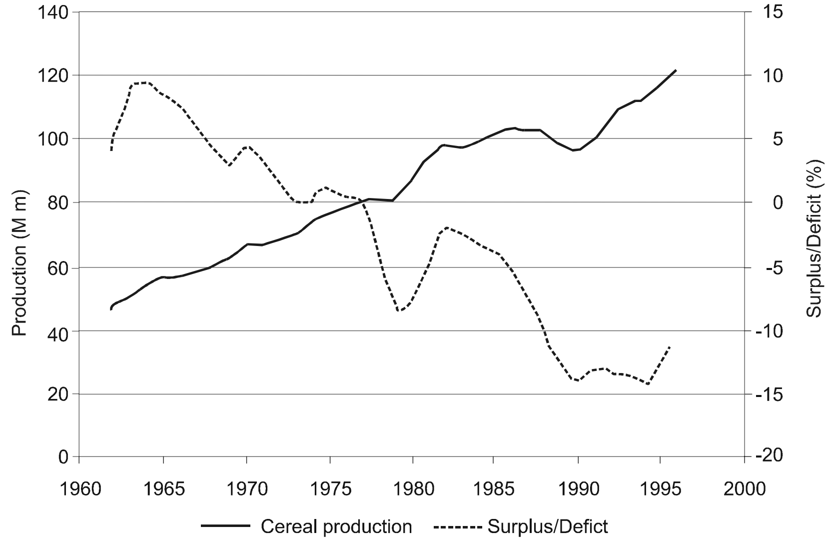
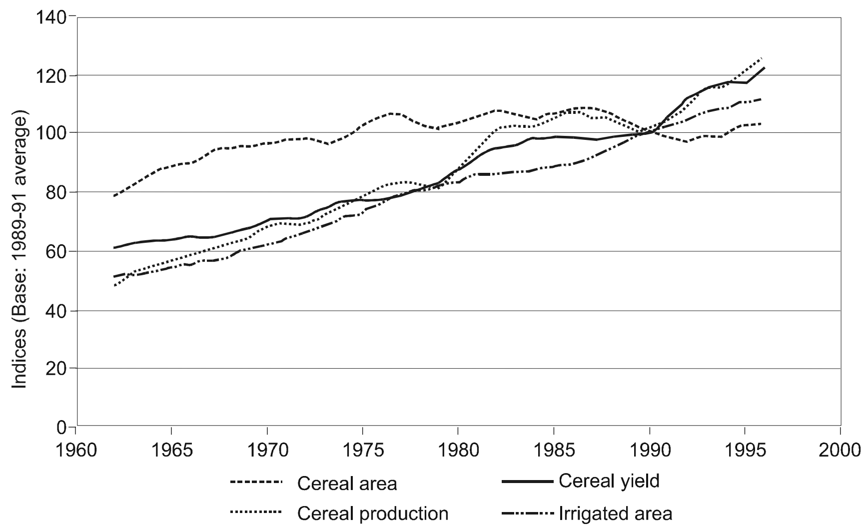


Figure 24. Cereal area, yield, production and net irrigated area indices, LAC region.



Unlike in Asia and the Pacific countries, the impact of irrigation development may have brought direct benefits to a small part of the LAC population. The reason for this is that only a little over one quarter of the population lives in rural areas, and a little under one quarter of the population depends for their livelihoods on agriculture (table 22).

The rural population is still the majority in most developing regions. Most of the rural population is employed in agriculture. Past trends indicate that irrigation development had contributed substantially for increasing crop productivity and, hence, production in most developing regions. Increased crop production has brought several benefits to most regions. The South Asian region as a whole became self-sufficient in their cereal requirement in the EAP region and would have recorded massive food deficits had there been no irrigation development. Also, increased food security at rural households and increased income for the rural population have been common features in most developing regions. Therefore, the agricultural development will still play a major role in future strategies of rural developments in the regions with a substantial rural population.

Table 22. Total, rural and agriculture population.

Year	Population Distribution								
	Total	Rural		Agriculture		Labor Force[1]		Female Labor Force[2]	
			% of total		% of rural		% of agriculture		% of total labor force
	Million	Million	%	Million	%	Million	%	Million	%
1965	250	116	46	116	46	38	33	5	14
1975	322	124	39	125	39	42	34	7	16
1985	01	127	32	122	30	44	36	8	17
1995	480	127	26	114	24	44	39	7	17

[1]This is the economically active population in agriculture.
[2]This is the economically active female population in agriculture.
Sources: FAO 1998; UN 1999.

Water Supply and Demand 1995–2025: Issues and Scenarios

In this section, we discuss water supply and demand projections for various regions. The period of projection is from 1995 to 2025. The discussion here is mainly based on the studies on world's future water supply and demand conducted by IWMI (Seckler et al. 1998; IWMI 2000). For the past few years, IWMI has been conducting research and developing different scenarios of water supply and demand for different countries. Results presented here are based on the IWMI base scenario, developed from the PODIUM,[4] the policy dialogue model.

For countries with a substantial rural population, the base scenario reflects targets to achieve the following four major objectives:

- Provide an adequate level of per capita food consumption to reduce extreme forms of nutritional poverty.
- Provide basic human needs of domestic and industrial activities.
- Increase food security and rural income through agricultural development with a focus on reducing food imports.
- Improve water quality and support environmental uses of water.

Activities for achieving these objectives include growth in agricultural area and crop productivity. The base scenario is rather more optimistic, in the sense that if the above objectives could be achieved within the constraints of available resources, countries have done their best as they could with these resources. A rather pessimistic scenario would be no growth in area and slower growth in productivity. The impact on food production from such a scenario will also be discussed.

The analysis in this section is based on 100 countries, which comprise 96 percent of the world's total population. Results presented here are aggregated at the regional level. The 100-country sample

[4]PODIUM, the policy dialogue model, is designed to explore the technical, social and economic aspects of alternative visions for the future. A brief discussion of the steps of computation in the PODIUM is given in the appendix.

contains 94, 96, 100, 99, 85 and 96 percents of the total population of the AFR, MENA, SA, EAP, EAC and LAC regions, respectively. The countries in North America, the European Union, Australia, New Zealand and Japan are aggregated into a single category.

Base Scenario

Water for food projections in the IWMI base scenario consists of four major steps. Future food demand for a country is projected first, followed by food supply projections. Water demand for food production is projected next. Water for food is combined with water for domestic and industrial sectors to project the total water demand. We discuss these steps in greater detail in the following sections.

Food Demand

Total food demand projections depend on three crucial factors:

- population growth
- increase in per capita consumption
- changes in the composition of diet

The importance of these three components on projections is discussed next.

Population growth. Population growth is a crucial factor in any future water development strategies for food and for domestic or industrial consumption. Large-scale water development projects, which start now, take several years for completion. The actual population at the time of completion of projects may be much larger than these projects are predicted to cater for. Some of these costly development projects may not be meaningful then. Therefore, assessing a reasonable population growth path is very important for deciding future water strategies.

The United Nations (UN) has three population projection paths: high, medium and low (UN 1999). While most agree that high projection is not realistic, some debate about the possible path from the medium to low projections. The UN believes that medium projection is reasonable but some argue for a low growth trajectory (Seckler and Rock 1995). Until this becomes clear, we take a compromise path: the average of UN's medium and low projections.

Even under the average growth scenario some developing country regions still have substantially high population growth than others. For example, the African region will have 87 percent more people in 2025 than in 1995; the MENA region will have 66 percent more people in 2025. Though the growth rates are smaller, the SA and EAP regions would have an added population of 529 and 398 million, respectively, by 2025. Overall, more than 95 percent of the total population increases are projected to be in the developing countries.

Nutritional consumption. The average daily per capita calorie supply from food is a good indicator of nutritional consumption. An important objective in the base scenario is to provide sufficient calorie supply per person per day to reduce extreme forms of food poverty. Most developing countries fall in this category.

A reasonably high calorie supply through a varied daily diet provides not only the minimum calorie requirements but also enough protein, mineral and vitamin needs. For developing countries, a calorie supply of 2,200 kcal per person per day would be sufficient for meeting most of the above requirements.

The present average per capita per day calorie supply of all regions is more than 2,200 kcal (table 23). Due to differences in income, substantial variations in per capita calorie intake exist between regions, and also between countries within regions. The consumption of at least 2,200 kcal per person per day requires a substantially high average per capita supply at the national level. A rule of thumb is that an average calorie supply of 2,700 to 3,000 kcal per person per day would be sufficient to meet the minimum requirement, even to most of the poorest of the poor people. [Note that while distribution of food may still be an issue, increased overall domestic supply can be expected to improve the access to food by poor people]

Table 23. Population and calorie supply (per capita per day).

Region	Population			Per Capita Calorie Supply		
	1995	2025	Annual growth	1995	2025	Annual growth
	Million	Million	%	Million	Million	%
All countries (45)	5,422	7,217	1.0	2,722	2,964	0.3
Developed counties	893	984	0.3	3,342	3,579	0.2
Developing countries	4,529	6,232	1.1	2,599	2,867	0.3
AFR	533	989	2.1	2,197	2,413	0.3
MENA	271	443	1.7	2,954	3,035	0.1
SA	1,233	1,762	1.2	2,360	2,741	0.5
EAP	1,759	2,158	0.7	2,740	3,034	0.3
CA	386	401	0.1	2,995	3,075	0.1
LAC	461	644	1.1	2,791	3,196	0.5
Other countries[1]	779	818	0.2	3,356	3,649	0.3

[1]North America, European Union, Australia, New Zealand and Japan are in this category.

The African and South Asian regions had the lowest average per capita calorie supplies in 1995, estimated at 2,197 kcal and 2,360 kcal, respectively. This indicates that a substantial number of poor people in these regions have been suffering from food poverty-nutritional deficiencies. The target average per capita calorie supplies in 2025 in these regions are 2,413 kcal and 2,741, respectively, still the lowest among all the regions (since these regions begin with a low base in 1995). The African region is projected to have the highest annual growth in total calorie consumption (2.3% annually) followed by MENA (1.8%) and South Asia (1.7%). The 2025 targets for other regions are more than 3,000 kcal. The world-level target for average daily calorie supply is above 2,700 kcal.

Composition of daily diet. Cereals dominate the daily diet of people in most countries. More than 65 percent of the daily calorie supply is provided by cereals: directly through cereal products and indirectly through animal products. However, the composition of cereal and meat products does vary across regions. In general, the poor regions such as South Asia and EAP still consume more cereal products, while rich countries consume more meat products.

More meat products in the diet mean more consumption of equivalent crop products. Production of one kilogram of meat product requires several kilograms of equivalent crop products. Under commercial production settings, the average ratios are more than 3 times for poultry products and more than 6 times for red meat products. Thus the changes in composition of diets have important implications for overall crop production.

In general, the tendency in developing countries (presently low-calorie-consuming countries) is to reduce direct cereal consumption (food) and increase the share of animal products in the daily diets (due to increase in incomes).[5] This is resulting in a shift from food to feed use of cereals. In the longer term, demand for feed can be expected to increase in these countries. However, in high-calorie-consuming countries, especially in developed countries there is a tendency to shift form red meats to white meat—with overall less meat consumption—and to increase the share of vegetables, pulses and fruits (mainly due to health concerns). These shifts, along with significant improvement in efficiency of converting feed into animal products, can be expected to free up some feed cereals.

The projected changes in the share of cereals and animal products in South Asia (64 to 60% from cereal products, and 8 to 11% from animal products), and in the EAP region (60 to 52% in cereals, 14 to 20% in animal products) are prominent (figure 25).

Figure 25a. Per capita calorie supply from cereal products, % of total.

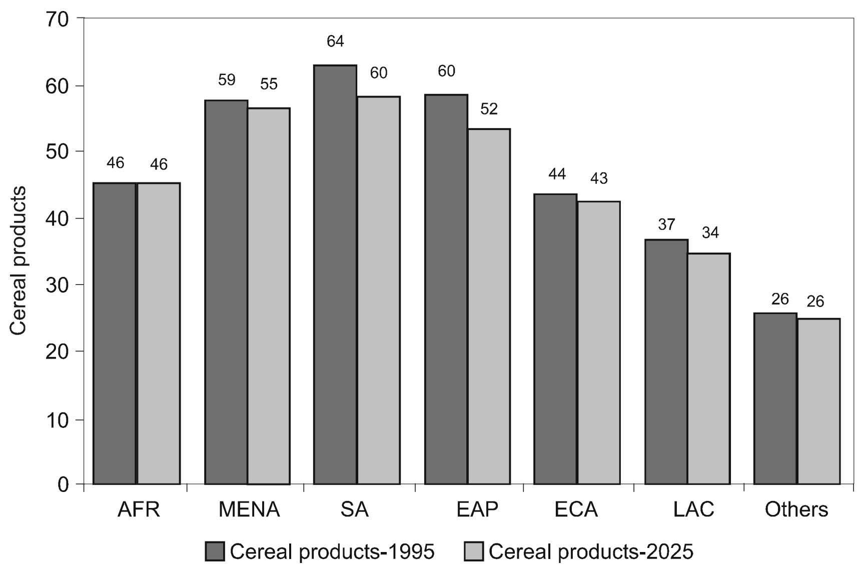
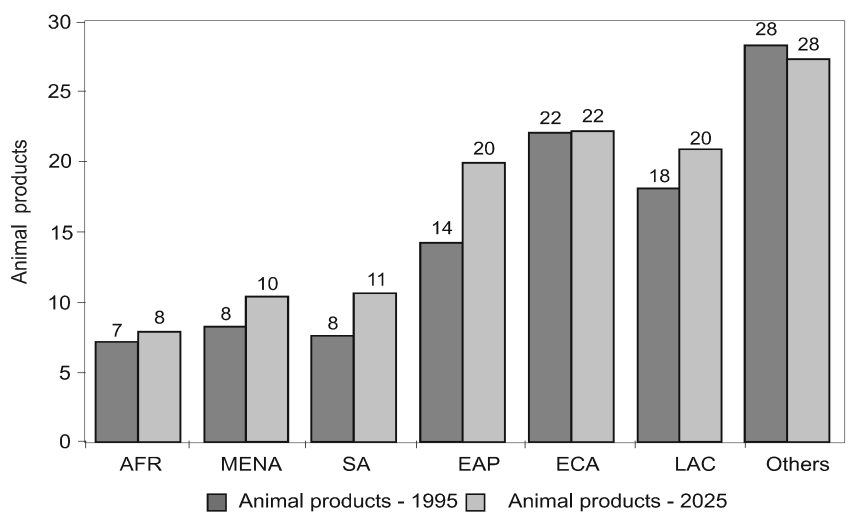


Figure 25b. Per capita calorie supply from animal products, % of total.



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[5]The income elasticity of animal products is generally high in the early stages of economic development.

At present, most of the animal products in developing countries are produced through traditional forms of feeding such as from pastures and other lands not suitable for crops or from waste products. This trend will change in the future. Most of the pasturelands for grazing are exploited to the full potential. The feeding mode through waste will reduce. The commercial forms of feeding, i.e., mainly feeds using maize, barley, soybean meal, etc., will increase.

Cereal consumption. Cereals form the dominant form of feed stuffs in commercial forms of animal husbandry. At present, almost 70 percent of the feed stuffs are from cereals. An increase in consumption of animal products in the human diet requires more feed cereals (table 24). The base scenario shows that all regions, except the ECA region, will have substantial increases in feed cereal consumption. The ECA region already has a rich calorie supply from animal products. On average, the food cereal consumption in developing countries is expected to increase at an annual rate of 1.1 percent, while feed cereal consumption is expected to increase at an annual rate of 2.1 percent.

Table 24. Food, feed and total cereal consumption.

Region	Food Cereals			Feed Cereals			Total Cereals		
	1995	2025	Annual growth	1995	2025	Annual growth	1995	2025	Annual growth
	M ha	M ha	%	M ha	M ha	%	M ha	M ha	%
All countries (45)	865	1,172	1.0	615	938	1.4	1,718	2,419	1.1
Developed countries	113	132	0.5	304	363	0.6	505	600	0.6
Developing countries	752	1040	1.1	311	575	2.1	1,213	1,819	1.4
AFR	66	134	2.4	8	16	2.4	87	178	2.4
MENA	59	91	1.5	25	55	2.6	93	161	1.8
SA	201	309	1.4	4	11	3.6	227	356	1.5
EAP	326	385	0.6	130	297	2.8	511	755	1.3
ECA	66	69	0.1	106	118	0.4	220	236	0.2
LAC	58	85	1.3	55	109	2.3	124	210	1.8
Other countries	89	99	0.3	288	334	0.5	455	523	0.5

Food Supply

In the base scenario, the additional food production, to meet increasing demand will be achieved mainly through productivity improvements with some growth in crop area. The growth in agricultural area and productivity in the base scenario depend on several factors:

- availability of utilizable water resources
- trade
- rural livelihood security and development policies
- irrigation and productivity growth
- domestic and industrial water supply
- water for the environment

Utilizable water resources. Growth in area in the future is constrained by the current level of development of utilizable water resources. Some countries have already developed a substantial portion of their utilizable water resources and are thus categorized as physically water scarce.[6] Some of these countries will have to import food for meeting increasing demand. Some countries may shift from low- to high-value crops, and increase trade for meeting increasing demand. Some of the other countries may have reached their development potential, yet have low water use efficiencies. These countries may have enough room for improving efficiencies and, thus, can save water and increase their crop area through higher cropping intensities.

Trade. Countries with no water scarcities may also shift from low- to high-value crops or improve other sectors of production. Some can meet their future food demand by exporting high-value crops. Yet, the world as a whole or even a region as a whole has limits in production increases of high-value crops. If production increases to such an extent that may glut the markets with surpluses, prices will be driven down. This will not help the countries, especially those in the developing world, that are supposed to benefit from shifts in cropping patterns.

