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The Role of Water Policy in Mexico:

Sustainability, Equity, and Economic Growth Considerations

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This working paper was prepared by Ariel Dinar and Musa Asad as a synthesis of the various background papers which served as inputs into the Economic Sector Work, "MEXICO**:** ASSESSMENT OF POLICY INTERVENTIONS IN THE WATER SECTOR." That study was part of a broader analysis of the sector. It intended to promote an analytical and consultative process among stakeholders on the multisectoral solutions required to fully address the challenges Mexico faces, and to provide a comprehensive framework to allow them to assess and prioritize policy interventions. A diverse group of core team members and consultants participated in the ESW. The core team members were: Musa Asad and Ariel Dinar (Team Co-Leaders), Ricardo Hernández, Juan Martínez, Douglas Olson, Monique Pelloux, Manuel Schiffler, and Steve Webb. The consultants were Julio Goicoechea, Hilda Guerrero, Consejo Consultivo del Agua (CCA), Instituto Nacional de Ecología (INE), FAO, Colegio de México (COLMEX), and Patricia Avila. Peer reviewers included Karin Kemper and Manuel Contijoch. José María Caballero, John Kellenberg, Gustavo Saltiel, Ethel Sennhauser, and David Rosenblatt provided constructive comments. Janice Molina provided valuable translation and editing support. Guidance was provided by Dr. Fernando Tudela Abad, Undersecretary of Environmental Planning and Policies for the Ministry of Environment (SEMARNAT), and Ing. César Herrera Toledo, Deputy Director, CONAGUA. The team acknowledges the financial support of the Bank–Netherlands Water Partnership Program (BNWPP) in the preparation of certain components of the ESW..

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Foreword

Mexico has great natural beauty and resources, of which water is one of the most precious both for its value in creating and sustaining life and as an indispensable resource for economic growth and development. In recent years, the sustainable management of this resource has become one of Mexico's greatest environmental challenges. In particular, economic growth along with population increases primarily in the north, northwest, and central regions has contributed to a rapid increase in the use of available water, thereby exacerbating existing regional differences in the availability of water. At the same time, Mexico continues to grapple with water management problems resulting from long periods of unsustainable exploitation of surface and ground water resources in most of its regions.

In recent decades, the decreased availability of water increased water pollution, combined with increased demand, have drawn the attention of both the Government of Mexico and civil society. Thus, the country has implemented a series of actions to mitigate the consequences of a potential depletion of water resources, and it has made significant achievements, including the definition of a legal and institutional framework for integrated water resource management, and the expansion of access to water and sanitation services which now reach 90 percent of the country's population.

Nevertheless, significant challenges remain, particularly in terms of improving water services and quality and defining the regulations required to implement the established legal and institutional framework. Over half of Mexican households still lack reliable and continuous water services. For most of the country, municipal effluents remain untreated and irrigation systems have rates of inefficiency that exceed 50 percent. These problems have an adverse impact on achieving both sustainable growth and improvements in the quality of life, especially among the most disadvantaged segments of the population.

Mexico is undergoing an important transition period and, with the support of public and private institutions and of civil society in general, it is introducing a series of reforms in the sector that will contribute to achieving the objectives of poverty eradication and addressing social disparities. The current scenario, in particular, presents important challenges and interesting opportunities. In this context, equal and fair access to water, both for human use and for promoting growth, are key conditions for achieving the goals of building a better and fairer country. In this context, the Mexico–World Bank Strategic Alliance identifies the water sector as a priority area for collaboration. Under this alliance, the Bank, as a development partner, was invited to provide technical assistance, international experience, and financial support for the preparation and implementation of programs to improve the quality of life of those directly affected by current problems facing the water sector.

The following report forms an integral part of the *Serie de Agua de México*, which is the result of joint work by the Bank and its Mexican counterpart over the past decade. This series of documents discusses the principal challenges in this sector, for the purpose of facilitating an intellectual debate aimed at seeking solutions to the country's most pressing water problems. Its ultimate purpose is to identify these challenges, promote reflection and debate, and offer alternatives in the search for solutions. We hope that the present report, together with the water series, may serve as useful instruments that contribute to the achievement of goals of poverty reduction, social inclusion, preservation of natural wealth, and sustainable economic development.

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Introduction

This working paper presents a summary of the results of a report which undertook an economic assessment of policy interventions in the Mexico water sector. The report constitutes part of, and seeks to provide the analytical underpinning for, an array of World Bank lending and advisory service products that are intended to support Mexico's efforts to develop a long-term sustainable water management system. Although the work involved extensive collaboration with both the government and Mexican specialists, the views expressed are attributable to the World Bank team that led the initiative. The summary distills the report's main findings and messages. Section A highlights the context for the assessment that was carried out, Section B describes the assessment objective and methodology, Section C describes the consultative process and main issues identified for purposes of focusing the analytical work, Section D identifies key analytical findings, and Section E focuses on some of the main conclusions and messages.

