Chapter 1
Water and Food Security Under Global Change

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Abstract This chapter describes the implications of global change for water and food security, focusing on the precarious situation of the poor in global change processes. While overall economic growth is reaching an increasing number of poor, and education and income opportunities have increased tremendously in many parts of the (urban) developing world, new challenges in the water-for-food arena are set to tip the balance towards increased hunger and childhood malnutrition with often irreversible, life-long consequences, particularly in parts of sub-Saharan Africa and South Asia, unless policy reforms and investments are urgently undertaken to ensure access to safe water and food under these global change processes. Key challenges whose outcomes need to be made more pro-poor include the global trade and finance regime, climate change, energy policy, investment policy, and foreign direct investment.

1.1 Introduction

The world has made significant progress in increasing agricultural productivity and reducing poverty since the 1960s. Yet real world food prices of most cereals and meats are now projected to rise, reversing a long-established downward trend with adverse impacts on poor consumers in the developing world. Growing resource scarcity, particularly of water, will increasingly constrain food production growth, and climatic stresses will likely shrink farmers' ability to produce food. Meanwhile, growing demand for high-value foods, such as livestock, fish, vegetables, and fruits will put further pressure on the natural resource base. Moreover, demands for biofuels increasingly compete with food for land and water resources. The consequences of these pressures will adversely affect food security and goals for human well-being, slowing progress in reducing childhood malnutrition.

While food and water security is largely determined by actions taken at the local or national scale, global factors, such as the global trade and finance systems, climate change and climate policy, energy policy, demographic changes, including migration, and foreign direct investment also affect local food and water security. Over the coming decades global change will affect food and water security in

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significant and highly uncertain ways, and there are strong indications that developing countries will bear the brunt of potentially adverse consequences. This is largely because poverty levels are high and developing country capacity to adapt to global change is weak. Rural populations of developing countries, for whom agricultural production is the primary source of direct and indirect employment and income, will be most affected due to agriculture's vulnerability to global change processes (Svendsen et al. 2008).

This chapter provides a brief overview of the status of water and food security in the world and introduces key forces of global change affecting the future of water and food security, particularly in developing countries. Based on this analysis, key research and policy questions are identified. The themes identified here are subsequently explored in greater detail in this volume.

1.2 Status of Water and Food Security

1.2.1 Water Security – Declining Rapidly

The world's water resources are under considerable stress. Growing national, regional, and seasonal water scarcities in much of the world pose severe challenges for national governments and international development and environmental communities. Historically, global freshwater use had increased at a rate of about 20% per decade between 1960 and 2000, with considerable regional variations due to different development pressures and efficiency changes. Because of uneven distribution of freshwater in space and time, however, today only 15% of the world's population lives with relative water abundance, and the majority is left with moderate to severe water stress (Vorosmarty et al. 2005). About 1.6 billion people live in areas of economic water scarcity where lack of human, institutional, and financial capital limit access to water even though water is available locally to meet human demands, particularly in South Asia and much of sub-Saharan Africa. A further 1.2 billion people live under conditions of physical water scarcity in river basins where water resources development has exceeded sustainable limits (CA 2007). In 2000, annual water availability per capita ranged from 10 cubic meters m^3 in Kuwait to 10 million m^3 in Greenland, with an average of 9,300 m^3. Developing countries average only two thirds of per capita water availability of the group of developed countries. By 2050, water availability levels are expected to decline by 50% to 6,200 m^3 per capita, on average, under normal climate conditions, as a result of population growth alone. Thus, little new water remains to be allocated, and an increasing number of countries are falling below the 1,000 m^3 per capita scarcity level.

The development of irrigated agriculture has played a major role in boosting agricultural yields and outputs in order to feed the world's growing population; and has helped maintain food production levels and contributed to price stability through greater control over production and increased scope for crop diversification. In developing countries, irrigation development has been particularly vital in

achieving food security, both locally, through increased income and improved health and nutrition, and nationally, by bridging the gap between production and demand; and was an important component of the Green Revolution technology package. The important role of irrigation for increased agricultural production and enhanced crop productivity has been well documented, particularly in Asia (see, e.g., Mellor 1985; Barker et al. 2004; Rosegrant et al. 1997, and many others).