The other alternative here is to reduce attention on the agriculture sector, and develop industrial and service sectors to pay for food imports. Until the industrial and service sectors can expand and absorb most rural labor, and also provide sufficient income, this alternative may not really be viable. The main reason for this is that a large part of the population in the developing region even by 2025 is projected to be still rural.

Rural livelihood security. In the short term, countries with a substantial rural population will perhaps be the most affected by possible increases in food trade. Until the other sectors can pay, these countries will have to spend their foreign exchange for importing food, which otherwise would have been spent on rural development activities. Therefore, the livelihood security of the rural population should be a major factor in the growth of agriculture into the next quarter century. For countries with a substantial rural population, the IWMI base scenario assumes an increase in food security and rural income through agricultural development and fewer imports. This assumption is very important for regions such as the SA, EAP and Africa. In these regions, more than 50 percent of the total population will still live in rural areas by 2025; and most of them will depend on agriculture for their livelihood.

Irrigation. The productivity growth during the last few decades has contributed most to the total increase in production. Irrigation, acting synergistically with high-yielding varieties and with better agronomic practices has contributed substantially to productivity growth. Though the contribution of irrigation to productivity growth is recognized, its extent is not exactly clear. Irrigation has contributed to yield increase in two ways. It increases average yield by providing more water supplies to marginal rain-fed lands in a predictable manner. This induces farmers to use more of other inputs such as better seeds, fertilizers and pesticide, etc., in a less-risky environment and improve their yields. Therefore, the knowledge of the interaction between irrigation and productivity growth is important for projecting future productivity growth.

In the base scenario, yield growth projections are based on past trends in yields, the yield gap (from the current to the technically and economically potential yield), yields of similar agro-climatic conditions, percent irrigated area and fertilizer use.

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[6]A country is categorized as "severe water scarce" if it has developed more than 60 percent of its utilizable water resources.

Domestic and industrial supply. With increasing income, urbanization and rapid industrialization, demand for water in the domestic and industrial sectors is increasing. Given that water is a basic human need in the domestic sector, and has a high value in the industrial sector, water use in these sectors generally attracts higher priority. In the base scenario, the basic requirements of these sectors are met first. If sufficient water resources remain after meeting domestic and industrial needs, the growth of irrigation is considered.

Water for the environment. The environmental sector is commonly neglected in most water resources planning. Even in this analysis we have not considered the environment sector separately. Yet we have taken precaution to constrain other sectors of water consumption, i.e., total evaporation of primary water supply, so that part of the developed water resources is available directly or as return flows for environmental uses such as supplies to estuaries and coastal areas, and supplies to flush salt and other pollutants, etc. In the base scenario, the total evaporation from the primary water supply to all sectors cannot exceed 75 percent.

Subject to the constraints and issues raised here, we have assumed values in growth of cereal area and yield for each country to project its cereal supply in 2025.

Cereal Supply

In the base scenario, the food supply projections are achieved through a combination of yield and area growth. First we discuss the growth in cereal supply. Then we discuss growth of cereal yield and area. The cereal production and the production surplus or deficit of cereals for different regions are presented in table 25. The production deficit/surplus is defined as the difference between total domestic production and consumption.

With the objective of self-sufficiency, developing countries will increase their domestic production and reduce production deficits with respect to consumption. The IWMI base scenario projects a slight increase in production deficit (106 M mt deficit in 1995 to 119 M mt deficit in 2025) for developing countries. However, this is an improvement in production deficit with respect

Table 25. Cereal production and production surplus or deficit.

Region	Cereal Production			Cereal Production Surplus or Deficit			
	1995	2025	Annual growth	1995	% of total consumption	2025	% of total consumption
	M mt	M mt	%	M mt	%	M Mt	%
All countries (45)	1,724	2,410	1.1	7	0.4	-9	-0.3
Developed countries	618	710	0.5	113	22	110	18
Developing countries	1,107	1,700	1.4	-106	-9	-119	-7
AFR	79	150	2.1	-8	-9	-27	-15
MENA	54	79	1.3	-40	-42	-82	-51
SA	229	344	1.4	2	1	-11	-3
EAP	475	752	1.5	-36	-7	-3	0
ECA	199	244	0.7	-21	-10	8	3
LAC	113	182	1.6	-11	-9	-29	-14
Other countries	576	660	0.5	120	26	136	26

to their consumption (a deficit of 9% of consumption in 1965 to a deficit of 7% of consumption in 2025). On the other hand, developed countries will continue to increase their production but at a slower pace than in the past, resulting in decrease in their production surpluses from 22 percent in 1995 to 18 percent in 2025.

Regions with substantial rural populations, except those in Africa, will be more or less self-sufficient in their cereal production. South Asia will have a small deficit (only 3% of consumption). This is mainly due to Pakistan's inability to meet its projected cereal demand in 2025. Other countries in the region will stay at the level of trend self-sufficiency. The East Asian and Pacific region will convert its production deficits in 1995 to a small surplus in 2025.

The African region's production deficit will increase from 9 percent of its consumption in 1995 to 15 percent of its consumption in 2025. The main reason for this is its high population growth. Also, the MENA region will have to increase its volume of imports, due mainly to existing water scarcities.

The ECA region is projected to reduce its production deficits and be self-sufficient in 2025. This is mainly due to production increases in transition economies in this region. They will do better and increase their growth in production in most sectors in the future than those recorded since the mid-eighties.

The Latin America and Caribbean region is projected to have minor production deficits in 2025. This region, with a smaller proportion of rural population will concentrate more on high-value crops and place more emphasis on other sectors. The region is expected to meet its cereal demand in the future through imports. However, Argentina, which has been a major cereal exporter in the past, will still have substantial surpluses for export in the future.

Growth in Cereal Yield

The irrigated cereal yield in all countries is projected to increase at an annual rate of 1.1 percent over the 30-year period (table 26). The gap between potential and actual yields in developing countries is much wider than that in developed countries. This implies that developing countries have room for further improvement through better water and land management. Irrigated yields in developing countries are projected to increase at an annual rate of 1.3 percent. The average cereal yield of all countries is projected to increase at an annual rate of 0.9 percent.

Table 26. Growth of cereal yield.

	Irrigated Cereal Yield			Rain-Fed Cereal Yield			Total Cereal Yield		
Region	1995	2025	Annual growth	1995	2025	Annual growth	1995	2025	Annual growth
	M ha	M ha	%	M ha	M ha	%	M ha	M ha	%
All countries (100)	3.32	4.65	1.1	2.08	2.33	0.4	2.47	3.22	0.9
Developed countries	5.17	6.48	0.8	3.76	4.47	0.6	4.05	4.99	0.7
Developing countries	3.01	4.38	1.3	1.52	1.70	0.4	2.03	2.80	1.1
AFR	2.25	3.19	1.2	0.97	1.26	0.9	1.03	1.35	0.9
MENA	3.08	4.29	1.1	0.81	0.93	0.5	1.85	2.39	0.9
SA	2.55	3.41	1.0	0.94	1.15	0.7	1.77	2.59	1.3
EAP	3.29	5.00	1.4	2.41	2.44	0.0	2.91	4.35	1.3
ECA	3.27	4.10	0.8	1.58	1.91	0.6	1.66	2.02	0.7
LAC	3.96	5.29	1.0	2.08	2.66	0.8	2.34	3.27	1.1
Other countries	5.27	6.60	0.8	4.11	4.89	0.6	4.37	5.36	0.7

Growth in Cereal Area

Following the past trends, the cereal area in developed countries is projected to continue to decline. With projected increase in cereal area in developing countries (mainly in Africa) the total cereal area in all countries will more than offset the area reduction in developed countries, resulting in an overall 3 percent area increase by 2025 (table 27).

The growth in irrigated area of all regions, except in Africa, will be at the expense of marginal rain-fed lands. At present, almost all cereal production in Africa is on rain-fed lands. More new land will be brought under rain-fed cultivation than under irrigation in Africa. A substantial amount of rain-fed cultivated area in South Asia and East Asia will be converted to irrigation. Latin America and the Caribbean region has the highest growth in irrigation, almost double the level in 1995. This is mainly due to irrigated area increases in Brazil, where the potential for bringing new area under irrigation is high.

Table 27. Growth of cereal area.

Region	Irrigated Cereal Area			Rain-Fed Cereal Area			Total Cereal Area		
	1995	2025	Annual growth	1995	2025	Annual growth	1995	2025	Annual growth
	M ha	M ha	%	M ha	M ha	%	M ha	M ha	%
All countries (100)	219	286	0.9	479	463	-0.1	698	749	0.2
Developed countries	31	37	0.5	121	106	-0.4	152	142	-0.2
Developing countries	188	250	1.0	358	357	0.0	546	607	0.4
AFR	4	5	1.2	74	106	1.2	77	112	1.2
MENA	13	14	0.2	16	19	0.6	29	33	0.4
SA	67	85	0.8	62	48	-0.8	129	133	0.1
EAP	94	129	1.1	69	44	-1.5	163	173	0.2
ECA	6	6	0.4	114	114	0.0	120	121	0.0
LAC	7	13	2.2	41	43	0.1	48	56	0.5
Other countries	29	34	0.5	103	89	-0.5	132	123	-0.2

Growth in Irrigation

The base scenario assumes that growth in cereal irrigated area is an indicator of the total growth of irrigated area. A substantial part of the total gross area growth is due to increase in the irrigation intensity. The net irrigated area of the world is projected to increase by 24 percent—from 253 M ha in 1995 to 312 M ha in 2025. The total increase in gross irrigated area over the 30-year period is projected to be 30 percent—from 354 M ha in 1995 to 466 M ha in 2025 (table 28). The difference between the projected gross irrigated area and the net irrigated area, i.e., 53 million ha, is due to increase in irrigation intensity. More than 85 percent of the area gain due to intensity increase is in developing countries. The countries with a substantial rural population such as those in South Asia and East Asian and Pacific regions are expected to substantially benefit from the intensity increase.

Part of the additional water requirement can be met from the existing supplies through improvements in irrigation efficiency or more recycling or both. The remaining water requirements, which cannot be met from the existing supplies, will have to be developed as primary irrigation water supplies. The primary irrigation water supply of the 100 countries is projected to increase from 1,708 km^3 to 2,021 km^3.

Table 28. Growth of total irrigated area and primary water supply.

Region	Net Irrigated Area			Gross Irrigated Area			Primary Irrigation Supply		
	1995	2025	Total growth	1995	2025	Total growth	1995	2025	Total growth
	M ha	M ha	%	M ha	M ha	%	km³	km³	%
All countries (100)	253	312	24	354	466	32	1708	2021	18
Developed countries	45	53	17	66	81	23	258	297	15
Developing countries	207	259	25	288	386	34	1449	1725	19
AFR	7	9	32	9	14	46	44	59	35
MENA	20	22	8	26	30	13	169	169	0
SA	78	90	16	101	128	27	595	692	16
EAP	67	89	33	112	154	38	423	524	24
ECA	25	28	11	25	29	15	150	154	3
LAC	16	29	79	22	42	91	110	180	64
Other countries	39	44	14	58	69	19	218	243	11

Total Water Diversions

Total water diversions and total primary water supply to agriculture, domestic and industrial sectors are given in table 29. Total water diversions in all countries will increase by about 1,040 km^3, while primary supply will increase by 577 km^3. Most of the additional water diversions (about 935 km^3 of the total water supply and 464 km^3 of the primary supply) will be in the developing countries.

The MENA region is already withdrawing a substantially high percentage (79%) of its potentially utilizable water resources. The SA region follows next with 43 percent. By 2025, the South Asia region will have to develop 52 percent of its PUWR to meet future demand. Compared to MENA and SA, other regions' primary water supplies are relatively small portions of their PUWR.

Table 29. Total water diversions.

Region	Total Water Supply			Total Primary Water Supply				
	1995	2025	Total growth	1995	% of PUWR	2025	% of PUWR	Total growth
	km³	km³	%	km³	%	km³	%	%
All countries (100)	3,307	4,352	32	2,371	14	2,948	17	24
Developed countries	917	1026	12	739	20	852	23	15
Developing countries	2,390	3,325	39	1,632	12	2,096	16	28
AFR	67	103	54	51	2	74	4	45
MENA	237	266	12	181	75	192	80	6
SA	866	1,117	29	615	45	754	55	23
EAP	776	1,242	60	482	18	692	25	44
ECA	324	361	11	210	8	221	9	5
LAC	194	353	82	140	3	237	5	69
Other countries	843	910	8	693	20	777	22	12

Water Scarcity

Countries are grouped into three categories of water scarcity: physical water scarcity, economic water scarcity and little or no water scarcity (figure 26).

Physical water scarcity. This is defined in terms of the magnitude of primary water supply (PWS) development with respect to potentially utilizable water resources (PUWR). The physical water-scarce condition is reached if primary water supply of a country exceeds 60 percent of its PUWR. This means that even with the highest feasible efficiency and productivity, PUWR of a country is not sufficient to meet the demand of agriculture, domestic and industrial sectors while satisfying its environmental needs. Countries in this category will have to transfer water from agriculture to other sectors and import food or invest in costly desalinization plants.

Economic water scarcity. Economic water-scarce countries have sufficient water resources to meet their additional PWS needs, but they require increasing their PWS through additional storage and conveyance facilities by more than 25 percent. Most of these countries face severe problems related to both finance and the capacity for development for increasing PWS to those levels.

The third category includes countries with little or no water scarcity. These countries are not physically water scarce and also need to develop less than 25 percent of additional PWS to meet their 2025 needs.

The MENA region as a whole is already physically water scarce (table 29). Indeed most countries in this region are physically water scarce, and they already import a substantial amount of their food requirements. Some countries such as Saudi Arabia and Kuwait are already investing in costly desalinization plants (WRI 1998).

Though other regions are not physically water scarce, substantial variations exist within regions. For example, the South Asian region as a whole is projected to be physically water scarce. But, India, the largest country in the region, is projected to reach the threshold of physical water scarcity by 2025. Pakistan is already severely water scarce. The EAP region as a whole is endowed with abundant water resources to meet its increasing water demands. Yet, China is expected to pass the threshold of physical water scarcity by 2025. The African region as a whole has sufficient water resources, but Southern Africa will be in the same situation as China.

It is also important to note that though individual countries face physical water scarcities substantial variations can exist within countries. For example, half of the Indian population lives in the arid northwest and southeast while the other half lives in regions with abundant water resources. Substantial variations also exist between north and south China. Some parts of Mexico are physically water scarce while others are not (Barker et al. 2000).

Another important aspect is temporal variation. Some countries, especially those in monsoonal Asia receive most of their rainfall in a few months in the wet season. These countries face severe water-scarce conditions in the other period (Amarasinghe et al.1999; Barker et al. 2000).

No Area Growth Scenario

This scenario assumes no growth in irrigated or rain-fed cereal area and a slower growth in irrigated yield. We assume half of the irrigated yield growth in the base scenario for the no-growth scenario. This is a rather pessimistic scenario that shows the negative impact of no growth in agricultural areas on food production. Such a scenario will cause less strain on water resources but will create substantial deficits in cereal production.

Figure 26. Projected water scarcity in 2025.