A. BACKGROUND

Water resources management is one of Mexico's most urgent environmental and resource problems, and one that imposes heavy costs on the economy. The country is slightly less than 2 million km^2 in size and the population has quadrupled from 25 million in 1950 to over 106 million in June 2005. Population growth has occurred nationwide, but because of internal migration it has been greater in the semi-arid and arid north, northwest, and central regions, which are precisely the regions with greater economic activity and where water is scarce. The resulting increased demand for water, combined with more intensive use of water (stimulated in part by price distortions and relatively weak monitoring and enforcement arrangements), has led to insufficient water availability to support natural ecosystems, and seriously constrains growth in many areas.

Mexico has demonstrated many accomplishments in the water sector, including a comprehensive legal system, a national water authority, a functioning water rights system, and an incipient water market. However, the country's water sector still faces significant challenges. These include issues of sustainability, economic efficiency (or limits to growth), and equity. For example: (i) increasing and continued overexploitation of water resources has significant negative impacts on the resource's near- and long-term availability; (ii) distorted prices, subsidies, and/or other incentives in the water and related sectors encourage unsustainable water resource use practices and discourage water allocation to its highest productive uses; (iii) laws, regulations, policies, and investments that create the conditions for unsustainable water use and/or distortions often result in an inequitable allocation of fiscal resources.

More specifically, nearly 80 percent of Mexico's rapidly growing population is now concentrated in the northern and central areas, which account for over 80 percent of GDP, over 90 percent of irrigation, and 75 percent of industrial activity. Institutional arrangements to address the consequent increase in demand for water resources are inadequate. Water prices, as well as electricity prices for pumping groundwater, do not reflect water scarcity. Thus, Mexico now faces a "water crisis" that includes the overexploitation of 102 of its 653 aquifers, accounting for more than half of groundwater extraction in the country. The National Water Commission (CONAGUA) estimates groundwater overextraction at almost 40 percent of total groundwater use. The value of the overextracted groundwater in agricultural production alone is estimated at more than US$1.2 billion or 0.2 percent of GDP. The depletion of many aquifers leads to nonprice and unregulated rationing, distorting growth in Mexico's most dynamic economic regions. Some apparent contradictions between the Constitution and national water laws and regulations further complicate this sort of rationing, particularly in relation to disenfranchised populations.

Although some irrigation is shifting to water-saving technologies, the shift is limited, and the crop mix remains largely the same because (i) water and electricity prices still give the false signal that water is abundant, and (ii) irrigation infrastructure is insufficient to allow farmers to shift to specialty crops. Moreover, agricultural producers benefit from low electricity tariffs for pumping. Consequently, farmers have little incentive to change current practices, which result in overpumping aquifers, lowering the groundwater

table(s), and in many cases allowing the intrusion of salt water. In addition, the financial cost to society of the nearly US$700 million per year electricity subsidy may represent only a fraction of the full economic cost, since environmental degradation is not valued properly.

In summary, with water in Mexico becoming very scarce spatially and over time, it is now a factor that limits economic activity and social well-being in selected regions. The identification of priorities and trade-offs in relation to water allocation requires careful and timely attention to address an ever-growing range of complications arising from the impact of various interlinked considerations, such as sustainability of water resources, fairness, pollution, environment, basic services, development, competition, and globalization. National policies, both within the water sector and for the overall economy, need to accommodate these issues. Otherwise, the trend in undervaluing and overexploiting water resources will lead to increasingly significant negative impacts on the overall economy and society.

B. OBJECTIVE AND METHODOLOGY

While the issues described above may be familiar to many experts in and outside Mexico, understanding of the economic implications of possible solutions is far less common. Moreover, agreement on the multisectoral solutions required to fully address these challenges has not yet been reached. ***Consequently, a comprehensive framework to allow various relevant stakeholders to assess and prioritize policy interventions is essential. This study has precisely this purpose***, and although indicative policy alternatives inherently arise from the study, it is not intended to provide a prescriptive set of preferred investments or policy recommendations.