Although the contribution of irrigation to the improvements in food security and rural welfare has been impressive, past experiences also indicate that inappropriate management of irrigation may lead to adverse environmental outcomes, including excessive water depletion, particularly of groundwater resources, pollution of freshwater resources, and waterlogging and salinization of formerly productive crop areas, often encouraged by the subsidies and distorted incentives that influence water use. While irrigation has contributed to water scarcity, water pollution, and ecosystem degradation, it has also helped conserve large areas of forest and other land. In the group of developing countries, 38% of the cereal harvested area that is irrigated accounted for 59% of cereal production in the mid-1990s. In developed countries, where irrigation plays a smaller role, 18% irrigated cereal area contributed 23% of total cereal production (Rosegrant et al. 2002). Thus, despite dramatic increases in irrigation infrastructure over the past half century, the bulk of the world's agricultural production still comes from predominantly rainfed lands. The challenges of growing water scarcity are heightened by the increasing costs of developing new water and the difficulties of financing agricultural water (Winpenny, this volume).

In addition to the fundamental role of water for food security, water is also essential for drinking and household uses, as an input into industrial production, and for environmental and ecosystem services. Access to safe drinking water and sanitation is critical in terms of health—particularly for children. Unsafe drinking water contributes to many health problems in poor countries. About 4 billion incidents of diarrhea occur annually, resulting in 2.2 million deaths, mainly of children under the age of 5 (WHO/UNICEF 2000). For more than one billion people across the globe, safe water is unavailable in sufficient quantities to meet minimum levels of health and welfare. Contaminated water supplies also affect the health and productivity of people through consumption of unsafe food and water.

Although the domestic and industrial sectors use far less water than irrigated agriculture, the growth in water consumption in these sectors has been rapid. Globally, withdrawals for domestic and industrial uses grew fourfold between 1950 and 1995, compared to just over a doubling for agricultural uses (Cosgrove and Rijsberman 2000).

1.2.2 Food Security - No Progress

Many parts of the developing world have experienced high economic growth in recent years, particularly developing Asia, but also parts of sub-Saharan Africa. Even countries with high prevalence of hunger reported strong growth. Despite

rapid agricultural and economic growth up to 2007, food security has remained out of reach for more than 800 million people. Average daily calorie availability in North America and Europe remains 50% higher than in sub-Saharan Africa, and a person in North America and Europe, on average, consumes eight times more meat than a person residing in sub-Saharan Africa. Moreover, childhood malnutrition levels are set to worsen over the next 20 years in sub-Saharan Africa. More than half of all childhood deaths are associated with being underweight, and malnourished children who survive into adulthood are more likely to suffer from chronic illness and disability, and have a higher probability of reduced physical and intellectual productivity (Pelletier et al. 1994)

In the last few years, real prices of food have increased dramatically as a result of changes in biofuel and climate policies, rising energy prices, declining food stocks, and market speculation. Between 2005 and the summer of 2008, the international prices of wheat and maize (corn) tripled, and that of rice grew fivefold. Poor people typically spend 50–70% of their income on food, and their wages did not adjust quickly enough to compensate for their shrinking purchasing power. From 2003/05 to 2007, the number of undernourished people increased from some 848 million to 923 million, largely because of the food price crisis (FAO 2008; Von Braun 2008a). Higher food price trends are likely to stay as a result of increased pressures on land and water resources, adverse impacts from climate change, and rapidly rising incomes in most of Asia and parts of sub-Saharan Africa. Given the long-term underinvestment in agriculture, and poor government policies in response to rising food prices in many countries, it is unlikely that the supply response will be strong enough in the short- to medium-term. High food-price triggers have included biofuel policies, which have led to large volumes of food crops being shifted into bioethanol and biodiesel production; bad weather in key production areas, such as droughts in wheat-producing Australia and Ukraine; and higher oil prices, which have contributed to increased costs of production inputs and transportation. Prices then spiraled further as a result of poor government policies such as export bans and import subsidies, combined with speculative trading and storage behavior in reaction to these policies.

However, the preconditions for rapidly rising food prices stem from underlying long-term trends in food supply and demand that have contributed to a tightening of global food markets during the past decade. Rapid growth in demand for meat and milk in most of the developing world put strong demand pressure on maize and other coarse feed grains, and small maize price increases had been projected for some time as a result. Other underlying factors include stronger economic growth in sub-Saharan Africa since the late 1990s, which has increased the demand for wheat and rice in the region; and rapid income growth and urbanization in developing Asia, which has led to increased demand for wheat, meat, milk, oils, and vegetables. On the supply side, long-term underlying factors include underinvestment in agricultural research and technology and rural infrastructure, especially irrigation, as well as increasing pressure on the natural-resource base (land and water).