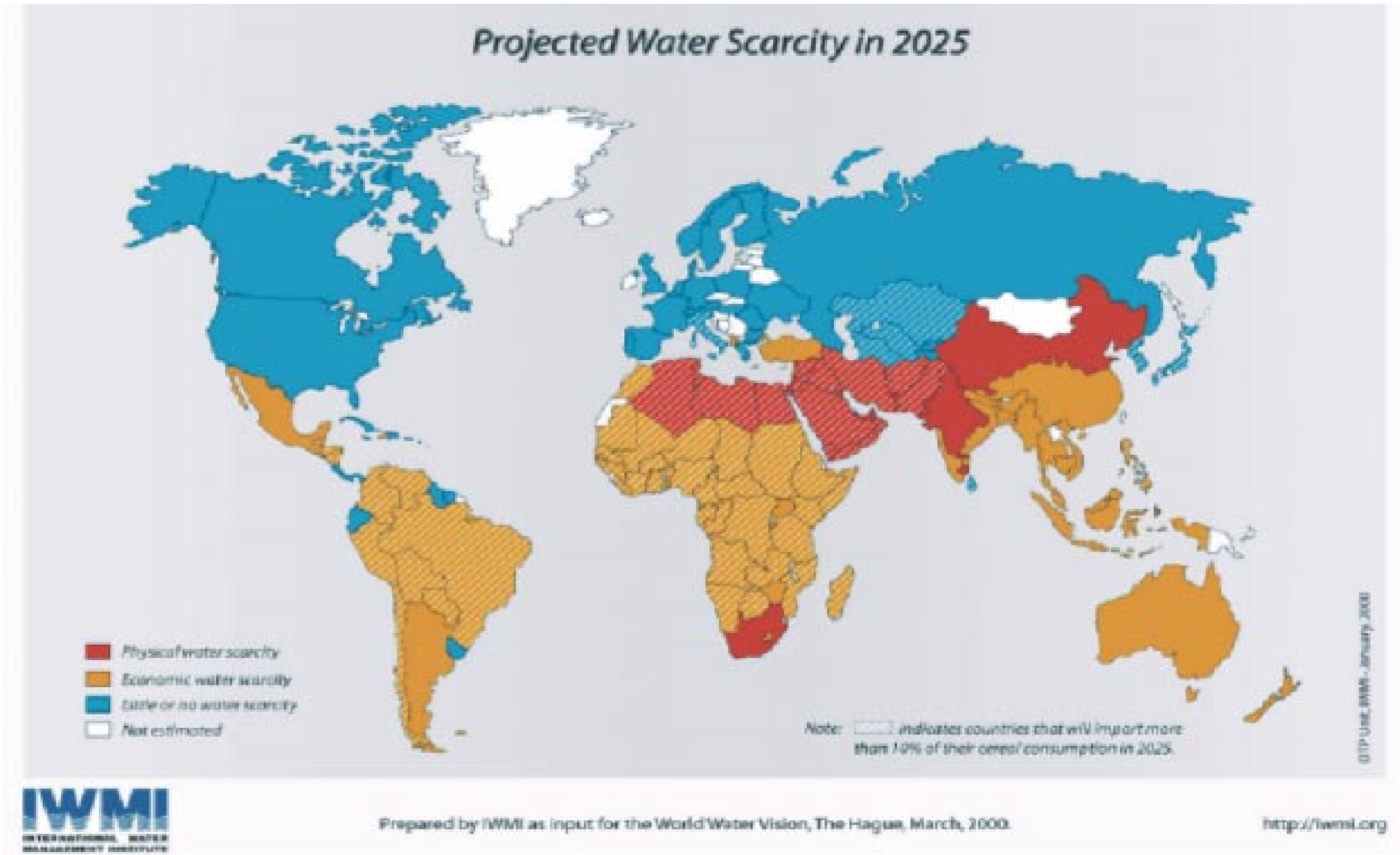
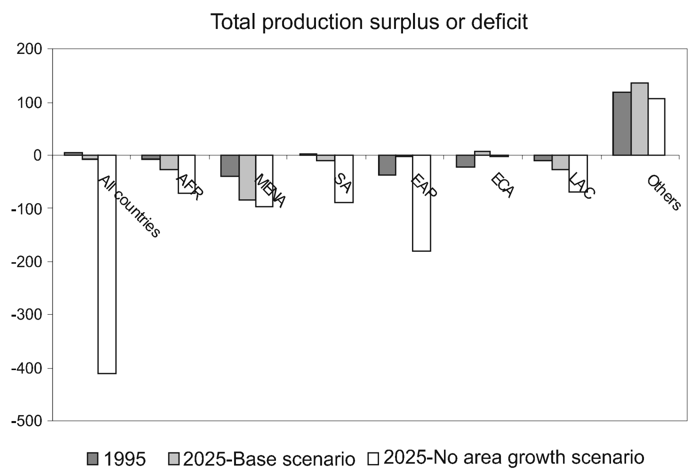
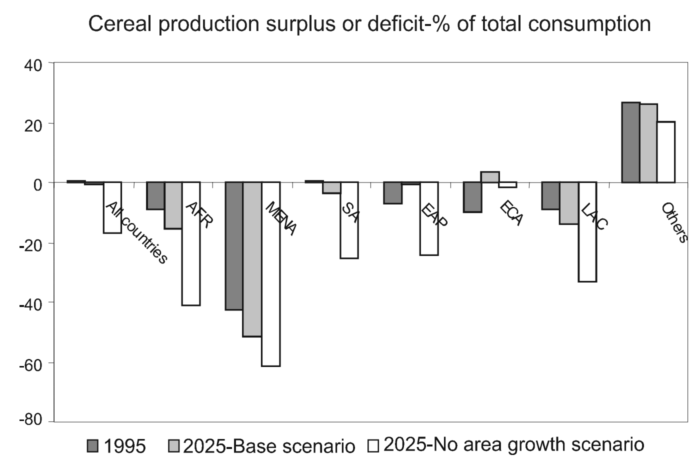


Figure 27 shows that all regions in the developing world will have substantial cereal deficits in 2025 under the no area growth scenario. All countries will have a production deficit of 419 M mt, equivalent to about 17 percent of their consumption. The greatest impact under the no area growth scenario will be in South Asia and EAP regions. In South Asia, the production deficits are projected to increase from 11 M mt under the base scenario to 89 M mt under the no area growth scenario. In East Asia, production deficit is projected to increase from 3 M mt under the base scenario to 182 M mt under the no area growth scenario. These regions being home to a large number of poor people will be affected the most under the no area growth scenario. Indeed, this scenario shows the significant role of irrigation on future food production in the developing region.

As mentioned at the beginning of the chapter, for countries with substantial rural populations the base scenario projections reflect an increase in food security and rural income through increased agricultural development. Indeed, the base scenario requires some increases in area development or increases in agricultural productivity or both. The no growth area scenario projects that developing regions would experience substantial food production deficits. As these regions are home to most of the rural population, it is expected that no agricultural area development would mostly affect the rural population. Therefore, it is expected that the level of future agricultural development could be strongly associated with future rural-development strategies.

Figure 27. Cereal production surplus or deficit.





Water for Rural Development

Rural Population

A large majority of the world's population still lives in rural areas, and this majority depends directly or indirectly on agriculture. In 1995, the world's rural population was estimated to be 55 percent of its total population. While this represents a decline of 10 percent from the proportion of rural population in 1965 (estimated to be 65%), in absolute terms, the rural population has increased from 2.1 billion in 1965 to 3.1 billion in 1965 (table 30). Much of the growth in rural population has been in Africa, South Asia, MENA and the EAP regions, which experienced growth rates of 88 percent, 73 percent, 66 percent and 43 percent, respectively, over this period. These four regions are home to 85 percent of the 1995 rural population. However, proportions of rural populations in the ECA and LAC regions have been declining.

The world's rural population is projected to grow at a slower rate over the coming decades, due to rapid urbanization and industrialization, particularly in developing countries. The total rural population over the next 30 years is projected to increase only by 6 percent, from 3.1 billion in 1995 to 3.3 billion in 2025. While the rural population in Africa, South Asia and MENA regions is projected to grow by 56 percent, 18 percent and 20 percent, respectively, the rural population in the EAP, LAC and ECA regions is projected to decline by 12 percent, 4 percent, and 27 percent, respectively. However, even with the projected slow growth in the overall rural population, more than 3.3 billion people are projected to live in rural areas by 2025, with over 90 percent of them projected to live in South Asia, EAP, Africa and the MENA regions.

Table 30. Rural population by region—past and future trends.

Region	Rural Population					
	1965	% of 1965 Total	1995	% of 1995 Total	2025	% of 2025 Total
All countries	2,157	65	3,113	55	3,303	42
Developed counties	226	31	213	23	164	16
Developing countries	1,931	74	2,900	61	3,139	46
AFR	215	86	404	71	633	58
MENA	73	61	120	42	145	30
SA	531	82	917	73	1,082	57
EAP	833	81	1,191	67	1,053	47
ECA	176	51	155	34	113	23
LAC	116	46	127	26	123	18
Other countries[1]	213	30	198	23	156	17

[1]Percent with respect to the UN medium projection.
Sources: UN 1999; FAO 1998.

Water and Rural Development: Past Links

As mentioned earlier, a large majority of the rural population of developing countries depends on agriculture. The development of irrigated agriculture in the past has helped in reducing rural unemployment and poverty, contributing to rural development, and in achieving partially or fully the goal of food self-sufficiency. For example, India, home to 25 percent of the world's rural population, has been more or less self-sufficient in food since the mid-seventies. China, another country with a substantial proportion of the world's rural population, produces more than two-thirds of its cereal from irrigated agriculture.

While irrigation development has been a major priority to expand agricultural frontiers, there has been relatively less attention towards domestic-sector water-development works in developing countries. In 1995, the developed and developing countries are estimated to have diverted 14 percent and 6 percent, respectively, of the total withdrawals for domestic use. South Asia, EAP and Africa, with the highest concentration of the world's rural population, have diverted only 2 percent, 6 percent and 10 percent of the total withdrawals, respectively, for domestic uses.

The annual average per capita domestic diversion in the developed and developing countries is estimated at 140 m^3 and 31 m^3, respectively. The per capita domestic withdrawals of some developing regions are even smaller than 20 m^3, which is recommended as the basic water requirement (BWR[7]) for a human being (Gleick 1996). For example, in 1995, Africa and South Asia are estimated to have withdrawn about 15 m^3 annually per person for domestic use. These values reflect the national averages, and since most domestic water supply developments have taken place in urban areas, the rural population has received domestic supplies that are considerably lower than the national averages.

Water for Rural Development: Future Directions

Industrial and urban sectors in most developing countries are continuing to expand and overall growth in these sectors is projected to be much higher in the future than in the past. The urban population in all regions except South Asia and Africa are projected to outnumber the rural population over the next 30 years. However, because of the large base population, the number of people living in rural areas is projected to be as high as the present levels. Consequently, the pressures on available water resources will continue to increase.

The vision for the future, according to the recently concluded second World Water Forum (Cosgrove and Rijsberman 2000) in The Hague is:

> *A world in which all people have access to safe and sufficient water resources to meet their needs, including food, in ways that maintain the integrity of freshwater ecosystems.*

In the regional consultations leading to the final vision at The Hague Forum, all regions have agreed that providing safe and adequate drinking water supply and adequate sanitation facilities for all human beings will have the highest priority in the coming decades.

Domestic water supply. At present, more than 40 percent of the rural population is estimated to have no access to safe drinking water supply and a significant number of people do not have access to the minimum required levels (World Bank 2000; WRI 1998). Moreover, 80 percent of the rural population is estimated to have no access to adequate sanitation. This means that about 1.8 billion people in rural areas are yet to receive new and increased domestic water supply facilities over the next three decades, which will require substantial increases in domestic withdrawals.

In the IWMI base scenario, most developing regions are projected to more than double their domestic water supply (table 31). Except for the African region, this level of increase would ensure

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[7]BWR is the recommended basic water requirement for domestic needs—drinking, sanitation, bathing and cooking, independent of climate, technology and culture—and per person per day it is 50 liters (Gleick 1996).

an average per capita domestic supply above the basic water requirement (BWR). In Africa, however, per capita domestic water withdrawals at present are significantly below the BWR. To raise average per capita domestic supply even to the level of BWR, Africa will have to increase its total domestic water supply by 140 percent.

Table 31. Per capita domestic and industrial withdrawals and growth in total domestic and industrial withdrawals.

Region	Per Capita Domestic Withdrawals		Per Capita Industrial Withdrawals		Growth[1] in Water Withdrawals	
	1995	2025	1995	2025	Domestic	Industrial
	m^3	m^3	m^3	m^3	%	%
All countries (100)	52	74	119	148	87	62
Developed counties	140	153	437	455	20	15
Developing countries	31	56	44	82	147	154
AFR	15	20	7	10	140	140
MENA	55	66	40	49	100	105
SA	13	28	15	45	219	326
EAP	27	78	31	119	251	370
ECA	85	105	240	259	29	12
LAC	68	95	46	75	95	125
Other countries[1]	155	162	511	542	11	12

[1]Growth of water withdrawals from 1995 to 2025 estimated under the IWMI base scenario.
Sources: WRI 2000; World Bank 2000; IWMI 2000.

Irrigation water supply. Despite the expected large growth in water withdrawals for the domestic sector, the agriculture sector will still remain the dominant water user in developing countries.The level of water use in the agriculture sector will be influenced by goals of self-sufficiency and food security at local, regional and national levels. In the past, food self-sufficiency has been the major goal of most developing countries. This has helped developing countries in increasing food production, improving overall food availability for rural households and reducing rural unemployment and has had overall positive effects in terms of reducing poverty.

However, as stated earlier, a significant proportion of the rural population in low-income developing countries is still below the poverty line. These countries are expected to continue to pursue a food self-sufficiency policy. In the consultations leading to The Hague Water Forum, some regions have agreed on food self-sufficiency goals over the next 30 years (WWC 2000).

The past trends indicate that in most regions, except Africa, agricultural area expansions have reached their potential limits. With the closing of land frontiers, future increases in food production in these regions are expected to come mainly from productivity increases and by supplementary irrigation of marginal rain-fed lands. In the IWMI base scenario, the EAP and ECA regions are projected to be self-sufficient in cereals (table 25). South Asia and LAC regions are projected to experience slight deficits, while Africa and MENA regions are projected to have substantial deficits.

Rain-fed cultivation dominates cereal production in the African region, and most countries in this region are operating at a level that is far below their true irrigation potential (WWC 2000). Productivity in irrigated lands is twice that in the rain-fed lands, and the average productivity levels are much lower than those in most other regions. Also, due to unreliable rainfall patterns, rain-fed crop failures are common in the region. Therefore, with a combination of expansion of irrigation over marginal rain-fed lands, whether through surface storage or through micro-scale irrigation techniques, an increase in productivity would have a substantial impact on food and livelihood security of the African rural population.

The MENA region is projected to have substantial deficits in cereal production (table 25). Utilizable water resource availability is a severe constraint in this region. Only a few options are available in the future for most MENA countries. These countries will need to transfer water to high-value sectors, and in an agriculture sector they will need to shift cropping patterns to high-value crops, and import more grains.

South Asia is also projected to have a slight deficit in cereal production. This region is expected to have the largest rural population in the world by 2025. As in the past, agriculture, and hence, water, will be crucial for rural development. However, the inadequacy of the availability of utilizable water resources is projected to be a major constraint for future irrigation expansions. For example, Pakistan is already severely water scarce, and some regions in India are expected to reach their irrigation potential soon. The productivity of both irrigated and rain-fed agriculture in most of South Asia is substantially lower than in other regions with similar agro-climatic conditions (Molden et al. 2001). A slight increase in productivity over and above the base scenario would ensure food self-sufficiency for the South Asian region. Because of the large rural population in South Asia and the small size of landholding per person actively engaged in agriculture, the rural population would benefit substantially from increasing water productivity, i.e., increasing crop per drop.

Unlike other developing regions, the contribution of the agriculture sector to the gross domestic production in the ECA and LAC regions is much smaller. Rain-fed farming is the dominant contributor to the agriculture production. For example, the irrigated cereal area in the ECA and LAC regions are only 5 percent and 14 percent, respectively, of the total cereal area and no major shift from rain-fed farming is expected in the future. Yet, there is considerable scope for improving water productivity in both regions.

Other water supply. There is evidence that the industrial and service sectors of developing countries are expanding and that competition for scarce water resource is increasing. In view of the increasing demand, the IWMI base scenario projects that withdrawals for the industrial sector will be greater than those for the domestic sector in most developing countries. South Asia and EAP regions are projected to quadruple their industrial supplies over the next 30 years. In Africa, MENA and LAC regions, industrial water withdrawals are projected to double over the next 30 years.

Similarly, the water allocation to the environment sector, which has received little attention in the past, is projected to increase significantly. Reliable past data on water needs in the environment sector are not available. Yet there is evidence that a substantial part of the primary withdrawals that were not used beneficially in the intended sectors are being used beneficially in the environment sector (Renault 1999). However, in the future, countries will have to allocate part of their developed water resources to the environment sector to flush out salt and other pollutants, to keep minimum levels of water flow in the rivers, and to maintain natural ecosystems. Further research is required to determine the level of water requirements in these sectors.

Summary

Only less than 1 percent (or 43,000 km^3) of the world's freshwater resources is available for beneficial human uses. In 1995, the average annual per capita renewable water resources was estimated at 7,500 m^3, which decreased by 41 percent from the 1965 level. With increasing world population, average annual per capita water availability is projected to further decrease to 5,500 m^3 in 2025. While the available water resources at the global level may be sufficient to fulfill human needs, their distribution across countries and regions is very uneven. On one extreme, Latin American and the Caribbean countries with only 8 percent of the world's population are endowed with 34 percent of the world's total renewable water resources. On the other extreme, South Asia with over one-fifth of the world's population has only 5 percent of the renewable water resources. Also, there are significant variations in water resource endowments within each of these regions.

Agriculture is the dominant user of water, accounting for 74 percent of the total water supplies in 1995. However, water diversions to the agriculture sector in developing countries are twice those in developed countries. South Asia, Middle East and North Africa (MENA) and Africa regions divert the largest proportions of their water supplies to agriculture, with the smallest proportions diverted to their industrial sectors. However, with the rapid growth in urban and industrial sectors in these countries, water diversions to these sectors will increase over the next two and a half decades.

As a result of agricultural and rural development efforts, the world has been able to produce more food than its consumption requirements. The world food production has almost doubled since 1965, and the total calorie consumption has increased by 86 percent over the past three decades. With the closing of land frontiers, crop areas have expanded only marginally. Productivity growth has been a major driving force for increased food production. Expansion in irrigation, adoption of high-yielding varieties, use of chemical fertilizers and better agronomic practices were the major contributing factors to productivity increases. At present, the world's irrigated cereal area accounts for 30 percent of the total harvested area but it contributes up to 43 percent of the total cereal production. On average, productivity on irrigated cereal lands is 60 percent higher than that on rain-fed lands. However, there are substantial variations in irrigated cereal productivity across regions and countries. For example, productivity of irrigated cereals in South Asia, and the East Asia and Pacific (EAP) regions is 172 percent and 100 percent, respectively, higher than that of rain-fed cereal lands.

After the 1980s, the South Asian region was able to keep its production surpluses or deficits (difference between domestic production and consumption) within 5 percent of the consumption needs even under extreme climatic conditions. In the EAP region, average per capita calorie supply increased by 37 percent over the period 1965 to 1995. While the region has been a net cereal importer, total production has increased from 183 M mt in 1965 to 476 M mt in 1995, due mainly to productivity increases associated with irrigated area expansions in the region. Similarly, irrigation-induced productivity growth in MENA and LAC regions has contributed significantly to the overall increase in food production in these regions.

Unlike in other regions, productivity growth in Africa has been very low. While cereal production over the past 30 years has more than doubled, it has resulted mainly from area expansion with a relatively smaller contribution from productivity growth. Only 5 percent of the total cereal area is estimated to be irrigated in 1995. This region has benefited the least from the global wave of irrigation development over the past three decades.