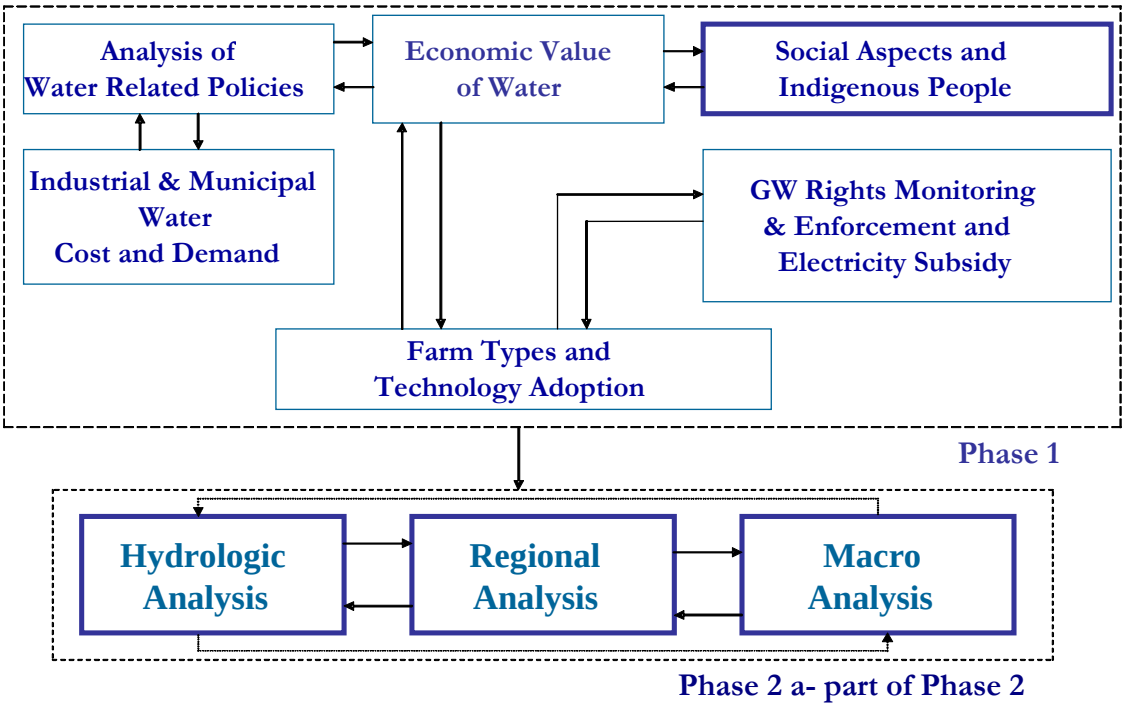
The study is part of a broader analysis of the sector. Its intent is to promote an **analytical and consultative process** that spanned at least two years and included the following:

- Identification of priority issues that represent the main challenges facing the water sector in Mexico. This was done through consultations with various stakeholders (high-level representatives from the Government of Mexico, academia, industry, municipalities, civil society, etc.). The results of this process are described in Section C below.
- Identification of a case study river basin (Río Bravo) and reaching agreement on a process for carrying out the analytical work.
- Completion of specific background papers to address the most pressing issues (see Section D below). These include:
    1. Economic Value of Water (EVW)
    2. Comparative Analysis of Water-Related Policies in Mexico and their Impact on Water Productivity and on Sectors and Socioeconomic Groups in Society
    3. The Cost of Providing and the Willingness to Pay for Water in the Municipal and Industrial Sectors

4. Identification of Farm Types and their Capacity to Adapt to Policy Interventions in the Río Bravo Basin
5. Agricultural Demand for Groundwater in Mexico: Impact of Water Rights Enforcement and Electricity Tariff on Groundwater Level and Quality
6. Assessment of Public Policies and Water Management in Indigenous Regions

- Development of analytical models to assess the linkages and impacts of various policy instruments on the water sector and the economy. The models draw on findings from the background papers for purposes of identifying an indicative set of policy interventions to simulate. The main policy messages derived from the application of these analytical models are highlighted in Section E below.

The following figure presents a scheme with the background papers of the study, their relationship to each other and to the analytical model.



C. Consultative Process and Priority Issues

The identification of priority issues for purposes of focusing this study is based on extensive collaboration with various stakeholders, including high-level representatives from government, academia, industry, municipalities, and civil society. Highlights of this process include the following events and activities:

1. Launching of videoconference workshop, Washington and Mexico City, June 2004
2. Meeting with Government of Mexico and civil society, Mexico City, August 2005
3. Workshop with COLMEX and civil society, Mexico City, November 2004
4. Working workshop, Davis, California, April 2005
5. Working workshop, Mexico City, May 2005
6. Meeting with Government of Mexico, Mexico City, June 2005
7. Meeting of Government of Mexico, Mexico City, November 2005
8. Dissemination and dialogue with civil society. Workshops with PAMAS/COLMEX/UNAM: (1) Villahermosa; (2) Puebla, (3) Hermosillo, February 2006.
9. Session at the 4th World Water Forum, Mexico City, March 2006
10. Global Distance Learning Network Initiative, in progress.

This consultative process is essential to the overall objective of the study to the extent that it helps inform meaningful policy dialogue and debate. It also forms the basis for the identification of the following priority issues analyzed by the study.

Sustainability Issues

Overexploitation of water resources. In part, because water prices (and electricity prices for pumping groundwater) do not reflect water scarcity, many water-intensive agricultural activities predominate in the dry central and northern regions, where most of the irrigated production takes place, leading to overexploited aquifers in many areas. CONAGUA estimates groundwater overextraction at 6 km^3/year, or almost 40 percent of the total groundwater use of 25.7 km^3/year. The depletion of many aquifers leads to nonprice and unregulated rationing, which distorts growth in Mexico's most dynamic economic regions. Most large industrial users supply themselves with water from their own sources. Some irrigation is shifting to water-saving techniques (e.g., drip rather than sprinkler or surface irrigation) in response to the shortages, but the shift is limited, and the crop mix remains largely the same because the prices (water and electricity) still give the false signal that water is abundant. In particular, agriculture benefits from low electricity tariffs for pumping. With a seemingly inexpensive groundwater cost, farmers, who apply myopic considerations and do not address relevant alternatives to substitute an attractive resource, overpump aquifers. This lowers the groundwater table(s) and in many cases allows the intrusion of saltwater.