The pressures on natural resources, combined with increasing distrust in the functioning of regional and global markets due to the food and energy price crises, have renewed attention to foreign direct investment in agriculture. A number of countries, many with severe natural resource constraints and dependent on food imports, but rich in capital, have begun investing in agriculture overseas to secure domestic supply. Large investments are reported for Mozambique, Brazil, Cambodia, Ethiopia, Sudan, Pakistan and Russia. To ensure that such investments make economic and social sense, economic viability should be assessed, land use rights, including informal rights, need to be honored, and local communities need to be part of negotiation processes to ensure that their water and food security is not worsened (Songwe and Deiniger 2009; von Braun 2008b).

1.3 Drivers of Global Change Affecting Water and Food Security[1]

A number of natural or human-induced drivers or forces directly or indirectly influence the future of water and food security. Categories of indirect drivers include demographic, economic, socio-political, scientific and technological, cultural and religious, and biogeophysical changes (IAASTD 2009; MEA 2005). Important direct forces include changes in food consumption patterns, natural resource management, land use change, climate change, energy, and labor. Trends and projections for key drivers are summarized in the following.

By 2050, the global population is expected to increase to 9.2 billion, 86% of whom will live in less-developed countries and 70% in urban areas. Urbanization and changing lifestyles are expected to lead to rapid increases in food demand exerting pressure on agricultural systems. In most scenario exercises, international trade in agricultural commodities is expected to grow with developing countries as a group increasing net import volumes. While difficult if not impossible to capture in quantitative scenario exercises, democratization, decentralization, and other sociopolitical developments are crucial in shaping agricultural and water policy choices.

Existing assessments project a combination of intensification of agricultural production and expansion of cultivated land to meet increasing demands for food, feed, fiber, and fuel. While there is general agreement that the focus will be on intensification, the final proportion and degree of intensification versus extensification remains a major uncertainty. Similarly, assessments conclude that water productivity will need to increase dramatically to meet future food and other demands, but how to increase productivity sustainably and economically remains a major implementation challenge. Recent scenario exercises indicate a major increase in biofuel production. In the medium term this might lead to a tradeoff between

[1]This section draws on IAASTD (2009, Chapter 4).

energy security and food security, with potentially adverse impacts on the poor. Scenarios that emphasize climate policy and energy security show that agriculture may become an important producer of biofuels with potentially adverse impacts on land and water availability for food production, with higher food prices, even in the longer term, as well as decreasing biodiversity. Most assessments also expect higher energy prices. These higher prices (and possible changes in energy subsidies) are likely to encourage the use of more energy-efficient technologies in agricultural production as well as in processing and distributing food.

Existing assessments also indicate that while agriculture is a major contributor to global environmental change, as reflected in land use change, land degradation, nutrient pollution, biodiversity loss, decreasing surface and groundwater availability, and climate change, the sector will also have to adapt to these changes. In particular, agriculture will be increasingly affected by climate change, including long-term changes in temperature and the spatial and temporal distribution of precipitation, and increased climate variability (i.e., increased frequency of droughts, floods, storms, and other extreme weather events). For agriculture, changes in seasonal variability and extreme events are even more important than changes in mean temperature and precipitation. Recent studies, such as the IPCC's Fourth Assessment Report (IPCC 2007), conclude that negative impacts on agriculture are concentrated in low-income regions. In temperate regions, on the other hand, impacts could result in net positive yields in the short term. Agriculture is also a source of greenhouse gas emissions and therefore agriculture can play a significant role in climate change mitigation.

Public investments in agricultural research and development have declined significantly over the last decades. Countering higher food prices and growing levels of poverty and malnutrition will require a reversal of these investment trends. Increased and diversified investments are needed in plant breeding, livestock improvement, and other interventions at the biological and molecular levels to enhance agricultural productivity. Policies that favor private investment in crop improvements in the developed and developing world are also critical. Finally, meeting the challenges of food production growth requires more long-term investments by farmers. Long-term investment in areas such as integrated soil fertility management, tree planting, and water harvesting in turn requires secure property rights to provide people with the incentive and authority to make such investments.