Looking ahead, cereal area in developed countries is projected to continue to decline in the IWMI base case scenario. However, it is expected to increase in developing countries, mainly in Africa. A significant part of the rain-fed area in South Asia and East Asia is projected to be converted to irrigated areas, and more new lands are expected to be brought under rain-fed cultivation in Africa. Irrigated cereal yield in all countries is expected to grow by 1.1 percent per annum over the next 25 years in the IWMI base case. With the objective of self-sufficiency, developing countries are projected to increase their domestic production and reduce their deficits. Developed countries will continue to increase their production but at a slower pace than in the past, resulting in decreases in their production surpluses by 2025. South Asia is projected to experience a small deficit due mainly to a projected increase in cereal demand in Pakistan by 2025. The EAP and Europe and Central Asia (ECA) regions are projected to reduce their production deficits and achieve self-sufficiency or a situation of small surplus by 2025. However, production deficits in Africa are projected to increase from 16 percent in 1995 to 21 percent in 2025. Similarly, production deficits in the MENA region are projected to increase due to water scarcities.

In the water-scarce, production-deficit regions, land degradation is also a major issue. An IBSRAM study on land degradation indicates that this problem has been moderate in Africa and LAC, strong in EAP, and severe in MENA and SA. The study further suggests that, while large investments will be required to bring new lands under cultivation in Africa, major interventions will be needed in EAP, MENA and SA to increase production and to prevent further land degradation. While, both this and the IBSRAM study reach the same conclusion that MENA and SA will experience a food deficit, the projected magnitudes are different in the studies (the former projecting moderate imports, the latter indicating massive food imports by these regions).

Most of the growth in water supply will occur in the developing countries. However, MENA, which is already physically water scarce, and South Asia are projected to experience water scarcity. While EAP and Africa will have sufficient water resources, China and Southern Africa are projected to pass the threshold of physical water scarcity.

The following key points regarding the future water situation should be noted.

- Water is becoming an extremely scarce resource in many countries, with growing demands and increasing competition across sectors and uses.
- With rapid growth in urbanization and industrialization in most developing countries, demand for water in these sectors is expected to continue to grow, which will require transfer of water from agriculture to these sectors.
- Water allocations to the environmental sector, which received little attention in the past, are expected to increase with growing recognition of the need and benefits of water in this sector.
- Despite the expected large growth in water withdrawals for the above sectors, agriculture will remain the dominant water user in most developing countries.
- Even with projected slow growth in the overall rural population, over 3.3 billion people will live in rural areas by 2025, with over 90 percent of them projected to live in South Asia, EAP, MENA and the Africa regions.
- Sustainable agricultural development and crop productivity enhancements will remain important for rural poverty alleviation and overall rural development in the developing regions. Sustainable and environmentally friendly irrigation development will be the key driving force to achieve growth in productivity.
- Countries facing economic water scarcity will need to develop additional water supplies through investments in additional water storage infrastructure or micro-scale irrigation developments. Those under physical water-scarcity conditions will need to invest in techniques to improve the productivity of water and in the overall improved management of water resources.

- Irrigation-induced environmental problems are increasing in many countries, particularly Asian countries, and need to be addressed on a priority basis, as these problems have serious consequences for productivity and poverty.

In concluding, we present the summary of the projections of key variables, the major conclusions on projected food and water situation, and the issues that are important to be considered in designing rural development strategies for different regions (see tables 32 to 37 and the conclusions).

Table 32. Region–Africa.

Factor		Units	1995 Value	2025 Projection	Annual Growth (%) 1995–2025
Population		Million	583	989	2.1
Cereal demand		M mt	87	178	2.4
Cereal production	– Total	M mt	79	150	2.1
	– Irrigation	M mt	8	16	2.4
	– Rain-fed	M mt	71	134	2.1
Growth in total irrigated area		M ha	9	14	1.3
Primary water supply		km^3	51	74	1.2
PWS[1], % of PUWR[2]		%	2	4	
Water diversions	– Total	m^3	66.9	103.2	1.5
	– Irrigation	km^3	56.4	76.8	1.0
	– Domestic	km^3	7.3	18.3	3.1
	– Industrial	km^3	3.3	8.1	3.1
Water-scarcity level [3]		Economic water scarcity (Total PWS<60% of PUWR but total growth in PWS is>25%)			

[1]PWS = Primary water supply.
[2]PUWR = Potentially utilizable water resources.
[3]Physical water scarce: If 2,025 PWS>60% of PUWR. Economic water scarce: If 2,025 PWS<60% PUWR but the ratio, 2,025 PWS/1995 PWS>125%.

Table 33. Region–MENA.

Factor		Units	1995 Value	2025 Projection	Annual Growth (%) 1995–2025
Population		Million	271	443	1.7
Cereal demand		M mt	93	161	1.8
Cereal production	– Total	M mt	54	79	1.3
	– Irrigation	M mt	41	61	1.3
	– Rain-fed	M mt	13	18	1.0
Growth in total irrigated area		M ha	26	30	0.4
Primary Water supply (PWS)		km^3	181	192	0.2
PWS - % of PUWR		%	75	80	
Water diversions	– Total	km^3	237	267	0.4
	– Irrigation	km^3	214	219	0.1
	– Domestic	km^3	13	27	2.3
	– Industrial	km^3	10	20	2.4
Water-scarcity level		Physically Water Scarce (2025 PWS>60% of PUWR)			

Table 34. Region–South Asia.

Factor		Units	1995 Value	2025 Projection	Annual Growth (%) 1995–2025
Population		Million	1,233	1,762	1.2
Cereal demand		M mt	227	356	1.5
Cereal production	– Total	M mt	229	344	1.3
	– Irrigation	M mt	170	289	1.8
	– Rain-fed	M mt	58	55	-0.2
Growth in total irrigated area		M ha	101	128	0.8
Primary Water supply (PWS)		km^3	615	754	0.7
PWS - % of PUWR		%	45	55	
Water diversions	– Total	km^3	866	1117	0.9
	– Irrigation	km^3	831	988	0.6
	– Domestic	km^3	16	50	3.9
	– Industrial	km^3	19	80	4.9
Water-scarcity level		No water scarcity (Total PWS<60% of PUWR and total growth in PWS is<25%)			

Table 35. Region–EAP.

Factor		Units	1995 Value	2025 Projection	Annual Growth (%) 1995–2025
Population		Million	1,759	2,158	0.7
Cereal demand		M mt	511	755	1.3
Cereal production	– Total	M mt	475	752	1.5
	– Irrigation	M mt	308	644	2.5
	– Rain-fed	M mt	168	107	-1.5
Growth in total irrigated area		M ha	112	154	1.1
Primary Water supply (PWS)		km^3	492	692	1.2
PWS - % of PUWR		%	17	25	
Water diversions	– Total	km^3	776	1,242	1.6
	– Irrigation	km^3	674	818	0.6
	– Domestic	km^3	47	168	4.3
	– Industrial	km^3	55	256	5.3
Water-scarcity level		Economic water scarcity (Total PWS<60% of PUWR but total growth in PWS is>25%)			

Table 36. Region–ECA.

Factor		Units	1995 Value	2025 Projection	Annual Growth (%) 1995–2025
Population		Million	386	401	0.1
Cereal demand		M mt	220	236	0.2
Cereal production	– Total	M mt	199	244	0.7
	– Irrigation	M mt	19	26	1.1
	– Rain-fed	M mt	180	218	0.6
Growth in total irrigated area		M ha	25	29	0.5
Primary Water supply (PWS)		km^3	210	221	0.2
PWS - % of PUWR		%	8	9	
Water diversions	– Total	km^3	324	361	0.4
	– Irrigation	km^3	199	216	0.3
	– Domestic	km^3	33	42	0.8
	– Industrial	km^3	93	104	0.4
Water-scarcity level		No water scarcity (Total PWS < 60% of PUWR and total growth in PWS is<25%)			

Table 37. Region–LAC.

Factor		Units	1995 Value	2025 Projection	Annual Growth (%) 1995–2025
Population		Million	461	644	1.1
Cereal demand		M mt	124	210	1.8
Cereal production	– Total	M mt	113	182	1.6
	– Irrigation	M mt	27	68	3.2
	– Rain-fed	M mt	86	113	0.9
Growth in total irrigated area		M ha	22	42	2.2
Primary Water supply (PWS)		km^3	140	237	1.8
PWS - % of PUWR		%	3	5	
Water diversions	– Total	km^3	194	352	2.0
	– Irrigation	km^3	141	243	1.8
	– Domestic	km^3	31	61	2.3
	– Industrial	km^3	21	48	2.7
Water-scarcity level		Economic scarcity (Total PWS<60% of PUWR but total growth in PWS is>25%)			

Major Conclusions—Africa

- The cereal production deficit (production minus demand) is projected to widen from 9 percent of the total demand in 1995 to 15 percent of the total demand in 2025.

- The African region is endowed with substantial renewable water resources not yet tapped for human use. Even though there is a projected increase of 45 percent in primary water supply (PWS), PWS is projected to be only 4 percent of potentially utilizable water resources. Therefore, the region as a whole is projected to be economic water scarce because of the need of financial and human resources to develop the resource. Much of sub-Saharan Africa is like this with the notable exception of much of southern Africa and South Africa, which as a country is physically water scarce.

- Irrigation is a small contributor to total food needs. There is apparently scope for expanding irrigation, but much effort is required in designing sustainable irrigation practices suited to African conditions.

Issues of Importance

- Most countries in the region can be categorized into high potential/high need areas. Only the southern-most Africa is water scarce.

- Substantial contribution of rain-fed agriculture to total production despite low land productivity.

- Scope for productivity improvements through supplemental irrigation in marginal rain-fed lands.

- Innovative smallholders' water and land management systems may offer solutions for poor smallholder farmers, especially if the institutional arrangements relating to land/water rights are adequately understood.

- Groundwater development opportunities.

- Concerns for environment and human health.

Major Conclusions—MENA Region

- Cereal production deficit (production minus demand) as a percent of total demand is projected to increase from 42 percent in 1995 to 51 percent in 2025.

- The MENA region is already physically water scarce (1995 primary water supply>60% of potentially utilizable water resources). The primary water supply is projected to increase by only 11 km^3 while total water diversions are projected to increase by 30 km^3. The domestic and industrial sectors are projected to account for two-thirds of the total diversion increase. Most of the increases in total diversion to domestic and industrial sectors are expected to be realized through recycling, or transfers of water from the agriculture sector.

Issues of Importance

- Most of the countries fall into the water-scarce category.

- Competition between sectors.

- Deteriorating water quality.

- Groundwater overdraft.

- The need for water productivity increases.

- The importance of trade.

Major Conclusions—South Asia

- A small deficit of cereal production is projected in 2025 (3% of total demand) from a small production surplus of 1% of the 1995 demand. The region as a whole is projected to be self-sufficient.

- The region as a whole is not water scarce because of the substantially high water endowment of a few countries like Bangladesh. The region can be split into two broad categories. A substantial part of South Asia, including Pakistan and the arid regions of India are physically water scarce. Other parts are economically water scarce.

- In the physically water-scarce regions, sustainable increases in the productivity of water in agriculture are a key focus. In other regions, there remains considerable scope for activities of pro-poor water-resources development.

Issues of Importance

- Most parts of South Asia are categorized into water-scarce areas. Other parts are high potential areas.
- Competition between sectors is projected to increase in water-scarce areas.
- There are opportunities in groundwater development in high potential areas.
- Groundwater overdevelopment in water-scarce areas.
- Deteriorating water quality.
- Concerns for environment and human health.

Major Conclusions—EAP Region

- The EAP region is projected to be self-sufficient in cereals in 2025 (a production deficit of 0.3% of the total demand in 2025 from a production deficit of 7% of the total demand in 1995).
- The region as a whole is only economically water scarce. However, the arid parts of China, the largest country in the region, is projected to be physically water scarce.

Issues of Importance

- The major part of EAP, especially the arid region of China, is water scarce. Other parts fall into the category of high-potential area.
- There is some concern about national food security in China because of unsustainable irrigation practices, including groundwater overdraft, in North China.
- Competition between sectors will increase.
- There are opportunities for water-resources development in high-potential areas.
- Groundwater overdevelopment in water-scarce areas is a major threat.
- Deteriorating water quality.
- Concerns for environment and human health.

Major Conclusions—ECA Region

- The ECA region is projected to have a small production surplus in 2025 (3% of the total demand) from a substantial production deficit in 1995 (10% of the 1995 demand).
- The region is not water scarce.

Issues of Importance

- Most parts of the region fall into the category of high-potential area.
- There is a substantial contribution from rain-fed agriculture to total production.
- Productivity improvements through supplemental irrigation in marginal rain-fed lands.
- Opportunities for groundwater development.
- Threats of groundwater overdevelopment.
- Deterioration of water quality.

Major Conclusions—LAC Region

- The LAC region is projected to stay in the cereal production deficit side (9% of the total demand in 1995 to 14% of the total demand in 2025).
- The region is endowed with substantial renewable water resources. The primary water supply is only a small portion of the renewable water resources. However, the region is projected to be economically water scarce because of the heavy water-related investments required to increase food production.
- Irrigation development and management continue to be an important issue.

Issues of Importance

- Most parts of the region fall into the category of high-potential area.
- Substantial contribution from rain-fed agriculture to total production.
- Supplemental irrigation in marginal rain-fed lands.
- Smallholder land and water-management systems.
- Opportunities of groundwater development.
- Threats of groundwater overdevelopment.
- Deterioration of water quality.

Appendix A

The PODIUM Model

The computations of the PODIUM model involve three major steps. First, the national cereal requirement of country, based on population, daily calorie intake and composition of diets are estimated (figure A1). Second, the cereal production, based on expected yields, and areas under both irrigated and rain-fed conditions are estimated (figure A2). Third, the water demand for the projected food production is estimated (figure A3). The PODIUM is developed in two versions: country-level PODIUM model (available at IWMI's website http://www.iwmi.org) and global- level PODIUM model. The country-level PODIUM data are entered into the global-level PODIUM and aggregated at a desired level. (Please refer to IWMI 2000, for more information on the computation in PODIUM).

The PODIUM projections for 100 countries under the base scenario (as displayed in tables B1 to B7 for regions) are given in appendix B.

Figure A1. Cereal requirement variables in the PODIUM.

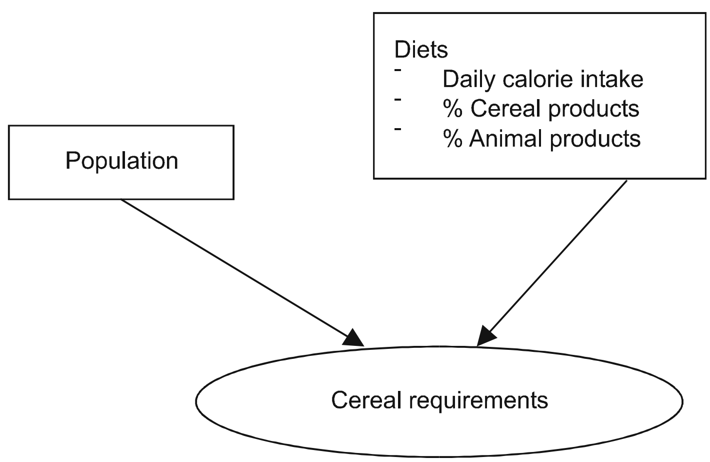

Figure A2. Cereal production variables in the PODIUM.

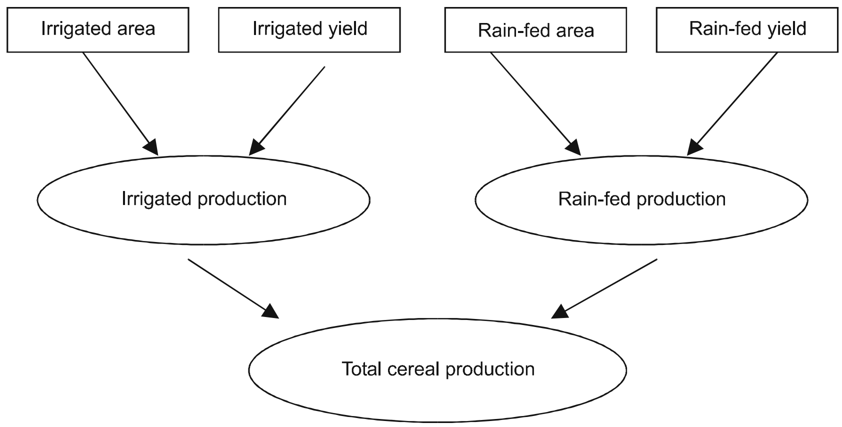

Figure A3. Water requirement variables in the PODIUM.