Environmental Concerns. Considerations of environmental uses of water, an important component of a healthy water resources sector, presently fail to place a value on in-stream and downstream value of water (e.g., mangroves and fishing) and the amount by which water overuse negatively impacts the environment. The Mexican Water Law acknowledges the need to maintain water flows for the use of biological systems. The National Commission on Biodiversity (CONABIO) has determined the hydrological areas of relevance for biodiversity. Even relatively small amounts of water flow can make an enormous difference in the conservation of riparian vegetation and the salinity balance

in coastal lagoons. A proper assessment of the added value of water use for environmental purposes could provide insights for a better integration of environmental considerations for water resources management.

Water Reuse. Direct and indirect reuse of both treated and untreated municipal and industrial wastewater has a long tradition in Mexico and is common throughout the country, except for coastal areas that discharge their wastewater into the sea. Most wastewater from Mexico's inland cities is reused indirectly in an unplanned manner, after being discharged into a river and blended. Some wastewater is reused directly and in a planned manner for irrigation, usually without any payments being made for the water. A small portion of treated wastewater is reused in industries, the only sector that is able and willing to pay significant sums for reused water.

Water as a Limiting Factor to Economic Growth

Competitiveness. As Mexico's economy becomes increasingly open, regional and international opportunities for economic expansion are growing. However, such opportunities have not been fully pursued, in part due to (i) inadequate incentives to improve water use, such as moving water from low- to high-value uses, and (ii) the water rights administration system in place that makes it difficult to trade in water and to adjust water use to sectoral demands and market signals. For example, some industries cannot be established in attractive regions due to difficulties in securing water rights.

Trade. The expansion of regulated international trade has been one of the most important economic changes affecting the use and value of water. As international trade opens more, as it has done in the last 20 years in Mexico, foreign supply and demand enter the picture, and the rational reallocation of production should move toward more water-productive activities, if there are relatively free market prices for water as well as for goods and nonwater inputs. Products with greater water intensity would be imported from places with more water, and Mexico would specialize in tradable products that need less water. The transmission of such information and incentives (including those for water) to producers in a market-driven economy would take place through changes in relative prices. But this has not happened for the most part, and thus the specialization of production within the nation's agricultural sector has shifted toward, not away from water-intensive activities. Irrigated production in agriculture reflects an increase in its share from 45 to 55 percent during the 1980s and 90s, and now accounts for about 70 percent of Mexico's agricultural exports.

Equity Considerations

Regional Differences. The expansion of agriculture and other economic activities in the north also results from several policy interventions. The highest federal spending per capita on hydraulic infrastructure, such as storage and conveyance, goes to the Federal District and to very arid states of the north—Baja California, Colima, and Sonora. Federal support per capita for agricultural programs, and subsidies for pumping irrigation water, also go to the states of the north and center, where most population and economic activities are concentrated and water is scarce. These observations have implications beyond economic efficiency and touch upon equity and poverty aspects as well.

The concentration of federal spending and subsidies for water supply and sanitation, hydraulic infrastructure, and agriculture in the north and center is understandable because these areas are more populated and in greater need of irrigation for agricultural production, but it also corresponds to a relative neglect of areas of greatest poverty. The concentration of agricultural programs in the wealthier and drier states may also have contributed to the overuse of groundwater, while less environmentally problematic rainfed agriculture in the poorer southern states may have been neglected.

Water Supply and Sanitation Coverage. Since the decentralization reforms in the 1980s, municipalities have assumed responsibility for water supply and sanitation. Coverage has continued to increase since then, largely thanks to federal and state subsidies, but service quality remains low (widespread intermittent supply, poor water quality). A large number of people lack service, including 13.2 million without piped water and 23.7 million without sanitary drainage. In addition, only about half of the households in poor urban neighborhoods receive water every day, 24 hours a day. Many water supply agencies suffer from high levels of nonrevenue water, low collection efficiency, overstaffing, and poor institutional capacity linked to high staff turnover. Few municipal or water supply agencies have acted decisively to resolve such inefficiencies, although revenues could be substantially increased, with minimal or no tariff increases, merely by focusing on bill collection and the reduction of distribution losses.

Crosscutting Issues

Localization and Decentralization. Notwithstanding CONAGUA's formally assigned role, in practice control of most water resources has been given to farmers. At the same time, while on average farmers in Irrigation Districts pay up to 80 percent of operation and maintenance (O&M) costs, they pay little or nothing for primary and secondary infrastructure investment costs. Local water authorities also have considerable control of water resources. They are supposed to pay something (generally less than the economic opportunity cost of the most valuable alternate water usage), but generally they do not. Industrial and commercial water users, at least the large ones, do pay substantial water use fees, but these users account for less than one-tenth of water usage. On the other hand, most local water supply agencies (*organismos operadores*) are still dependent on the municipalities and subject to political interference in their daily operation, a situation that does not lead to efficient supply and service provision. The 2004 National Water Law (NWL) strongly supports basin- and aquifer-level water resources planning and management to be carried out through the participation of various government departments representing the different administrative levels of government (federal, state, municipal), water users, and the private sector. However, implementation of this new legal and institutional framework remains pending.