Over the next decades new constraints will be placed on water supplies available for irrigation as well as for rainfed agriculture. Demand for water use in agriculture will continue to increase as a result of population and economic growth. Non-irrigation demands are expected to grow even faster, putting pressure on supplies available for irrigation. Unsustainable groundwater use is constraining irrigation water supplies in many already water-scarce areas. Environmental demands for water will also vie for scarce water supplies in the future. Water quality problems are another factor that should be considered in water resources management, as all sectors will increasingly compete for unpolluted water supplies as water quality continues to degrade.

Climate variability is a major contributor to drought, which is particularly problematic for rainfed cultivation. Drought not only lowers average expected yields but also exacerbates other production uncertainties. When faced with drought conditions

farmers–particularly poorer farmers–become less likely to adopt modern technologies and practices that involve greater outlays of cash and labor inputs (despite the greater profits they might offer overall), in order to avoid or minimize risk.

Water scarcity is expected to increasingly constrain production with little additional water available for agriculture due to the slow increase in supply and rapid shifts of water from agriculture in key water-scarce agricultural regions including China, India, the Middle East, and North Africa. Climate change will increase heat and drought stress in many of the current breadbaskets in China, India, and the United States and even more so in the already stressed areas of sub-Saharan Africa. Once plants are weakened from abiotic stresses, biotic stresses tend to set in and the incidence of pest and diseases tends to increase.

Moreover, with declining availability of water and land that can be profitably brought under cultivation, expansion in area is not expected to contribute significantly to future production growth. The projected slow growth in crop area places the burden to meet future cereal demand on crop yield growth, which will require sufficient availability and judicious application of water resources and complementary inputs.

Fifty-three percent of cereal production growth during 2000–2050 is expected to be met from irrigated agriculture. A growing share of these cereals is projected to be used as animal feed to meet the rapidly growing demand for livestock production, particularly in Asia (Delgado et al. 1999). In addition, more affluent diets will translate into greater demand for more water-intensive crops, such as sugarcane and horticultural crops. Globally, irrigated and rainfed harvested areas are expected to increase by 0.24% and 0.13% per year, respectively, out to 2050. Total harvested area is projected to expand until around 2025 followed by a contraction during 2025–2050 as population pressure declines. However, total harvested irrigated area is expected to continue to increase to 473 million hectares by 2050. Most of the expansion is expected for Asia, followed by Latin America. In sub-Saharan Africa, only 6% of cultivated area is currently irrigated. Despite projections that irrigated area will more than double in the region; irrigation will remain negligible from a global perspective, accounting for 2% of total harvested irrigated area by 2050.

1.3.1 Globalization: Curse or Cure?

In the past, water planning and management practices and processes were comparatively simpler: the driving forces were primarily population growth and urbanization, both of which could be predicted with a certain degree of accuracy. While population growth and urbanization will continue to have impacts on water planning and management for the next 4–6 decades, these impacts are likely to be dwarfed in many parts of the world by emerging new forces. One of these emerging forces is globalization, which makes water management a significantly more complex task than ever before in history. Furthermore, the water sector will have to face increasingly more uncertainties in terms of planning and management.

Globalization in the present context is defined as increased integration of economies, societies, and cultural systems across national boundaries—and reflects the economic face of global change. The globalization process will accelerate significantly in the coming years because of the expanding international market economy, the increase in foreign direct investments, the growth of multinational corporations from both the developed and developing world, the continued information and communication revolution, and legal and illegal migration. National borders are likely to be less important than in the past because of freer trade and finance; rapid movement of knowledge, information, and people; and many other associated reasons.

Recent signs of a much more globalized, integrated world are the energy crisis of 2005–2007, the food price crisis of 2005–2008, and the financial crisis of 2008–2009. These crises have affected all countries in differing ways, but generally poor and vulnerable producers and consumers have fared worst. While these crises might slow global integration processes in the short term and favor enhanced regional integration, it is unlikely that they will cause a significant shift in the direction of these processes.

The question that then arises is how will these developments grounded in increasing globalization affect water management in terms of both quantity and quality. Undoubtedly, water management will be affected by complementary and contradictory forces of globalization through various pathways, only some of which can be predicted with some degree of confidence while others remain unknown. The forces of globalization will bring both advantages and disadvantages to water management, and the impacts will be both positive and negative, over space and time. Many, if not most, of these impacts will be indirect, increasing complexity in the water management process with the passage of time.