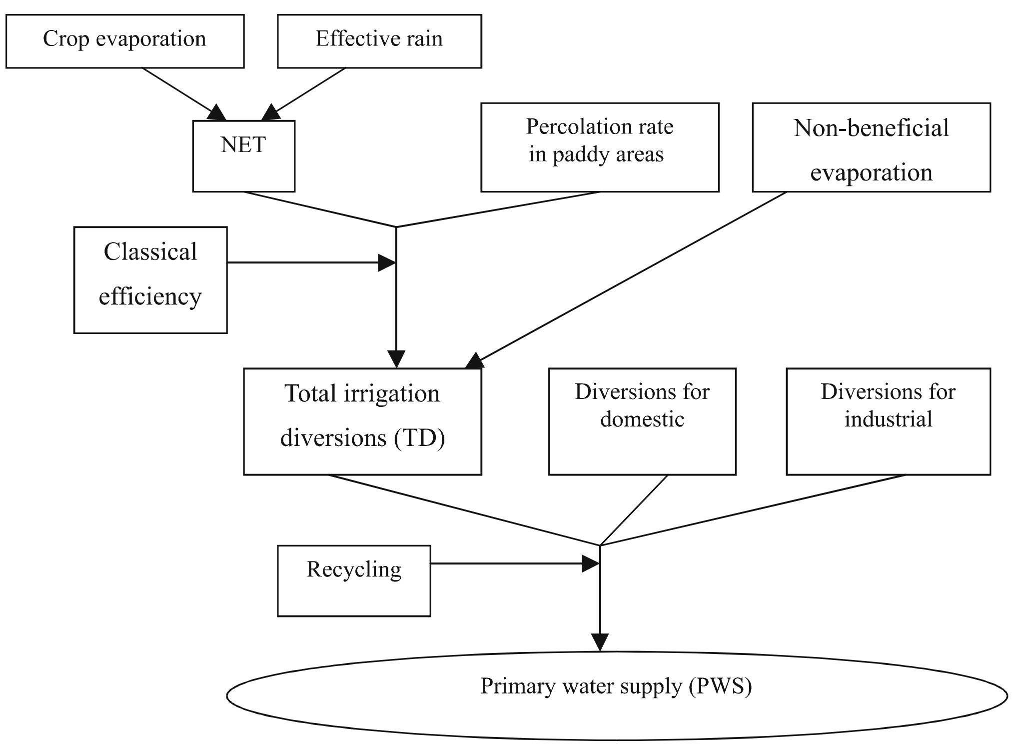

Table B 1. Population and per capita per day calorie supply. Table B 2. Food, feed and total cereal consumption.

Country	Region	Population			Per Capita Calorie Supply			Food Cereal			Feed Cereal			Total Cereal		
		1995 Million	2025 Million	Annual growth %	1995 kcal	2025 kcal	Annual growth %	1995 M mt	2025 M mt	Annual growth %	1995 M mt	2025 M mt	Annual growth %	1995 M mt	2025 M mt	Annual growth %
Angola	AFR	11.0	24.4	2.7	1927	2127	0.3	0.7	1.8	3.22	0.0	0.1	4.4	0.8	2.1	3.3
Benin	AFR	5.3	10.8	2.4	2363	2607	0.3	0.6	1.4	2.88	0.0	0.1	4.0	0.8	1.9	2.9
Burkina Faso	AFR	10.4	22.9	2.7	2254	2482	0.3	2.2	5.5	3.16	0.0	0.0	0.0	2.6	6.5	3.2
Burundi	AFR	6.2	11.3	2.0	1711	1953	0.4	0.2	0.4	2.44	0.0	0.0	3.5	0.3	0.7	2.5
Cameroon	AFR	13.2	25.3	2.2	2200	2425	0.3	1.3	2.8	2.70	0.0	0.0	3.8	1.5	3.3	2.7
Cent Afr Rep	AFR	3.3	5.5	1.7	1928	2126	0.3	0.1	0.3	2.24	0.0	0.0	3.4	0.2	0.3	2.3
Chad	AFR	6.7	13.5	2.4	1902	2100	0.3	0.8	2.0	2.87	0.0	0.1	4.0	1.0	2.4	2.9
Congo, Dem R	AFR	45.4	101.9	2.7	1879	2072	0.3	1.6	4.1	3.25	0.0	0.1	4.4	1.8	4.8	3.3
Congo, Rep	AFR	2.6	5.5	2.6	2125	2344	0.3	0.1	0.3	3.11	0.0	0.0	4.3	0.1	0.3	3.1
Côte d'Ivoire	AFR	13.5	22.5	1.7	2378	2623	0.3	1.5	2.9	2.22	0.1	0.2	3.4	1.9	3.7	2.3
Dominican Rep	AFR	7.8	10.8	1.1	2323	2724	0.5	0.6	0.9	1.33	0.7	1.5	2.7	1.3	2.5	2.1
Ethiopia	AFR	55.4	111.8	2.4	1781	2035	0.4	8.1	18.5	2.78	0.1	0.5	3.9	9.2	21.1	2.8
Ghana	AFR	17.6	35.6	2.4	2562	2824	0.3	1.5	3.6	2.86	0.1	0.2	4.0	2.0	4.8	2.9
Guinea	AFR	7.2	12.3	1.8	2134	2353	0.3	0.8	1.6	2.32	0.0	0.0	0.0	0.9	1.9	2.3
Kenya	AFR	27.2	39.9	1.3	1990	2271	0.4	3.3	5.5	1.69	0.1	0.3	2.8	3.7	6.2	1.7
Madagascar	AFR	13.7	28.2	2.4	1991	2272	0.4	1.5	3.4	2.83	0.1	0.4	3.9	1.9	4.6	2.9
Mali	AFR	9.9	20.5	2.4	2099	2314	0.3	2.0	4.7	2.96	0.0	0.0	0.0	2.2	5.4	3.0
Mauritania	AFR	2.3	4.6	2.3	2975	2902	-0.1	0.4	0.9	2.96	0.0	0.1	4.1	0.4	1.1	3.0
Mozambique	AFR	17.4	29.9	1.8	1718	1929	0.4	1.5	2.9	2.25	0.0	0.0	3.4	1.6	3.1	2.3
Niger	AFR	9.2	21.1	2.8	2090	2305	0.3	1.9	5.2	3.34	0.1	0.4	4.5	2.5	6.9	3.4
Nigeria	AFR	99.0	178.7	2.0	2554	2822	0.3	14.2	28.8	2.39	2.0	5.0	3.2	21.0	43.7	2.5
Senegal	AFR	8.3	16.3	2.3	2392	2638	0.3	1.4	3.1	2.77	0.0	0.1	3.9	1.6	3.7	2.8
Somalia	AFR	8.2	20.5	3.1	1579	1802	0.4	0.4	1.1	3.52	0.0	0.0	0.0	0.4	1.2	3.5
South Africa	AFR	37.5	43.9	0.5	2882	2996	0.1	7.7	9.2	0.63	3.6	4.8	1.0	12.3	15.2	0.7
Sudan	AFR	26.6	45.0	1.8	2354	2704	0.5	4.3	8.2	2.19	0.1	0.3	3.2	4.9	9.4	2.2
Tanzania	AFR	29.9	55.3	2.1	2017	2302	0.4	3.2	6.7	2.48	0.2	0.4	3.6	4.3	9.1	2.5

		Table B 1. Population and per capita per day calorie supply.						Table B 2. Food, feed and total cereal consumption.								
		Population			Per Capita Calorie Supply			Food Cereal			Feed Cereal			Total Cereal		
Country	Region	1995	2025	Annual growth	1995	2025	Annual growth	1995	2025	Annual growth	1995	2025	Annual growth	1995	2025	Annual growth
Malaysia	EAP	20.1	29.7	1.3	2848	3137	0.3	2.6	4.0	1.44	2.3	5.1	2.7	5.2	9.7	2.1
Myanmar	EAP	42.9	55.5	0.9	2711	2929	0.3	9.9	13.0	0.91	0.6	1.6	3.4	11.6	16.1	1.1
Philippines	EAP	68.4	104.2	1.4	2366	2688	0.4	8.7	13.3	1.43	3.9	10.7	3.4	13.7	25.9	2.1
Thailand	EAP	58.6	70.4	0.6	2330	2473	0.2	7.3	8.0	0.28	5.1	11.2	2.7	14.2	21.4	1.4
Vietnam	EAP	73.9	105.5	1.2	2449	2715	0.3	13.3	19.8	1.33	0.4	1.2	3.4	15.7	24.1	1.4
Hungary	ECA	10.2	8.7	-0.5	3359	3454	0.1	1.2	1.0	-0.68	6.6	7.5	0.5	10.0	10.5	0.2
Kazakhstan	ECA	16.5	16.7	0.0	3117	3284	0.2	4.0	4.1	0.11	4.3	5.2	0.7	11.9	13.2	0.3
Kyrgyzstan	ECA	4.6	7.6	1.7	2398	2526	0.2	0.8	1.3	1.78	0.5	1.1	2.4	1.5	2.8	2.0
Poland	ECA	38.6	38.6	0.0	3309	3401	0.1	6.0	5.7	-0.16	16.1	19.7	0.7	25.9	29.4	0.4
Romania	ECA	22.7	19.8	-0.5	2927	3008	0.1	3.9	3.2	-0.63	10.5	10.2	-0.1	17.2	15.9	-0.3
Russian Fed	ECA	148.1	134.5	-0.3	2814	2894	0.1	22.2	19.8	-0.38	42.9	45.7	0.2	84.2	83.1	0.0
Tajikistan	ECA	5.8	8.5	1.3	2231	2351	0.2	1.1	1.7	1.36	0.0	0.1	1.9	1.2	1.8	1.4
Turkey	ECA	61.3	83.5	1.0	3563	3501	-0.1	13.9	17.7	0.81	6.4	10.2	1.6	29.8	40.3	1.0
Turkmenistan	ECA	4.1	6.1	1.3	2583	2721	0.2	0.7	1.1	1.38	0.5	0.8	2.0	1.4	2.2	1.6
Ukraine	ECA	51.4	45.1	-0.4	2880	2962	0.1	8.4	7.2	-0.49	17.3	16.2	-0.2	31.8	28.8	-0.3
Uzbekistan	ECA	22.5	32.1	1.2	2565	2703	0.2	4.3	6.2	1.25	0.5	0.9	1.8	5.4	8.0	1.3
Argentina	LAC	34.8	45.2	0.9	3117	3471	0.4	4.5	6.0	1.01	5.4	8.3	1.5	12.6	18.2	1.2
Bolivia	LAC	7.4	12.6	1.8	2161	2534	0.5	0.9	1.6	2.03	0.2	0.6	3.4	1.3	2.7	2.3
Brazil	LAC	159.3	208.2	0.9	2878	3378	0.5	17.3	23.3	0.99	28.2	54.7	2.2	52.2	88.0	1.8
Chile	LAC	14.2	18.8	0.9	2766	3244	0.5	1.9	2.7	1.19	1.6	3.3	2.5	3.7	6.4	1.8
Colombia	LAC	38.5	57.9	1.4	2735	3164	0.5	3.6	5.8	1.61	1.7	3.7	2.6	5.6	10.0	2.0
Costa Rica	LAC	3.6	5.7	1.6	2814	3301	0.5	0.4	0.7	1.86	0.3	0.8	3.2	0.7	1.6	2.5
Cuba	LAC	11.0	11.6	0.2	2349	2754	0.5	1.2	1.4	0.44	0.4	0.7	1.8	1.7	2.2	0.8
Ecuador	LAC	11.5	17.1	1.4	2533	2971	0.5	1.2	2.0	1.61	0.3	0.7	2.9	1.8	3.2	1.9
El Salvador	LAC	5.7	8.7	1.4	2540	2980	0.5	0.9	1.5	1.71	0.3	0.7	3.1	1.3	2.3	2.1
Guatemala	LAC	10.0	19.1	2.2	2250	2637	0.5	1.5	3.1	2.45	0.2	0.5	3.8	1.8	3.8	2.6

Table B 1. Population and per capita per day calorie supply.

Table B 2. Food, feed and total cereal consumption.

		Population			Per Capita Calorie Supply			Food Cereal			Feed Cereal			Total Cereal		
Country	Region	1995 Million	2025 Million	Annual growth %	1995 kcal	2025 kcal	Annual growth %	1995 M mt	2025 M mt	Annual growth %	1995 M mt	2025 M mt	Annual growth %	1995 M mt	2025 M mt	Annual growth %
Cambodia	EAP	10.0	15.8	1.5	1979	2240	0.4	1.7	3.0	1.86	0.0	0.1	3.4	2.0	3.6	1.9
China	EAP	1220.5	1437.2	0.5	2766	3112	0.4	231.3	259.3	0.38	107.1	241.2	2.7	379.9	553.8	1.3
Indonesia	EAP	197.5	260.2	0.9	2880	3067	0.2	39.9	53.5	0.98	2.1	5.3	3.1	46.3	64.8	1.1
Korea D P Rep	EAP	22.2	28.6	0.8	2395	2595	0.3	3.2	4.2	0.88	0.7	1.8	3.0	5.1	7.5	1.3
Korea Rep	EAP	44.9	51.1	0.4	3302	3350	0.0	7.6	7.1	-0.21	7.8	18.5	2.9	17.4	28.0	1.6
Malaysia	EAP	20.1	29.7	1.3	2848	3137	0.3	2.6	4.0	1.44	2.3	5.1	2.7	5.2	9.7	2.1
Myanmar	EAP	42.9	55.5	0.9	2711	2929	0.3	9.9	13.0	0.91	0.6	1.6	3.4	11.6	16.1	1.1
Philippines	EAP	68.4	104.2	1.4	2366	2688	0.4	8.7	13.3	1.43	3.9	10.7	3.4	13.7	25.9	2.1
Thailand	EAP	58.6	70.4	0.6	2330	2473	0.2	7.3	8.0	0.28	5.1	11.2	2.7	14.2	21.4	1.4
Vietnam	EAP	73.9	105.5	1.2	2449	2715	0.3	13.3	19.8	1.33	0.4	1.2	3.4	15.7	24.1	1.4
Hungary	ECA	10.2	8.7	-0.5	3359	3454	0.1	1.2	1.0	-0.68	6.6	7.5	0.5	10.0	10.5	0.2
Kazakhstan	ECA	16.5	16.7	0.0	3117	3284	0.2	4.0	4.1	0.11	4.3	5.2	0.7	11.9	13.2	0.3
Kyrgyzstan	ECA	4.6	7.6	1.7	2398	2526	0.2	0.8	1.3	1.78	0.5	1.1	2.4	1.5	2.8	2.0
Poland	ECA	38.6	38.6	0.0	3309	3401	0.1	6.0	5.7	-0.16	16.1	19.7	0.7	25.9	29.4	0.4
Romania	ECA	22.7	19.8	-0.5	2927	3008	0.1	3.9	3.2	-0.63	10.5	10.2	-0.1	17.2	15.9	-0.3
Russian Fed	ECA	148.1	134.5	-0.3	2814	2894	0.1	22.2	19.8	-0.38	42.9	45.7	0.2	84.2	83.1	0.0
Tajikistan	ECA	5.8	8.5	1.3	2231	2351	0.2	1.1	1.7	1.36	0.0	0.1	1.9	1.2	1.8	1.4
Turkey	ECA	61.3	83.5	1.0	3563	3501	-0.1	13.9	17.7	0.81	6.4	10.2	1.6	29.8	40.3	1.0
Turkmenistan	ECA	4.1	6.1	1.3	2583	2721	0.2	0.7	1.1	1.38	0.5	0.8	2.0	1.4	2.2	1.6
Ukraine	ECA	51.4	45.1	-0.4	2880	2962	0.1	8.4	7.2	-0.49	17.3	16.2	-0.2	31.8	28.8	-0.3
Uzbekistan	ECA	22.5	32.1	1.2	2565	2703	0.2	4.3	6.2	1.25	0.5	0.9	1.8	5.4	8.0	1.3
Argentina	LAC	34.8	45.2	0.9	3117	3471	0.4	4.5	6.0	1.01	5.4	8.3	1.5	12.6	18.2	1.2
Bolivia	LAC	7.4	12.6	1.8	2161	2534	0.5	0.9	1.6	2.03	0.2	0.6	3.4	1.3	2.7	2.3

Table B 3. Cereal production and production surplus/deficit.

Table B 4. Growth of irrigated, rain-fed and average cereal yield.