Water Rights. Administration of water rights, although considerably modernized relative to pre-1990 circumstances, remains inadequate. Legal and institutional uncertainties, complications related to rights concessions, inadequate enforcement of existing legislation and regulations, and limited economic incentives to promote more efficient intra- and intersectoral water use are some of the main issues to be addressed over the coming years.

D. MAIN ANALYTICAL FINDINGS

International experience suggests that the priority issues identified above are not unique to Mexico. Countries as diverse as Morocco, India, Brazil, Australia, South Africa, and others have grappled with similar challenges. Among the lessons learned from experience over the past two decades, the following seems to be especially relevant for Mexico. The main challenge is to develop a pragmatic approach that respects the principles of efficiency, equity, and sustainability, while recognizing that water management is intensely political, and that reform requires the articulation of prioritized, sequenced, practical, and patient interventions. This would require both management and infrastructure development interventions. An essential aspect of this approach would be to find the right balance between these interventions. Given the scarcity of water resources in Mexico, this balancing act requires informed policy makers across sectors to engage in a decision-making dialogue based on a common analytical framework. The main findings from the background papers provide an indicative set of policy alternatives that could address issues of sustainability, equity, and economic efficiency (or constraints to growth).

Economic Value of Water (EVW)

Policy makers can learn a great deal from a relatively simple analysis (tool) that provides the economic value of water (EVW) across uses and regions. The reported values give policy makers a signal about the performance of the policies leading to a given allocation of the water among various sectors or various regions in the economy net of transaction costs. These transaction costs include the cost of pumping water, the cost of transferring water rights, and various indirect costs. The EVW prioritizes water uses based on their water productivity. However, transaction costs can be substantial and make unfeasible those water reallocations that would otherwise seem economically feasible. Therefore, the usefulness of an EVW analysis lies in its broad basis for dialogue among various stakeholders and its flexibility to incorporate alternative policy intervention considerations and their costs. The following table presents the differences both within three regions of the Río Bravo basin and among water use activities. The EVW differences tell the policy makers a story. It is particularly noteworthy that irrigated agriculture and livestock are associated with the lowest EVW (measured in MXN/m^3), yet together they consume the lion's share of the water in the basin.

Present Water Allocation and EVW in Three Regions of the Río Bravo Basin (in Mexican pesos)

	Juarez		Saltillo		Bajo San Juan		Total
	000000 m^3	MXN /m^3	000000 m^3	MXN /m^3	000000 m^3	MXN/ m^3	000000 m^3
Irrigated crops[a]	88,529	0.15	29,117	0.43	117,331	0.2	234,978 (97)
Livestock	134	33	1,114	15	161	44	1,410 (<1)
Mining	0.214	7,832	0.268	5723	1.613	413,950	2.095 (<1)
Manufacturing	260	7974	98	24642	109	7,885	468 (<1)
Construction	78	1,327	105	539	80	1,108	264 (<1)
Nonfinancial Services	2,244	948	1,177	762	1,214	680	4636 (2)
Total (water)	91,248		31,613		118,898		241,761

Note: [a]Values used in irrigated agriculture are for net water consumption. Rounded shares are in parentheses.

Consequently, the apparent imbalance between water used in irrigated agriculture and its value added to the economy implies questions of equity, productivity, and efficiency for the regional economy and the overall economy. Policy interventions to address these questions include the following:

- In the agricultural sector, both improved irrigation technologies and more profitable cropping patterns could be considered. Besides its beneficial effect in terms of higher productivity and labor demand, the quality of the output may also be improved, thus better positioning the region in local and foreign markets.
- Free trade agreements could facilitate a greater shift toward high-value crops, thereby stimulating the growth of technological and infrastructure investment for regions and the overall economy.
- The improvement of water use allocations is closely linked to the legal and regulatory system. Transparent and accurate public water rights registries, for example, could lead to more efficient and equitable water allocation, including the potential for market-based exchanges that direct water toward its most productive use.

Comparative Analysis of Current Water-Related Policies

The development of a comprehensive framework to assess the impact of policy interventions in the water sector requires an understanding of intra- and intersectoral policies. The main findings indicate that Mexico maintains a somewhat confusing and conflicting array of laws, regulations, and policies that affect the extraction and use of water along with the processing of wastewater. More specifically:

- Responsibilities and authorities for water resources management are specified in the Mexican Constitution (Articles 27 and 115) and in specific laws such as the National Water Law and the General Law of Ecological Balance and Environmental Protection. Other laws such as the Fiscal Coordination Law, the Federal Rights Law, the National Water Commission Rules, the Federal Rights Law, and the General Health Law further complicate the legal framework by

adding multiple and sometimes contradicting layers of regulation. The distribution of responsibilities among a large number of federal, state, and local authorities has led to uneven results and there is widespread noncompliance with many applicable regulations.