On the positive side, knowledge and experiences from developing countries are now becoming increasingly shared because of the communication and information revolution. For instance, developing countries can now find out how their counterparts are solving specific water-related problems under similar social, economic, and institutional conditions. This interchange of knowledge and experience between developing countries is now increasing exponentially, resulting in the use of more sustainable and cost-effective solutions to shared challenges. The revolution in information and communication technologies has generally benefited rural households, promoting greater inclusion of individuals in rural networks, such as water user associations, and helps smallholder farmers, irrigators or not, to keep up with fluctuations in input and output markets, which have become more volatile as a result of globalization.

On the negative side, increased globalization is saddling developing countries with Western paradigms and institutions, which are often inappropriate in that context. By the time the inappropriateness of these paradigms is realized, considerable resources would have been spent, and the problems are likely to have become more acute and complex.

Trade and investment agreements, as well as other bilateral or multilateral agreements, influence how water is being used and allocated both directly and indirectly in developing countries. For instance, the sale of water across borders and foreign investments in water supply and sanitation services have created concerns about continued water availability for local users. A wave of internationally driven private

investments reached developing countries in Latin America and Asia during the early 1990s leading to controversy in many communities where privatization was being considered. While private sector investment in water has the potential to improve the delivery of water and sanitation services, concerns over sustained access to basic services, perceived and actual levels of corruption, and hikes in water tariffs for urban users have stymied the development of private infrastructure projects in many communities.

While water pricing can help in cost recovery for operations and maintenance, it is important that special efforts are made to expand services to poorer areas, including slums. With continuing declines in multilateral investments in irrigation development (an exception is sub-Saharan Africa) and tightening budgets of developing-country governments, water pricing in the agricultural sector also has the potential to improve cost recovery for irrigation and extend the service life of existing projects. Changes in subsidies for irrigation water and innovative pricing schemes can help ensure more efficient use of water for agriculture. Improved strategies for investment in irrigation, public finance, and cost recovery in the irrigation sector can lead to increased agricultural productivity and, in turn, increase food and water security on a larger scale.

In addition to impacts on the availability of water, water quality and ecosystem services are being challenged as a result of global change processes. For example, transboundary water pollution, a reality in many developed countries today, is becoming increasingly prevalent in developing countries as well.

Globalization can affect food security in other ways as well. Trade can potentially be used as a strategy to alleviate the impact of changes in the global water cycle on food production. Trade in "virtual water" is a strategy that could be employed by water-scarce countries in which high water-consuming crops, livestock, and fish products are imported while more drought-tolerant crops are produced at home.

1.4 Global Changes Addressed in This Volume

Given the high stakes for the poor—as evidenced by the large adverse impacts on vulnerable populations from the recent energy, food, and financial crises—an examination of the role of factors driving global change in water and food security and mechanisms to enhance the positive and reduce the adverse impacts of globalization processes is urgently needed.

Key questions that need to be addressed include:

- What are the key forces and emerging issues affecting water and food security for the poor over the coming decades?
- What are the impacts of these key drivers on water and food security and the livelihoods of the poor?
- How can the forces of globalization affecting water and food security be harnessed to improve the outcomes for the poor in the water and food sectors?
- Which policies and investments can improve water and food security for the poor and how can these be financed?

This volume examines the various drivers of global change, including climate change, the use of agricultural knowledge, science, and technology, and trade; as well as the outcomes of global change processes, including impacts on water quality and human well-being. Several authors examine potential policy and institutional solutions afforded by globalization to the challenges ahead, particularly the role of trade policy. Financing water development in a more globalized world and adapting to climate change are also examined.

The first part of the book sets the scene by describing the evolution of water and food security under resource scarcity. Rosegrant et al. describe megatrends and emerging issues affecting irrigation and food production in Chapter 2. They affirm the increasing role of developing countries in global food markets and describe how globalization will increasingly affect water use and food production. The authors identify aquaculture, biotechnology, and climate change as major challenges for future water management in agriculture.

Climate change and globalization are closely interlinked and interdependent. While the exact impacts of climate change are uncertain, climate change will alter the comparative advantage of regions to grow and export food through changes in both water quantity and quality. Authors Aggarwal and Singh discuss the potential adverse implications of both global climate change and increasing climatic variability in Chapter 3. They find that considerable uncertainties remain in our understanding of the vulnerability of agriculture to climate change due to inadequate tools used to study the impacts of climate change, as well as due to large uncertainties related to the spatial and temporal pattern of climatic changes. The authors argue for 'no-regrets' adaptation strategies that support both sustainable development and mitigate adverse impacts from climate change.