		Cereal Production			Cereal Production Surplus/Deficit				Irrigated Cereal Yield			Rain-Fed Cereal Yield			Average Cereal Yield		
Country	Region	1995 M mt	2025 M mt	Annual growth %	1995 M mt	% of consum. %	2025 M mt	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %
Angola	AFR	0.4	1.1	3.8	-0.4	-55	-1.0	-48	0.00	0.00	0.0	0.43	0.73	1.8	0.43	0.73	1.8
Benin	AFR	0.7	1.7	3.0	-0.1	-13	-0.2	-10	1.68	2.43	1.3	1.01	1.70	1.8	1.02	1.72	1.7
Burkina Faso	AFR	2.4	6.2	3.2	-0.2	-6	-0.4	-6	2.37	3.44	1.3	0.75	1.22	1.6	0.78	1.28	1.7
Burundi	AFR	0.2	0.5	2.3	-0.1	-22	-0.2	-27	1.50	2.02	1.0	1.22	1.78	1.3	1.24	1.80	1.2
Cameroon	AFR	1.1	2.2	2.2	-0.3	-23	-1.1	-33	4.02	4.67	0.5	1.26	1.70	1.0	1.29	1.73	1.0
Cent Afr Rep	AFR	0.1	0.3	2.8	-0.1	-33	-0.1	-22	1.50	1.74	0.5	0.90	1.30	1.3	0.90	1.30	1.3
Chad	AFR	1.0	2.2	2.8	-0.1	-5	-0.2	-9	1.82	2.65	1.3	0.63	0.91	1.3	0.63	0.91	1.2
Congo,Dem R	AFR	1.5	4.3	3.5	-0.3	-16	-0.5	-10	1.72	2.00	0.5	0.72	1.30	2.0	0.73	1.30	2.0
Congo, Rep	AFR	0.0	0.0	1.5	-0.1	-95	-0.3	-97	2.98	4.02	1.0	0.26	0.31	0.5	0.26	0.31	0.5
Côte d’Ivoire	AFR	1.3	2.3	2.0	-0.6	-33	-1.4	-38	2.42	3.26	1.0	0.81	1.10	1.0	0.86	1.17	1.0
Dominican Rep	AFR	0.3	0.7	2.5	-1.0	-74	-1.7	-70	3.08	3.58	0.5	1.39	1.62	0.5	2.56	2.97	0.5
Ethiopia	AFR	9.2	14.5	1.5	0.0	0	-6.6	-31	2.20	3.98	2.0	1.33	1.54	0.5	1.34	1.57	0.5
Ghana	AFR	1.7	2.6	1.5	-0.4	-18	-2.2	-46	2.95	3.43	0.5	1.31	1.52	0.5	1.31	1.52	0.5
Guinea	AFR	0.6	1.4	2.9	-0.3	-37	-0.5	-24	2.23	2.59	0.5	0.85	1.15	1.0	0.91	1.19	0.9
Kenya	AFR	3.2	7.8	3.0	-0.5	-13	1.6	26	4.02	4.67	0.5	1.77	2.39	1.0	1.79	2.40	1.0
Madagascar	AFR	1.8	3.5	2.2	-0.1	-7	-1.1	-24	1.75	2.74	1.5	1.21	1.63	1.0	1.36	1.96	1.2
Mali	AFR	2.2	6.0	3.5	-0.1	-3	0.6	12	1.33	1.79	1.0	0.74	1.33	2.0	0.76	1.35	1.9
Mauritania	AFR	0.2	0.7	4.0	-0.2	-54	-0.4	-39	2.05	3.20	1.5	0.65	1.18	2.0	0.69	1.23	1.9
Mozambique	AFR	1.1	2.6	3.0	-0.5	-33	-0.5	-17	0.81	1.27	1.5	0.64	1.15	2.0	0.65	1.16	2.0
Niger	AFR	2.3	5.6	3.0	-0.2	-9	-1.3	-19	2.56	4.00	1.5	0.32	0.50	1.5	0.33	0.51	1.5
Nigeria	AFR	19.9	38.8	2.2	-1.0	-5	-4.9	-11	3.07	4.14	1.0	1.00	1.25	0.8	1.12	1.39	0.7
Senegal	AFR	0.9	2.5	3.3	-0.7	-41	-1.2	-33	1.77	2.77	1.5	0.72	1.21	1.8	0.75	1.26	1.7
Somalia	AFR	0.3	0.9	3.3	-0.1	-25	-0.4	-31	0.84	1.31	1.5	0.43	0.72	1.8	0.44	0.73	1.7
South Africa	AFR	13.0	16.6	0.8	0.7	6	1.3	9	2.50	3.37	1.0	1.92	2.41	0.8	1.96	2.50	0.8
Sudan	AFR	4.6	7.8	1.8	-0.3	-7	-1.6	-17	1.49	2.33	1.5	0.40	0.47	0.5	0.52	0.66	0.8
Tanzania	AFR	4.1	7.5	2.0	-0.2	-5	-1.6	-18	2.29	3.57	1.5	1.26	1.70	1.0	1.28	1.75	1.0

Table B 3. Cereal production and production surplus/deficit.

Table B 4. Growth of irrigated, rain-fed and average cereal yield.

		Cereal Production			Cereal Production Surplus/Deficit				Irrigated Cereal Yield			Rain-Fed Cereal Yield			Average Cereal Yield		
Country	Region	1995 M mt	2025 M mt	Annual growth %	1995 M mt	% of consum. %	2025 M mt	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %
Uganda	AFR	1.8	3.3	2.0	0.0	-1	-1.5	-31	1.96	3.06	1.5	1.40	1.88	1.0	1.40	1.89	1.0
Zambia	AFR	1.2	2.9	3.0	-0.4	-24	-0.4	-12	2.73	3.17	0.5	1.51	2.04	1.0	1.55	2.07	1.0
Zimbabwe	AFR	2.3	3.7	1.6	0.1	2	0.2	6	3.42	4.61	1.0	1.11	1.50	1.0	1.18	1.63	1.1
Algeria	MENA	2.7	3.2	0.6	-6.3	-70	-11.9	-79	4.90	5.05	0.1	1.02	1.18	0.5	1.06	1.27	0.6
Egypt	MENA	13.8	17.6	0.8	-8.3	-38	-18.3	-51	5.48	5.99	0.3	0.00	0.00	#DIV/0	5.48	5.99	0.3
Iran	MENA	15.5	26.1	1.8	-5.5	-26	-6.6	-20	3.04	5.05	1.7	0.58	0.67	0.5	1.72	2.50	1.2
Iraq	MENA	2.7	4.9	2.0	-1.4	-34	-3.5	-42	0.80	1.45	2.0	0.00	0.00	#DIV/0	0.80	1.45	2.0
Israel	MENA	0.2	0.2	0.0	-2.7	-94	-3.7	-95	2.02	2.72	1.0	0.00	0.00	0.0	2.02	2.72	1.0
Jordan	MENA	0.1	0.1	0.3	-1.5	-93	-3.7	-97	5.20	6.04	0.5	0.57	0.66	0.5	1.13	1.42	0.8
Libya	MENA	0.2	0.3	2.3	-2.0	-92	-3.8	-92	1.30	1.75	1.0	0.04	0.05	1.0	0.35	0.60	1.8
Morocco	MENA	6.2	9.3	1.3	-2.7	-30	-3.5	-27	3.10	4.18	1.0	1.02	1.18	0.5	1.34	1.71	0.8
Saudi Arabia	MENA	4.7	4.0	-0.5	-5.5	-54	-18.0	-82	3.80	4.41	0.5	0.00	0.00	0.0	3.80	4.41	0.5
Syria	MENA	5.7	9.6	1.7	0.0	1	-1.5	-13	4.76	6.42	1.0	0.66	0.77	0.5	1.67	2.08	0.7
Tunisia	MENA	1.4	1.7	0.6	-1.8	-56	-3.1	-65	4.30	5.80	1.0	1.16	1.34	0.5	1.27	1.52	0.6
Yemen	MENA	0.8	1.8	3.0	-2.0	-72	-4.9	-73	1.45	2.62	2.0	0.87	1.35	1.5	1.05	1.75	1.7
Afghanistan	SA	3.2	7.4	2.8	-0.2	-5	-1.0	-12	1.35	2.28	1.8	0.39	0.61	1.5	1.29	2.17	1.8
Bangladesh	SA	20.2	31.8	1.5	-1.8	-8	-1.6	-5	2.86	3.32	0.5	0.70	0.95	1.0	1.78	2.80	1.5
India	SA	175.8	256.5	1.3	3.7	2	-2.4	-1	2.66	3.58	1.0	0.95	1.10	0.5	1.74	2.54	1.3
Nepal	SA	4.9	9.3	2.2	0.1	2	0.1	1	1.87	2.52	1.0	1.40	2.03	1.3	1.53	2.18	1.2
Pakistan	SA	22.7	36.2	1.6	0.9	4	-5.4	-13	2.20	2.97	1.0	0.00	0.00	0.0	2.20	2.97	1.0
Sri Lanka	SA	1.7	2.9	1.8	-1.2	-40	-1.2	-29	2.45	3.83	1.5	0.79	1.14	1.3	2.01	2.95	1.3
Cambodia	EAP	2.0	4.4	2.6	0.0	0	0.8	23	1.87	2.92	1.5	1.03	1.61	1.5	1.13	1.82	1.6
China	EAP	363.5	572.4	1.5	-16.4	-4	18.7	3	3.34	5.22	1.5	2.96	3.44	0.5	3.21	5.05	1.5
Indonesia	EAP	39.4	62.1	1.5	-6.8	-15	-2.6	-4	3.47	4.35	0.8	2.06	2.40	0.5	2.78	3.24	0.5
Korea D P Rep	EAP	3.8	6.7	1.9	-1.3	-25	-0.8	-11	3.31	4.45	1.0	1.52	2.37	1.5	2.66	4.04	1.4

Table B 3. Cereal production and production surplus/deficit.

Table B 4. Growth of irrigated, rain-fed and average cereal yield.

		Cereal Production			Cereal Production Surplus/Deficit				Irrigated Cereal Yield			Rain-Fed Cereal Yield			Average Cereal Yield		
Country	Region	1995 M mt	2025 M mt	Annual growth %	1995 M mt	% of consum. %	2025 M mt	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %
Korea Rep	EAP	5.0	12.5	3.1	-12.4	-71	-15.6	-55	4.43	6.93	1.5	2.40	5.04	2.5	4.21	6.72	1.6
Malaysia	EAP	1.5	4.2	3.5	-3.7	-72	-5.5	-57	2.38	4.31	2.0	1.61	2.16	1.0	2.10	3.25	1.5
Myanmar	EAP	12.1	17.9	1.3	0.5	4	1.8	11	2.75	3.19	0.5	1.76	2.05	0.5	1.99	2.36	0.6
Philippines	EAP	11.2	18.0	1.6	-2.5	-18	-7.9	-31	2.18	3.62	1.7	1.47	1.84	0.8	1.76	2.82	1.6
Thailand	EAP	19.0	24.5	0.8	4.8	34	3.1	14	2.68	3.61	1.0	1.32	1.42	0.2	1.75	2.62	1.4
Vietnam	EAP	17.8	29.2	1.7	2.0	13	5.1	21	3.17	4.27	1.0	2.02	2.34	0.5	2.44	2.97	0.7
Hungary	ECA	11.4	17.9	1.5	1.4	15	7.4	71	4.75	5.52	0.5	4.03	4.69	0.5	4.04	4.69	0.5
Kazakhstan	ECA	12.3	14.3	0.5	0.4	3	1.1	8	1.80	2.09	0.5	0.61	0.71	0.5	0.65	0.76	0.5
Kyrgyzstan	ECA	1.2	2.1	1.9	-0.4	-24	-0.7	-25	2.50	3.37	1.0	0.86	1.00	0.5	1.99	2.64	0.9
Poland	ECA	23.8	32.1	1.0	-2.1	-8	2.7	9	2.80	3.77	1.0	2.83	3.82	1.0	2.83	3.82	1.0
Romania	ECA	17.7	20.5	0.5	0.5	3	4.7	29	4.00	4.65	0.5	2.64	3.07	0.5	2.81	3.26	0.5
Russian Fed	ECA	69.2	80.3	0.5	-15.0	-18	-2.8	-3	2.70	3.14	0.5	1.26	1.46	0.5	1.30	1.51	0.5
Tajikistan	ECA	0.3	0.5	1.7	-0.9	-74	-1.3	-72	1.68	2.62	1.5	0.93	1.08	0.5	1.12	1.37	0.7
Turkey	ECA	29.7	40.2	1.0	-0.2	-1	-0.2	0	4.82	6.03	0.8	1.87	2.34	0.8	2.01	2.63	0.9
Turkmenistan	ECA	0.9	1.6	1.9	-0.5	-34	-0.6	-26	2.36	3.19	1.0	1.35	1.57	0.5	1.58	1.80	0.4
Ukraine	ECA	29.6	29.9	0.0	-2.2	-7	1.1	4	4.60	5.34	0.5	2.26	2.62	0.5	2.42	2.84	0.5
Uzbekistan	ECA	3.0	4.7	1.5	-2.4	-45	-3.3	-42	2.50	3.37	1.0	1.52	1.77	0.5	1.78	2.08	0.5
Argentina	LAC	24.6	33.5	1.0	12.0	95	15.3	84	4.82	5.59	0.5	2.52	2.92	0.5	2.76	3.23	0.5
Bolivia	LAC	1.0	2.3	2.8	-0.3	-23	-0.4	-13	1.79	3.01	1.8	1.42	2.39	1.8	1.46	2.45	1.7
Brazil	LAC	42.6	63.3	1.3	-9.7	-18	-24.8	-28	2.95	5.35	2.0	2.16	2.91	1.0	2.21	3.28	1.3
Chile	LAC	2.6	5.3	2.4	-1.1	-30	-1.1	-17	6.08	7.06	0.5	2.77	3.74	1.0	4.33	4.90	0.4
Colombia	LAC	2.9	6.1	2.5	-2.7	-48	-3.9	-39	3.40	4.58	1.0	1.83	2.46	1.0	2.19	3.93	2.0
Costa Rica	LAC	0.1	0.3	1.9	-0.6	-80	-1.3	-84	2.98	4.02	1.0	1.69	2.28	1.0	2.39	3.09	0.9
Cuba	LAC	0.3	0.6	2.5	-1.5	-85	-1.6	-74	1.86	2.50	1.0	0.96	1.29	1.0	1.53	1.78	0.5
Ecuador	LAC	1.5	2.8	2.0	-0.3	-17	-0.4	-14	2.54	3.42	1.0	1.13	1.42	0.8	1.51	1.76	0.5

Table B 3. Cereal production and production surplus/deficit.

Table B 4. Growth of irrigated, rain-fed and average cereal yield.

		Cereal Production			Cereal Production Surplus/Deficit				Irrigated Cereal Yield			Rain-Fed Cereal Yield			Average Cereal Yield		
Country	Region	1995 M mt	2025 M mt	Annual growth %	1995 M mt	% of consum. %	2025 M mt	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %	1995 t/ha	2025 t/ha	Annual growth %
El Salvador	LAC	0.8	1.5	2.0	-0.4	-36	-0.9	-37	3.24	4.37	1.0	1.82	2.45	1.0	1.86	2.50	1.0
Guatemala	LAC	1.2	2.5	2.5	-0.6	-33	-1.3	-35	3.04	3.52	0.5	1.84	2.13	0.5	1.85	2.15	0.5
Haiti	LAC	0.4	1.0	3.5	-0.4	-54	-0.3	-25	1.58	2.13	1.0	0.78	1.22	1.5	0.86	1.32	1.4
Honduras	LAC	0.7	1.6	2.7	-0.3	-27	-0.5	-25	2.57	3.47	1.0	1.31	1.90	1.3	1.45	2.05	1.2
Mexico	LAC	26.4	43.1	1.6	-0.5	-2	-2.6	-6	4.66	5.41	0.5	1.82	2.12	0.5	2.48	3.48	1.1
Nicaragua	LAC	0.5	1.0	2.2	-0.2	-27	-0.6	-35	3.00	4.04	1.0	1.36	1.98	1.3	1.49	2.13	1.2
Panama	LAC	0.3	0.6	2.6	-0.3	-54	-0.4	-44	2.90	5.26	2.0	1.39	2.18	1.5	1.48	2.36	1.6
Paraguay	LAC	1.1	2.2	2.3	0.1	10	-0.3	-13	2.79	4.35	1.5	2.10	3.05	1.3	2.13	3.11	1.3
Peru	LAC	1.9	5.0	3.3	-2.5	-57	-2.7	-35	3.03	5.48	2.0	1.03	2.01	2.3	2.23	5.42	3.0
Uruguay	LAC	1.6	2.8	2.0	0.7	74	1.4	104	3.69	4.97	1.0	2.29	3.08	1.0	2.66	3.55	1.0
Venezuela	LAC	2.0	6.3	3.8	-2.5	-55	-2.1	-25	3.36	6.55	2.3	2.17	3.65	1.8	2.50	4.25	1.8
Australia	OTHER	24.7	33.2	1.0	16.4	195	22.1	198	4.50	6.07	1.0	1.63	2.05	0.8	1.76	2.36	1.0
Bulgaria	OTHER	5.4	10.5	2.2	0.2	3	5.8	120	3.50	4.06	0.5	2.59	3.01	0.5	2.66	3.07	0.5
Canada	OTHER	52.5	53.1	0.0	22.9	78	19.6	59	4.00	6.25	1.5	2.70	3.13	0.5	2.72	3.20	0.5
France	OTHER	57.6	57.6	0.0	27.5	91	20.0	53	7.50	8.71	0.5	6.70	7.78	0.5	6.70	7.78	0.5
Germany	OTHER	40.8	47.4	0.5	6.4	19	7.8	20	7.10	8.25	0.5	6.08	7.06	0.5	6.08	7.06	0.5
Greece	OTHER	4.9	7.2	1.3	0.1	1	2.0	37	5.50	6.39	0.5	0.62	0.72	0.5	3.67	4.05	0.3
Italy	OTHER	19.2	19.8	0.1	-3.4	-15	-2.6	-12	7.20	7.42	0.1	3.50	4.06	0.5	4.65	5.56	0.6
Japan	OTHER	9.3	9.2	0.0	-28.6	-76	-31.4	-77	4.25	4.93	0.5	0.00	0.00	0.0	4.25	4.93	0.5
Netherlands	OTHER	1.5	2.4	1.5	-3.9	-72	-3.5	-60	0.00	0.00	0.0	7.76	9.01	0.5	7.76	9.01	0.5
Portugal	OTHER	1.5	2.4	1.5	-2.0	-57	-1.5	-39	3.00	4.69	1.5	1.05	1.42	1.0	2.22	3.44	1.5
Spain	OTHER	16.2	19.2	0.6	-4.1	-20	-1.9	-9	4.00	5.39	1.0	1.56	1.81	0.5	2.45	3.38	1.1
UK	OTHER	21.6	21.6	0.0	2.6	14	1.3	7	8.00	8.24	0.1	6.93	8.05	0.5	6.93	8.05	0.5
USA	OTHER	320.3	376.0	0.5	86.5	37	98.7	36	5.50	6.88	0.8	4.91	6.14	0.8	5.10	6.46	0.8

Table B 5. Growth of irrigated, rain-fed and total cereal area.