- The Law on Contribution of Improvements indicates that income received through the application of this law shall be allocated to the National Water Commission for the construction, repair, expansion, completion, or modernization of federal public works for hydraulic infrastructure. However, such infrastructure is generally very important for and directly involves states and municipalities. As a result, the limits to fiscal and administrative decentralization under this legislation may exclude participation by important stakeholders.
- The Fiscal Coordination Law requires states and municipalities to spend federal revenue for "achievement of and compliance with the objectives that this law establishes for each type of contribution…": education, health, social infrastructure, municipal strengthening, and public safety. Aside from the implicit limits to decentralization, the law fails to specify allocations for the environment or wastewater treatment infrastructure.
- The Federal Rights Law recognizes the economic value of water. The law, subject to annual modification, requires a high water fee for industrial users and a lower fee for municipal users. Agricultural use is exempt from water fees, except for a minor charge under implementation as of 2004. This generates significant distortions in the efficient allocation of water resources and in the functioning of markets. It also inhibits and delays the possibilities for improving the marginal productivity of water.
- The General Health Law establishes that "persons involved in supplying water may not suppress the provision of drinking water and drainage services to inhabited buildings, except in cases determined by applicable general provisions." Implicitly not allowing service to be cut off eliminates a very powerful incentive to compel customers to pay for drinking water, drainage, and treatment services.
- NOM-ECOL-002 (dumping of wastewater in municipal drainages). Surveillance and monitoring are major problems because on the one hand municipalities lack the institutional and operational capacity for surveillance, and on the other hand they lack the required incentives. In the event of noncompliance, there are limited or no provisions for sanctions through the retention of budget allocations.
- There are confusion and scattered authorities in terms of surveillance of the quality of marine waters (CONAGUA, Health, Navy, and PROFEPA). This allows coastal municipalities that dump wastewater into the sea to more easily evade the responsibility of treating it.

In summary, the analysis of the existing legal and policy framework highlights the fragmented nature of the sector, the limited institutional capacity, and the lack of incentives to meet national objectives. These limitations and constraints are crosscutting. If institutional, legal and regulatory, and monitoring and enforcement arrangements are not adequately addressed, few if any of the policy alternatives the present study seeks to

identify would be effective. Broad regional interventions that could create market-based incentives, such as a tradable water rights system, require strong institutional, legal, regulatory, and monitoring and enforcement mechanisms to function well. Performance-based incentives to improve utilities would be most effective when adequate monitoring and enforcement arrangements are in place. Targeted interventions would be most beneficial when combined with an appropriate legal, regulatory, and institutional framework that assures the right pricing signals.

The Cost of Providing and the Willingness to Pay for Water Supply

Municipal and industrial (M&I) sectors in Mexico only consume around 15 percent of available water. Nevertheless, the consumption trend is growing rapidly, and M&I users compete with irrigation water users in certain regions, particularly in the Río Bravo and growing urban centers. The findings of many reports commissioned by the Government of Mexico suggest that the cost of supplying water in Mexico is relatively high, and that for many reasons, the water supply companies do not demonstrate financial sustainability. To identify policy interventions that could improve the performance of water supply companies, it is important to understand the water supply data. Otherwise, policy makers cannot assess the potential impact of, for example, performance-based incentives for utilities.

Urban Sector. The national average unit costs in Mexican pesos (MXN) of municipal water production and supply, evaluated for a sample of 2,356 operating agencies in the country, are MXN 1.95/m^3 (US$0.21) and MXN 2.55/$m^3$ (US$0.28), respectively. Nationally, because municipal water agencies' net income is negative (MXN -0.17/m^3), 65 percent of operating agencies do not recover their water supply costs. Analysis suggests that one of the main reasons for this problem is that only about 60 percent of all water produced is invoiced. The underlying problems relate to inadequate billing, limited use of leak-and-detect systems, and inefficiency in water use and conservation. Ironically, studies indicate that the percentage of average monthly income that a Mexican family is willing to pay for water supply service (for example, 4 percent in Mexico City and Guadalajara) is similar to that reported in other regions of the world (3.5 percent). This suggests that while there is a willingness to pay for improved water supply services, the (temporary) inefficiency of the suppliers does not allow appropriate cost recovery, and this may have a vicious effect on users who are unhappy and unwilling to pay. CONAGUA has designed programs (e.g., PRODDER) to address this issue, but these may be susceptible to the limitations of federal subsidies, rather than creating incentives and enforcement mechanisms that target the underlying system inefficiencies.

Industrial Sector. Analysis indicates that unit fees and water productivity vary widely among regions (i.e., fees ranging between MXN .84/m^3 and MXN .06/m^3, and water productivity estimates ranging from MXN 14.27/m^3 to MXN 0.77/m^3). This seems to derive from a nationally designed differential tariff system that may be based largely on political determinations. Policy alternatives that shift tariff design more toward water use efficiency considerations could yield benefits for regions and the overall economy. At the same time, since the share of water cost in relation to an industrial firm's total costs

seems to be nominal (often on the order of just 2 percent), industries should be able to respond adequately to a redesign of the tariff system.

In summary, many of the M&I water supply service problems arise from inadequate management practices and inefficient pricing systems. However, there appears to be ample scope for improvements without introducing inequitable or infeasible increases in water fees. Policy alternatives that shift away from political considerations toward water use efficiency objectives should be given closer attention in this regard.