In Chapter 4, Msangi et al. describe the impact of biofuel policies, which are driven, in part, by global climate policies, on water and food security. Biofuels have been touted as a sustainable energy alternative to fossil-based fuels that may help resource-constrained nations cope with rising energy prices, while also providing income to poor farmers and rural communities around the globe. Rising fuel prices, growing energy demand, concerns over climate change due to greenhouse gas emissions, increased desire for renewable energy resources and domestic energy independence, and the push for new markets for crops are all factors driving interest in expanding biofuel production. Potential adverse impacts from rapid biofuel expansion include upward pressure on international food prices, making staple crops less affordable for poor consumers; increased competition over land and water resources; and degradation of soil quality and fertility, in particular, and biodiversity and ecosystems, in general.

Authors in the second part of the book explore how trade as a key instrument of globalization affects water and food security. Trade liberalization allows countries to specialize in those goods and services where they have an advantage, allowing water and other natural resources to be used more efficiently in the production of food and other goods. When countries produce and trade according to their comparative advantage, then total output and economic welfare can be increased. According to Bouët et al. (2007) a more open trade regime in agriculture would benefit developing countries in general. However, advances in poverty reduction would be minor.

On the water side, Berrittella et al. (2007) find that overall trade liberalization has a small effect (less than 10%) on water use. Trade liberalization tends to reduce water use in water-scarce regions, and increase water use in water-abundant regions. As a result of lack of progress of the Doha Round of the World Trade Organization (WTO), many countries are increasingly engaging in regional and bilateral trade agreements. According to Bouët and Laborde (2008) failure of the Doha negotiations could result in a loss of more than US$1 trillion in world trade.

In Chapter 5, Sigman and Chang discuss mechanisms by which trade may facilitate coordination on enhanced water outcomes, in this case, for improved water quality. The authors show that trade can provide greater opportunities for policy coordination between trading partners who share a resource. If trade facilitates improved international cooperation in the management of shared natural resources, then these benefits should be added to the other economic gains from expanded trade. In Chapter 6, Ramirez-Vallejo and Rogers examine the trade-water nexus from a virtual water angle. The authors examine whether the argument of virtual water applies in the real world and offer possible explanations for its failure using the case of the North American Free Trade Agreement. Chapter 7 of Briones et al. examines the impacts of the recent rapid increase in global fisheries exports on the welfare of the population in the exporting regions. The authors examine both the impact of exports on local food security as well as the risk for small-scale farmers to be left out of the export bonanza, particularly with the advent of food safety regulations.

The third part of this volume focuses on the legal, institutional, and financial implications of a more global world for water. The authors look at the implications of international investment agreements involving water, the role of the public versus the private sector in provisioning water in the context of globalization, and the opportunities and challenges related to financing water supply and irrigation services under increasingly constrained national budgets, with new financial tools, some of them afforded by more globalized markets. Winpenny in Chapter 8 provides an overview of the scope, sources, and scale of water sector financing. He concludes that international financial flows of all kinds into the water sector have been in decline since the late 1990s and are unlikely to fully recover to their earlier levels. He identifies the mobilization of local savings through the development of local capital markets as the most promising, long-term avenue for the provision of water services for the poor.

In Chapter 9, José Esteban Castro explores the recent experiences of private-sector participation in the provision of water and sanitation services. He shows that the theoretical and empirical evidence does not support the claim that private-sector participation produces higher levels of efficiency than public operators in the provision of water and sanitation services. He concludes, therefore, that a reorientation toward increased state involvement in the provision of water supply and sanitation is needed.

In Chapter 10, Gallagher O'Neal presents a case study on financing municipal water supply services along the US-Mexican border that draws on some of the themes introduced in Chapters 8 and 9. The chapter shows how local communities, federal governments, international agencies, and the private sector can create an environment that is conducive to investments in infrastructure.

Miguel Solanes in Chapter 11 examines the decisions of arbitration tribunals created under international investment agreements as they relate to water. He identifies various imbalances in these agreements, which tend to favor the investors and could lead to unbalanced decisions in water allocation and use, and potentially adverse outcomes for the poor.

Chapter 12 summarizes the main lessons on the impact of global change on water and food security and identifies avenues for policy reform and investment based on the discussions in this volume. The chapter concludes by identifying needs for research and policy action in this area.

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