Country	Region	Irrigated Cereal Area			Rain-Fed Cereal Area			Total Cereal Area		
		1995	2025	Annual growth	1995	2025	Annual growth	1995	2025	Annual //////*growth
		M ha	M ha	%	M ha	M ha	%	M ha	M ha	%
Angola	AFR	0.00	0.00	0.0	0.84	1.52	2.0	0.84	1.52	2.0
Benin	AFR	0.01	0.02	2.5	0.67	0.97	1.2	0.68	0.99	1.3
Burkina Faso	AFR	0.04	0.13	4.0	3.05	4.70	1.5	3.09	4.83	1.5
Burundi	AFR	0.01	0.03	2.1	0.18	0.24	0.9	0.20	0.26	1.0
Cameroon	AFR	0.01	0.01	1.0	0.87	1.26	1.3	0.88	1.28	1.3
Cent Far Rep	AFR	0.00	0.00	0.0	0.13	0.20	1.5	0.13	0.20	1.5
Chad	AFR	0.00	0.00	1.1	1.51	2.37	1.5	1.51	2.37	1.5
Congo, Dem R	AFR	0.02	0.04	2.0	2.11	3.30	1.5	2.13	3.33	1.5
Congo, Rep	AFR	0.00	0.00	0.0	0.03	0.03	1.0	0.03	0.03	1.0
Côte d'Ivoire	AFR	0.04	0.07	1.5	1.44	1.93	1.0	1.48	2.00	1.0
Dominican Rep	AFR	0.09	0.17	2.0	0.04	0.08	2.0	0.14	0.25	2.0
Ethiopia	AFR	0.09	0.12	1.0	6.76	9.11	1.0	6.84	9.22	1.0
Ghana	AFR	0.00	0.00	0.0	1.27	1.71	1.0	1.27	1.71	1.0
Guinea	AFR	0.03	0.03	0.7	0.63	1.16	2.0	0.66	1.19	2.0
Kenya	AFR	0.02	0.02	1.0	1.78	3.23	2.0	1.79	3.25	2.0
Madagascar	AFR	0.35	0.53	1.3	0.97	1.27	0.9	1.33	1.79	1.0
Mali	AFR	0.12	0.16	1.0	2.75	4.32	1.5	2.87	4.48	1.5
Mauritania	AFR	0.01	0.01	1.3	0.28	0.52	2.0	0.29	0.53	2.0
Mozambique	AFR	0.10	0.14	1.2	1.54	2.07	1.0	1.64	2.21	1.0
Niger	AFR	0.03	0.05	2.1	6.94	10.83	1.5	6.97	10.89	1.5
Nigeria	AFR	1.06	1.43	1.0	16.75	26.41	1.5	17.81	27.84	1.5
Senegal	AFR	0.04	0.06	1.5	1.22	1.90	1.5	1.25	1.96	1.5
Somalia	AFR	0.01	0.03	1.8	0.73	1.14	1.5	0.75	1.17	1.5
South Africa	AFR	0.43	0.64	1.3	6.20	5.99	-0.1	6.63	6.63	0.0
Sudan	AFR	0.91	1.22	1.0	7.91	10.67	1.0	8.82	11.89	1.0
Tanzania	AFR	0.06	0.11	1.7	3.11	4.17	1.0	3.18	4.28	1.0
Uganda	AFR	0.01	0.02	0.5	1.29	1.74	1.0	1.30	1.75	1.0

Table B 5. Growth of irrigated, rain-fed, and total cereal area.

Country	Region	Irrigated Cereal Area			Rain-Fed Cereal Area			Total Cereal Area		
		1995	2025	Annual growth	1995	2025	Annual growth	1995	2025	Annual //////*growth
		M ha	M ha	%	M ha	M ha	%	M ha	M ha	%
Zambia	AFR	0.02	0.04	2.0	0.75	1.37	2.0	0.78	1.41	2.0
Zimbabwe	AFR	0.06	0.09	1.6	1.88	2.16	0.5	1.94	2.26	0.5
Algeria	MENA	0.03	0.06	2.5	2.48	2.45	0.0	2.51	2.51	0.0
Egypt	MENA	2.52	2.93	0.5	0.00	0.00	0.0	2.52	2.93	0.5
Iran	MENA	4.18	4.36	0.1	4.82	6.09	0.8	9.00	10.45	0.5
Iraq	MENA	3.36	3.36	0.0	0.00	0.00	0.0	3.36	3.36	0.0
Israel	MENA	0.09	0.07	-1.0	0.00	0.00	0.0	0.09	0.07	-1.0
Jordan	MENA	0.01	0.01	0.0	0.09	0.08	-0.6	0.10	0.09	-0.5
Libya	MENA	0.12	0.17	1.4	0.35	0.36	0.2	0.46	0.54	0.5
Morocco	MENA	0.72	0.96	1.0	3.94	4.45	0.4	4.65	5.40	0.5
Saudi Arabia	MENA	1.23	0.91	-1.0	0.00	0.00	0.0	1.23	0.91	-1.0
Syria	MENA	0.84	1.07	0.8	2.56	3.52	1.1	3.40	4.59	1.0
Tunisia	MENA	0.04	0.04	0.4	1.05	1.04	0.0	1.09	1.09	0.0
Yemen	MENA	0.22	0.32	1.2	0.50	0.71	1.2	0.72	1.04	1.2
Afghanistan	SA	2.34	3.19	1.0	0.18	0.21	0.6	2.52	3.39	1.0
Bangladesh	SA	5.67	8.87	1.5	5.67	2.47	-2.7	11.34	11.34	0.0
India	SA	46.97	58.65	0.7	53.85	42.16	-0.8	100.82	100.82	0.0
Nepal	SA	0.89	1.28	1.2	2.28	2.99	0.9	3.17	4.27	1.0
Pakistan	SA	10.30	12.17	0.6	0.00	0.00	0.0	10.30	12.17	0.6
Sri Lanka	SA	0.63	0.67	0.2	0.23	0.32	1.2	0.86	0.99	0.5
Cambodia	EAP	0.22	0.38	1.9	1.59	2.05	0.9	1.80	2.43	1.0
China	EAP	73.93	102.50	1.1	39.36	10.80	-4.2	113.30	113.30	0.0
Indonesia	EAP	7.18	8.33	0.5	7.03	10.83	1.4	14.21	19.16	1.0
Korea D P Rep	EAP	0.91	1.33	1.3	0.51	0.33	-1.4	1.43	1.66	0.5
Korea Rep	EAP	1.06	1.65	1.5	0.13	0.20	1.5	1.19	1.86	1.5
Malaysia	EAP	0.45	0.65	1.2	0.26	0.63	3.1	0.71	1.28	2.0
Myanmar	EAP	1.41	2.08	1.3	4.64	5.50	0.6	6.05	7.58	0.8

Table B 5. Growth of irrigated, rain-fed and total cereal area.

Country	Region	Irrigated Cereal Area			Rain-Fed Cereal Area			Total Cereal Area		
		1995	2025	Annual growth	1995	2025	Annual growth	1995	2025	Annual //////*growth
		M ha	M ha	%	M ha	M ha	%	M ha	M ha	%
Philippines	EAP	2.61	3.51	1.0	3.76	2.87	-0.9	6.37	6.37	0.0
Thailand	EAP	3.44	5.12	1.3	7.44	4.25	-1.9	10.88	9.37	-0.5
Vietnam	EAP	2.66	3.21	0.6	4.64	6.62	1.2	7.29	9.83	1.0
Hungary	ECA	0.01	0.01	1.5	2.83	3.81	1.0	2.83	3.82	1.0
Kazakhstan	ECA	0.64	0.64	0.0	18.21	18.21	0.0	18.85	18.85	0.0
Kyrgyzstan	ECA	0.41	0.55	1.0	0.18	0.24	1.0	0.59	0.79	1.0
Poland	ECA	0.08	0.08	0.0	8.32	8.32	0.0	8.40	8.40	0.0
Romania	ECA	0.78	0.78	0.0	5.52	5.52	0.0	6.30	6.30	0.0
Russian Fed	ECA	1.61	1.61	0.0	51.48	51.48	0.0	53.09	53.09	0.0
Tajikistan	ECA	0.07	0.07	0.0	0.21	0.31	1.3	0.28	0.38	1.0
Turkey	ECA	0.69	1.18	1.8	14.04	14.10	0.0	14.73	15.27	0.1
Turkmenistan	ECA	0.13	0.13	0.0	0.45	0.78	1.8	0.58	0.91	1.5
Ukraine	ECA	0.85	0.85	0.0	11.36	9.65	-0.5	12.21	10.51	-0.5
Uzbekistan	ECA	0.44	0.44	0.0	1.22	1.79	1.3	1.66	2.23	1.0
Argentina	LAC	0.95	1.21	0.8	7.95	9.13	0.5	8.91	10.34	0.5
Bolivia	LAC	0.08	0.09	0.5	0.62	0.86	1.1	0.70	0.94	1.0
Brazil	LAC	1.21	2.94	3.0	18.09	16.35	-0.3	19.29	19.29	0.0
Chile	LAC	0.28	0.38	1.0	0.32	0.71	2.7	0.60	1.09	2.0
Colombia	LAC	0.31	1.08	4.3	1.04	0.48	-2.5	1.35	1.56	0.5
Costa Rica	LAC	0.03	0.04	0.5	0.03	0.04	1.5	0.06	0.08	1.0
Cuba	LAC	0.11	0.13	0.5	0.06	0.19	3.7	0.18	0.32	2.0
Ecuador	LAC	0.27	0.27	0.0	0.74	1.31	1.9	1.01	1.58	1.5
El Salvador	LAC	0.01	0.02	0.6	0.42	0.57	1.0	0.43	0.58	1.0
Guatemala	LAC	0.01	0.01	2.2	0.64	1.15	2.0	0.64	1.17	2.0
Haiti	LAC	0.04	0.08	2.3	0.38	0.68	2.0	0.42	0.76	2.0
Honduras	LAC	0.06	0.07	1.0	0.45	0.71	1.6	0.50	0.79	1.5
Mexico	LAC	2.46	5.11	2.5	8.21	7.28	-0.4	10.67	12.39	0.5

Table B 5. Growth of irrigated, rain-fed and total cereal area.

Country	Region	Irrigated Cereal Area			Rain-Fed Cereal Area			Total Cereal Area		
		1995	2025	Annual growth	1995	2025	Annual growth	1995	2025	Annual //////*growth
		M ha	M ha	%	M ha	M ha	%	M ha	M ha	%
Nicaragua	LAC	0.03	0.04	0.7	0.33	0.45	1.0	0.36	0.48	1.0
Panama	LAC	0.01	0.01	1.0	0.17	0.22	1.0	0.18	0.24	1.0
Paraguay	LAC	0.02	0.03	1.2	0.51	0.68	1.0	0.53	0.72	1.0
Peru	LAC	0.51	0.90	2.0	0.34	0.02	-9.3	0.84	0.92	0.3
Uruguay	LAC	0.16	0.20	0.7	0.43	0.59	1.1	0.59	0.79	1.0
Venezuela	LAC	0.23	0.31	1.0	0.59	1.17	2.3	0.82	1.48	2.0
Australia	OTHER	0.62	1.11	2.0	13.43	12.94	-0.1	14.05	14.05	0.0
Bulgaria	OTHER	0.16	0.20	0.8	1.89	3.24	1.8	2.04	3.44	1.8
Canada	OTHER	0.36	0.36	0.0	18.94	16.25	-0.5	19.29	16.60	-0.5
France	OTHER	0.02	0.02	0.0	8.59	7.39	-0.5	8.60	7.40	-0.5
Germany	OTHER	0.00	0.00	0.0	6.72	6.72	0.0	6.72	6.72	0.0
Greece	OTHER	0.83	1.05	0.8	0.50	0.74	1.3	1.32	1.79	1.0
Italy	OTHER	1.29	1.59	0.7	2.85	1.97	-1.2	4.14	3.56	-0.5
Japan	OTHER	2.18	1.87	-0.5	0.00	0.00	0.0	2.18	1.87	-0.5
Netherlands	OTHER	0.00	0.00	0.0	0.19	0.26	1.0	0.19	0.26	1.0
Portugal	OTHER	0.42	0.43	0.1	0.28	0.27	-0.2	0.69	0.69	0.0
Spain	OTHER	2.41	2.50	0.1	4.20	3.19	-0.9	6.61	5.69	-0.5
UK	OTHER	0.00	0.00	0.0	3.11	2.68	-0.5	3.12	2.68	-0.5
USA	OTHER	20.93	25.05	0.6	41.83	33.16	-0.8	62.76	58.22	-0.2

Table B 6. Growth of total irrigated area and primary irrigation supply.

Country	Region	Net Irrigated Area			Gross Irrigated Area			Primary Irrigation Supply		
		1995	2025	Total growth	1995	2025	Total growth	1995	2025	Total growth
		M ha	M ha	%	M ha	M ha	%	km^3	km^3	%
Angola	AFR	0.1	0.1	0.5	0.1	0.1	0.7	0.3	0.3	20
Benin	AFR	0.0	0.0	2.0	0.0	0.0	2.5	0.1	0.1	93
Burkina Faso	AFR	0.0	0.1	4.0	0.0	0.1	4.0	0.3	0.9	189
Burundi	AFR	0.0	0.0	1.5	0.0	0.0	2.1	0.0	0.1	86
Cameroon	AFR	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	-2
Cent Far Rep	AFR	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	28
Chad	AFR	0.0	0.0	1.0	0.0	0.0	1.1	0.1	0.1	33
Congo, Dem R	AFR	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.1	53
Congo, Rep	AFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-5
Côte d’Ivoire	AFR	0.1	0.1	1.5	0.1	0.2	1.5	0.3	0.5	37
Dominican Rep	AFR	0.3	0.5	2.0	0.5	0.9	2.0	2.3	3.8	62
Ethiopia	AFR	0.2	0.2	0.8	0.3	0.5	1.0	0.8	1.1	33
Ghana	AFR	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	-10
Guinea	AFR	0.1	0.1	0.5	0.2	0.2	0.7	0.4	0.5	18
Kenya	AFR	0.1	0.1	1.0	0.1	0.2	1.0	0.7	0.8	22
Madagascar	AFR	1.1	1.5	1.0	1.1	1.6	1.3	1.5	2.4	62
Mali	AFR	0.1	0.1	1.0	0.2	0.2	1.0	0.9	1.2	29
Mauritania	AFR	0.0	0.1	1.0	0.0	0.1	1.3	0.5	0.7	34
Mozambique	AFR	0.1	0.1	1.0	0.1	0.2	1.2	0.5	0.6	39
Niger	AFR	0.1	0.1	1.5	0.1	0.1	2.1	0.6	1.1	73
Nigeria	AFR	1.0	1.2	0.6	1.3	1.8	1.0	4.4	5.7	32
Senegal	AFR	0.1	0.1	1.5	0.1	0.2	1.5	0.8	1.2	45
Somalia	AFR	0.2	0.3	1.5	0.2	0.3	1.8	1.4	2.5	73
South Africa	AFR	1.3	1.7	1.0	2.0	2.9	1.3	10.1	13.3	32
Sudan	AFR	1.9	2.3	0.5	1.9	2.6	1.0	15.7	19.4	23
Tanzania	AFR	0.2	0.3	1.5	0.3	0.5	1.7	0.7	1.1	64
Uganda	AFR	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	2

Table B 6. Growth of total irrigated area and primary irrigation supply.

Country	Region	Net Irrigated Area			Gross Irrigated Area			Primary Irrigation Supply		
		1995	2025	Total growth	1995	2025	Total growth	1995	2025	Total growth
		M ha	M ha	%	M ha	M ha	%	km^3	km^3	%
Zambia	AFR	0.0	0.1	2.0	0.1	0.2	2.0	0.3	0.5	63
Zimbabwe	AFR	0.1	0.2	1.5	0.2	0.3	1.6	0.9	1.2	44
Algeria	MENA	0.6	1.0	2.0	0.6	1.2	2.5	1.6	3.4	109
Egypt	MENA	3.3	3.7	0.4	5.1	6.0	0.5	27.9	29.4	5
Iran	MENA	7.3	7.3	0.0	8.4	8.7	0.1	73.2	65.4	-11
Iraq	MENA	3.5	3.7	0.2	4.9	5.3	0.3	27.4	29.2	7
Israel	MENA	0.2	0.2	0.0	0.2	0.2	0.0	0.8	0.8	-4
Jordan	MENA	0.1	0.1	0.0	0.1	0.1	0.0	0.7	0.6	-21
Libya	MENA	0.5	0.6	1.0	0.6	0.9	1.4	2.4	3.7	55
Morocco	MENA	1.3	1.5	0.6	1.9	2.5	1.0	7.4	9.0	22
Saudi Arabia	MENA	1.5	1.1	-1.0	1.9	1.4	-1.0	11.3	7.5	-34
Syria	MENA	1.1	1.4	0.7	1.6	2.1	0.8	9.9	11.9	20
Tunisia	MENA	0.4	0.4	0.4	0.4	0.4	0.4	1.6	1.6	0
Yemen	MENA	0.5	0.7	1.0	0.7	0.9	1.2	5.1	7.0	38
Afghanistan	SA	2.8	4.4	1.5	3.2	5.7	1.9	24.4	37.2	52
Bangladesh	SA	3.4	5.2	1.4	5.7	8.9	1.5	20.2	26.7	32
India	SA	54.3	63.1	0.5	72.3	90.2	0.7	368.0	428.9	17
Nepal	SA	0.9	1.2	1.0	1.2	1.7	1.2	3.4	4.7	41
Pakistan	SA	16.0	16.0	0.0	17.6	20.8	0.6	172.1	188.1	9
Sri Lanka	SA	0.6	0.6	0.0	0.8	0.9	0.2	6.8	6.2	-8
Cambodia	EAP	0.2	0.3	1.5	0.2	0.4	1.9	0.6	1.1	95
China	EAP	49.7	67.0	1.0	87.0	120.6	1.1	325.8	406.4	25
Indonesia	EAP	4.6	5.0	0.3	7.6	8.8	0.5	32.9	34.8	6
Korea D P Rep	EAP	1.5	2.1	1.3	1.5	2.1	1.3	5.4	6.8	26
Korea Rep	EAP	1.2	1.9	1.5	1.2	1.9	1.5	8.0	10.1	27
Malaysia	EAP	0.3	0.5	1.0	0.5	0.7	1.2	2.2	2.7	23

Table B 6. Growth of total irrigated area and primary irrigation supply.