Farmers' Capacity to Adapt to Policy Interventions in the Río Bravo Basin

As indicated in the EVW analysis, the Río Bravo Basin (RBB) is a major user of irrigation water. It encompasses 11 Irrigation Districts (ID) and 3,223 Irrigation Units (IU), with a total irrigated area of 794,000 ha.

Using farm-level production data, it is possible to assess how various farm types respond to different policy interventions at the farm level. Such information, although localized, provides interesting insights to policy makers. For example, it is possible to assess the capacity of farmers to respond to broad policies that shift subsidies away from groundwater pumping toward technology adoption, or that allow water use rights to be shifted among crops/sectors/regions under a tradable rights system. It is also possible to assess the impact of more targeted interventions that focus on, for example, changing water allocation and farming techniques to improve degraded areas and resources. The analysis carried out yields a number of prospective policy solutions that could improve irrigation water use efficiency, including the following:

Reducing Harvested Area. Generally, the irrigation schedule of different crops in IDs follows the same scheme, established to assure the irrigation of grains (maize and sorghum). Therefore, other crops using surface water must irrigate according to that general scheme. This may explain the relative inflexibility of the irrigated agricultural sector to adjust to varying climate conditions and water availability across years. As such, limited options available to farmers are limited, and the main one they use to respond to reduced water availability is a reduction in the harvested area. Depending on the EVW for different types of water use, area reductions could be offset by investments in technological improvements.

On-farm Water Allocation Flexibility. Water allocation rules are rigid and designed to accommodate grains. For example, in the case of vegetables, which are not technically feasible with the grain irrigation schedule, farmers use groundwater to supplement surface water. In this case, each farmer makes his own schedule for irrigation, leading to suboptimal water applications and inefficiency. Several policy interventions may address such problems. One possible solution is the creation of an on-farm reservoir that would be filled by the scheduled water supply and used for irrigation by crop demand and available technology. Policies that can package technologies and crop mixes, along with credit and extension for constructing and operating an on-farm small reservoir, can make a difference.

Part-time Farming and Water Use Efficiency. Despite severe water scarcity in the RBB, irrigation efficiency tends to be very low. Modernization of irrigation networks and

modification of on-farm technologies are now being undertaken. Although these interventions may lead to increased water use efficiency, the problem may lie elsewhere. More than 50 percent of the irrigated land is absentee-owned and leased. Research suggests that renters, as compared to owners/operators, are less inclined to improve their water use by investing in management and infrastructure. Finding a cost-sharing formula that will accommodate the large share of absentee owners in the region could allow a reduction in average water application of 20,000 m^3/ha.

Groundwater Regulation. The cost of groundwater supply (mainly due to the energy subsidy) is very similar to the price of surface water rights in dry years. As such, farmers are likely to run their pumps more frequently. Policies that promote joint use of groundwater and surface water across years, with different types of groundwater recharge incentives in abundant years, could address current groundwater overexploitation problems.

Impact of Enforcement and Electricity Fees on Groundwater

One of Mexico's most troubling environmental problems is the unsustainable management and use of groundwater. Because of various policy interventions that led to mismanagement of this resource, groundwater stocks are being polluted and depleted. Groundwater is consumed by both agricultural and urban uses. Seventy percent of urban water supply in Mexico is from groundwater, and it serves 75 million urban inhabitants. However, it is irrigated agriculture that consumes the lion's share of groundwater and thus it is natural that policy interventions should primarily address agricultural users.

As indicated above, there were 102 overexploited aquifers in Mexico in 2005 (out of the 188 most important ones). The number of overexploited aquifers has grown steadily over the last 30 years. Due to overexploitation, the groundwater reserve is being depleted at an annual rate of 6 km^3. It appears that 66 percent of the groundwater used in the country is extracted from these aquifers, and they receive 79 percent of the national recharge.

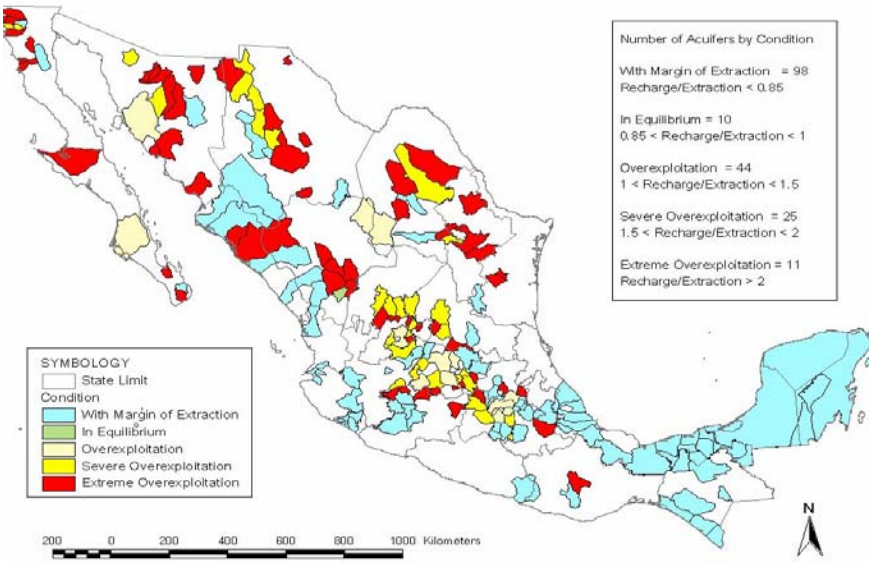
The location of the overexploited aquifers is both an indicator and warning. As the figure below shows, most of the extremely overexploited aquifers are in the central-northern regions of Mexico, where water scarcity is an issue and where the most active water-using economic sectors operate. The geographical distribution of this resource implies scarcity where the economic activity takes place.