Country	Region	Net Irrigated Area			Gross Irrigated Area			Primary Irrigation Supply		
		1995	2025	Total growth	1995	2025	Total growth	1995	2025	Total growth
		M ha	M ha	%	M ha	M ha	%	km^3	km^3	%
Myanmar	EAP	1.6	2.2	1.0	1.8	2.6	1.3	1.9	4.2	118
Philippines	EAP	1.6	1.9	0.7	2.6	3.5	1.0	13.9	17.1	23
Thailand	EAP	4.7	6.4	1.0	6.9	10.2	1.3	14.0	21.5	53
Vietnam	EAP	2.0	2.3	0.4	2.8	3.4	0.6	17.9	18.9	6
Hungary	ECA	0.2	0.3	1.5	0.2	0.3	1.5	0.8	1.2	51
Kazakhstan	ECA	2.3	2.3	0.0	2.3	2.3	0.0	15.7	13.8	-13
Kyrgyzstan	ECA	1.1	1.4	1.0	1.1	1.4	1.0	9.0	11.0	23
Poland	ECA	0.1	0.1	0.0	0.1	0.1	0.0	0.3	0.3	-13
Romania	ECA	3.1	3.1	0.0	3.1	3.1	0.0	15.7	13.7	-13
Russian Fed	ECA	5.4	5.4	0.0	5.4	5.4	0.0	22.3	20.0	-10
Tajikistan	ECA	0.7	0.7	0.0	0.7	0.7	0.0	6.0	5.4	-10
Turkey	ECA	4.2	6.6	1.5	4.6	7.9	1.8	21.5	35.2	64
Turkmenistan	ECA	1.3	1.3	0.0	1.3	1.3	0.0	10.9	10.1	-8
Ukraine	ECA	2.6	2.6	0.0	2.6	2.6	0.0	13.9	12.4	-10
Uzbekistan	ECA	4.0	4.0	0.0	4.0	4.0	0.0	33.6	31.0	-8
Argentina	LAC	1.7	2.0	0.5	2.7	3.5	0.8	12.0	13.4	12
Bolivia	LAC	0.1	0.1	0.5	0.2	0.2	0.5	0.9	1.0	6
Brazil	LAC	3.1	6.9	2.7	4.8	11.8	3.0	16.9	36.4	115
Chile	LAC	1.3	1.7	1.0	2.3	3.2	1.0	9.8	12.0	23
Colombia	LAC	1.0	3.4	4.0	1.4	4.7	4.3	0.6	2.1	279
Costa Rica	LAC	0.1	0.1	0.5	0.3	0.3	0.5	0.8	0.8	5
Cuba	LAC	0.9	1.0	0.2	1.5	1.7	0.5	7.8	8.1	4
Ecuador	LAC	0.2	0.2	0.0	0.5	0.5	0.0	3.3	3.0	-10
El Salvador	LAC	0.1	0.1	0.5	0.2	0.2	0.6	0.6	0.6	12
Guatemala	LAC	0.1	0.2	2.0	0.2	0.4	2.2	0.2	0.5	105
Haiti	LAC	0.1	0.2	2.0	0.1	0.2	2.3	0.3	0.6	88
Honduras	LAC	0.1	0.1	1.0	0.1	0.2	1.0	0.4	0.4	19

Table B 6. Growth of total irrigated area and primary irrigation supply.

Country	Region	Net Irrigated Area			Gross Irrigated Area			Primary Irrigation Supply		
		1995	2025	Total growth	1995	2025	Total growth	1995	2025	Total growth
		M ha	M ha	%	M ha	M ha	%	km^3	km^3	%
Mexico	LAC	5.0	9.1	2.0	5.2	10.7	2.5	50.5	92.4	83
Nicaragua	LAC	0.1	0.1	0.5	0.1	0.2	0.7	0.3	0.4	22
Panama	LAC	0.0	0.0	1.0	0.1	0.1	1.0	0.2	0.2	22
Paraguay	LAC	0.1	0.1	1.0	0.1	0.1	1.2	0.4	0.5	32
Peru	LAC	1.7	3.1	2.0	2.0	3.9	2.3	2.0	4.7	129
Uruguay	LAC	0.1	0.2	0.5	0.2	0.3	0.7	1.0	1.1	10
Venezuela	LAC	0.2	0.3	1.0	0.3	0.5	1.0	1.6	1.8	16
Australia	OTHER	2.3	3.8	1.7	3.4	6.2	2.0	14.4	23.9	66
Bulgaria	OTHER	0.8	0.8	0.0	0.8	0.8	0.0	3.2	3.1	-6
Canada	OTHER	0.7	0.7	0.0	0.7	0.7	0.0	2.0	1.8	-8
France	OTHER	1.6	1.6	0.0	1.6	1.6	0.0	5.6	5.6	0
Germany	OTHER	0.5	0.5	0.0	0.5	0.5	0.0	1.3	1.3	0
Greece	OTHER	1.3	1.6	0.5	1.5	1.9	0.8	2.9	3.8	29
Italy	OTHER	2.7	3.3	0.7	5.1	6.3	0.7	17.3	19.3	12
Japan	OTHER	2.7	2.4	-0.5	2.7	2.4	-0.5	18.4	14.4	-22
Netherlands	OTHER	0.6	0.7	0.5	0.6	0.7	0.5	0.8	0.9	11
Portugal	OTHER	0.6	0.6	0.0	1.1	1.1	0.1	2.0	2.0	1
Spain	OTHER	3.6	3.6	0.0	4.8	5.0	0.1	17.6	17.7	0
UK	OTHER	0.1	0.1	0.0	0.1	0.1	0.0	0.2	0.2	-9
USA	OTHER	21.4	24.9	0.5	34.9	41.8	0.6	132.2	148.9	13

Table B 7. Total water withdrawals, primary water supply.

Country	Region	Total Water Withdrawals			Total Primary Water Supply					
		1995	2025	Total growth	1995	% of PUWR	2025	% of PUWR	Total growth	Scarcity level
		k³	km³	%	km³	%	km³	%	%	
Angola	AFR	0.47	0.94	2.3	0.4	0.5	0.6	0.8	66	Economic
Benin	AFR	0.14	0.38	3.4	0.1	0.6	0.2	1.3	138	Economic
Burkina Faso	AFR	0.52	1.65	3.9	0.4	3.4	1.1	10.3	199	Economic
Burundi	AFR	0.13	0.30	3.0	0.1	0.4	0.1	1.0	118	Economic
Cameroon	AFR	0.31	0.85	3.4	0.2	0.2	0.4	0.5	129	Economic
Cent Far Rep	AFR	0.02	0.07	3.5	0.0	0.0	0.0	0.0	127	Economic
Chad	AFR	0.17	0.32	2.0	0.1	0.5	0.2	0.8	61	Economic
Congo, Dem R	AFR	0.35	1.41	4.8	0.2	0.1	0.7	0.2	238	Economic
Congo, Rep	AFR	0.04	0.15	4.9	0.0	0.0	0.1	0.0	269	Economic
Côte d'Ivoire	AFR	0.76	1.45	2.2	0.5	1.3	0.9	2.2	75	Economic
Dominican Rep	AFR	3.20	5.59	1.9	2.6	25.8	4.3	43.9	70	Economic
Ethiopia	AFR	1.25	2.47	2.3	0.9	2.1	1.5	3.4	59	Economic
Ghana	AFR	0.23	0.66	3.6	0.2	0.7	0.4	1.6	141	Economic
Guinea	AFR	0.73	1.07	1.3	0.5	0.8	0.7	1.1	44	Economic
Kenya	AFR	1.35	2.28	1.8	1.0	5.7	1.6	8.6	51	Economic
Madagascar	AFR	2.54	4.32	1.8	1.6	1.3	2.8	2.4	78	Economic
Mali	AFR	1.18	1.56	0.9	1.0	1.3	1.3	1.7	35	Economic
Mauritania	AFR	0.74	1.16	1.5	0.6	5.2	0.9	8.0	54	Economic
Mozambique	AFR	0.66	1.03	1.5	0.5	0.3	0.8	0.5	51	Economic
Niger	AFR	0.99	1.96	2.3	0.7	2.4	1.3	4.6	90	Economic
Nigeria	AFR	8.29	14.56	1.9	5.0	3.1	7.6	4.8	53	Economic
Senegal	AFR	1.18	1.95	1.7	0.9	4.8	1.4	7.5	58	Economic
Somalia	AFR	1.93	3.40	1.9	1.5	11.9	2.6	20.9	76	Economic
South Africa	AFR	16.49	21.05	0.8	14.1	47.1	18.6	62.1	32	Physical
Sudan	AFR	19.84	26.52	1.0	16.0	16.2	20.2	20.4	26	Economic
Tanzania	AFR	1.09	2.03	2.1	0.8	1.0	1.4	1.7	78	Economic

Table B 7. Total water withdrawals, primary water supply.

Country	Region	Total Water Withdrawals 1995	Total Water Withdrawals 2025	Total Water Withdrawals Total growth	Total Primary Water Supply 1995	% of PUWR	2025	% of PUWR	Total growth	Scarcity level
		k^3	km^3	%	km^3	%	km^3	%	%	
Uganda	AFR	0.09	0.31	4.1	0.1	0.2	0.2	0.5	161	Economic
Zambia	AFR	0.80	1.56	2.2	0.5	1.0	0.9	1.7	73	Economic
Zimbabwe	AFR	1.42	2.24	1.5	1.0	1.6	1.5	2.5	52	Economic
Algeria	MENA	3.97	7.55	2.2	2.8	32.2	5.3	61.7	92	Physical
Egypt	MENA	46.14	56.36	0.7	31.3	53.7	36.1	62.0	15	Physical
Iran	MENA	96.63	96.96	0.0	75.3	91.2	69.0	83.6	-8	Physical
Iraq	MENA	36.84	38.82	0.2	28.8	63.6	30.7	67.9	7	Physical
Israel	MENA	1.46	1.59	0.3	1.1	61.1	1.1	64.3	5	Physical
Jordan	MENA	1.08	1.45	1.0	0.8	150.7	0.8	150.6	0	Physical
Libya	MENA	3.79	5.41	1.2	2.7	554.9	4.0	836.5	51	Physical
Morocco	MENA	11.46	15.88	1.1	7.9	40.6	10.2	52.3	29	Economic
Saudi Arabia	MENA	14.35	13.01	-0.3	13.0	677.5	12.8	666.3	-2	Physical
Syria	MENA	12.68	16.35	0.9	10.2	65.0	12.6	79.9	23	Physical
Tunisia	MENA	2.25	2.77	0.7	1.7	72.3	1.8	76.8	6	Physical
Yemen	MENA	6.31	9.37	1.3	5.2	184.4	7.4	262.8	42	Physical
Afghanistan	SA	31.01	49.26	1.6	24.6	69.4	37.7	106.6	54	Physical
Bangladesh	SA	24.20	35.71	1.3	20.8	7.5	28.3	10.2	36	Economic
India	SA	617.44	811.76	0.9	381.2	49.2	473.0	61.1	24	Physical
Nepal	SA	5.10	7.37	1.2	3.4	7.3	5.0	10.7	46	Economic
Pakistan	SA	177.67	203.35	0.5	177.7	89.3	203.4	102.2	14	Physical
Sri Lanka	SA	10.17	9.97	-0.1	6.9	20.1	6.7	19.4	-3	Little or no
Cambodia	EAP	0.80	1.58	2.3	0.6	0.3	1.1	0.6	99	Economic
China	EAP	581.62	916.82	1.5	359.0	44.3	504.2	62.3	40	Physical
Indonesia	EAP	65.17	82.76	0.8	34.8	6.7	40.8	7.8	17	Little or no
Korea D P Rep	EAP	10.90	14.44	0.9	8.0	30.3	10.0	37.7	25	Economic
Korea Rep	EAP	17.91	26.58	1.3	12.7	22.9	17.2	30.9	35	Economic
Malaysia	EAP	8.39	29.99	4.3	5.5	2.4	16.4	7.2	199	Economic

Table B 7. Total water withdrawals, primary water supply.

Country	Region	Total Water Withdrawals			Total Primary Water Supply					
		1995	2025	Total growth	1995	% of PUWR	2025	% of PUWR	Total growth	Scarcity level
		k^3	km^3	%	km^3	%	km^3	%	%	
Myanmar	EAP	2.66	6.32	2.9	2.1	0.7	4.6	1.6	119	Economic
Philippines	EAP	34.20	69.66	2.4	21.4	13.4	37.9	23.7	78	Economic
Thailand	EAP	20.69	42.23	2.4	16.0	16.8	30.0	31.5	88	Economic
Vietnam	EAP	33.97	51.43	1.4	22.1	5.7	30.1	7.7	36	Economic
Hungary	ECA	5.49	7.94	1.2	4.8	5.1	7.1	7.5	48	Economic
Kazakhstan	ECA	25.24	23.85	-0.2	18.3	24.5	16.1	21.5	-12	Little or no
Kyrgyzstan	ECA	11.41	14.27	0.7	9.2	31.4	11.4	38.7	23	Little or no
Poland	ECA	9.75	13.25	1.0	3.3	9.9	3.8	11.2	13	Little or no
Romania	ECA	29.55	31.66	0.2	19.1	15.6	17.6	14.3	-8	Little or no
Russian Fed	ECA	90.94	80.72	-0.4	52.1	3.0	43.5	2.5	-17	Little or no
Tajikistan	ECA	8.06	7.77	-0.1	6.3	8.4	5.8	7.7	-9	Little or no
Turkey	ECA	51.42	92.85	2.0	27.0	21.0	52.3	40.6	94	Economic
Turkmenistan	ECA	13.61	13.18	-0.1	11.1	19.6	10.3	18.3	-7	Little or no
Ukraine	ECA	34.94	31.87	-0.3	23.4	18.6	20.4	16.2	-13	Little or no
Uzbekistan	ECA	43.79	43.36	0.0	34.9	41.8	32.7	39.2	-6	Little or no
Argentina	LAC	24.90	34.19	1.1	17.0	3.2	22.7	4.2	34	Economic
Bolivia	LAC	1.35	1.72	0.8	1.0	0.4	1.3	0.5	23	Little or no
Brazil	LAC	47.97	102.33	2.6	28.3	3.5	55.6	6.8	97	Economic
Chile	LAC	13.83	20.54	1.3	11.0	6.2	15.1	8.5	38	Economic
Colombia	LAC	4.03	11.26	3.5	2.5	0.5	6.3	1.3	149	Economic
Costa Rica	LAC	1.13	1.41	0.7	0.9	1.7	1.1	2.0	17	Little or no
Cuba	LAC	9.61	10.93	0.4	8.4	48.5	9.3	53.6	11	Little or no
Ecuador	LAC	4.95	5.28	0.2	3.7	2.3	3.9	2.4	4	Little or no
El Salvador	LAC	0.79	1.07	1.0	0.6	5.5	0.8	6.9	25	Economic
Guatemala	LAC	0.46	1.19	3.2	0.4	0.7	0.8	1.5	133	Economic
Haiti	LAC	0.42	0.79	2.1	0.3	6.4	0.6	12.2	91	Economic

Table B 7. Total water withdrawals, primary water supply.

Country	Region	Total Water Withdrawals			Total Primary Water Supply					
		1995	2025	Total growth	1995	% of PUWR	2025	% of PUWR	Total growth	Scarcity level
		k^3	km^3	%	km^3	%	km^3	%	%	
Honduras	LAC	0.61	0.99	1.6	0.5	1.7	0.7	2.4	45	Economic
Mexico	LAC	71.34	137.35	2.2	57.0	27.3	104.6	50.2	83	Economic
Nicaragua	LAC	0.80	1.57	2.2	0.6	0.7	0.9	1.0	48	Economic
Panama	LAC	0.51	0.93	2.1	0.4	0.5	0.6	0.8	60	Economic
Paraguay	LAC	0.62	0.97	1.5	0.5	0.2	0.7	0.2	45	Economic
Peru	LAC	4.59	10.50	2.8	3.2	0.6	6.9	1.4	116	Economic
Uruguay	LAC	1.73	2.01	0.5	1.1	1.2	1.2	1.4	13	Little or no
Venezuela	LAC	4.38	7.78	1.9	2.9	0.4	4.4	0.6	50	Economic
Australia	OTHER	27.38	40.50	1.3	24.4	11.5	36.3	17.2	49	Economic
Bulgaria	OTHER	9.91	12.43	0.8	8.7	10.3	10.5	12.4	20	Little or no
Canada	OTHER	43.61	52.95	0.6	43.0	6.3	52.5	7.7	22	Little or no
France	OTHER	37.27	38.42	0.1	33.6	28.7	34.6	29.6	3	Little or no
Germany	OTHER	43.97	42.44	-0.1	40.2	39.7	38.8	38.3	-3	Little or no
Greece	OTHER	5.65	8.25	1.3	4.3	8.9	6.1	12.6	43	Economic
Italy	OTHER	43.93	42.68	-0.1	35.8	37.3	35.6	37.1	0	Little or no
Japan	OTHER	108.52	90.22	-0.6	60.9	41.5	54.6	37.2	-10	Little or no
Netherlands	OTHER	6.37	6.48	0.1	5.8	7.4	5.9	7.6	2	Little or no
Portugal	OTHER	6.58	8.20	0.7	4.6	14.3	5.8	18.4	28	Economic
Spain	OTHER	32.29	33.31	0.1	28.5	50.5	29.7	52.4	4	Little or no
UK	OTHER	11.67	11.66	0.0	9.5	14.7	9.5	14.7	0	Little or no
USA	OTHER	465.90	522.79	0.4	393.8	21.5	457.5	25.0	16	Little or no

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