The root of the problem is in part the unsustainable use of water in irrigation. It is fostered by direct subsidies (or lack of appropriate pricing) for the resource and by indirect subsidies, known as "*Tarifa 09*" (see the following Box), for electrical power used in groundwater pumping for irrigation. Such subsidies have been the result of concern and political pressure to aid the agricultural sector through subsidies, guarantee prices, pesticides, seeds, and several other factors of agricultural production in order to increase the sector's competitiveness.

Tarifa 09

The average cost of producing electricity in Mexico is MXN 0.61 MXN (MXN 10.7 /US dollar) per kilowatt hour (KwH) without considering additional transmission costs. The fee for a farmer benefiting from a concession is MXN 0.22 per KwH (Tarifa 09-CU), which corresponds to a subsidy of 63 percent (other subsidies are also included under Tarifa 09, such as the night rate). Federal Electricity Commission data for 2002 and 2003 suggest that the number of users benefiting from Tarifa 09 is 96,000. Only 55,000 users hold a concession title while 41,000 do not. Altogether they receive an annual subsidy of approximately US$684 million or MXN 7,327 million through Tarifa 09.

The 188 Most Important Aquifers and their Levels of Exploitation



Source: Prepared by INE with data from CONAGUA, Water Statistics in Mexico, 2005 edition

In addition to being destructive in the use of water resources and in creating externalities, Tarifa 09 is also distributed unequally among concession users and among nonconcession users. In a very gross distinction, nearly 70,000 users (concession and nonconcession) receive an annual subsidy of less than MXN 20,000, and 33 users receive an annual subsidy in excess of MXN 500,000. Moreover, data on groundwater extraction suggest that the total volume extracted exceeds the concession volume in 80 percent of cases. The larger the concession, the smaller the probability of overextraction is. Users consuming less than their concession rate are those who have access to already overexploited aquifers. They face higher pumping costs, a direct result of externalities not being properly internalized or allocated among all relevant users.

Clearly, maintaining this sort of inefficient and inequitable subsidy is unsustainable. It is equally apparent that reduction/removal of the electricity subsidy would induce farmers to reduce their pumping, introduce irrigation technology improvements, and change cropping patterns. However, policy options for eliminating the subsidy may be difficult to

implement and may create political unrest. On the other hand, decoupling the subsidy from the resource could allow the effect of a price increase (subsidy removal) while mitigating the risk of political and social unrest. The following table highlights the decoupling options.

Decoupling Alternatives and their Impacts

Decoupling alternative	Affected groups	Expected impact
(1) Refunding only for overexploited aquifers.	Will affect only 30% of users.	Sends a signal to users in the most affected aquifers. Allows flexibility and adaptation over time.
(2) Refunding an average subsidy to each farmer.	Attractive to small concession holders and harmful to large ones.	May not be politically feasible.
(3) Refunding based on historical consumption.	Will maintain the status quo in terms of nominal payments.	May create tension regarding the basis for calculation (the period used for averaging quantities of water use).
(4) Refunding to concession holders only.	Users with no concessions will be deprived.	Needs a political determination. Could generate a market for concessions.
(5) Refunding on a per hectare basis.	Similar to alternative 3, except that the base is area rather than historical use.	Will need to be closely monitored. Recommended not to distinguish among crops.

In summary, groundwater overexploitation represents an urgent environmental and economic problem for Mexico. Subsidy programs that induce water users to increase groundwater exploitation rather than improve water use efficiency, appear to be unsustainable. At the same time, policy options are available to substantially reorient such subsidies, thereby improving the sustainability of water resources while mitigating the risk of political and social unrest that could result from simply eliminating the subsidies altogether.

Public Policies and Water Management in Indigenous Regions

Estimates of the indigenous population in Mexico vary, depending on the criteria used. The predominant official criterion deals with language: population above age 5 who speaks an indigenous language; and according to the 2000 population and housing census, the population was 6,044,547. Nevertheless, if criteria are expanded, the population would total 12,707,000 (according to official sources such as the National Commission for Indigenous Peoples' Development and the National Population Council).

The following table highlights the difficult conditions under which the indigenous populations live. Their income levels are the country's lowest because of the type of

activities they carry out (subsistence production). Their access to and opportunities for infrastructure and public services are also unequal.

Indigenous peoples are important not only for their location in the principal zones of water production (temperate forests; hot and humid rainforests), but also because they possess a diversity of water cultures which in the pre-Hispanic period contributed to the development of the Mesoamerican civilization and the formation of "water societies." These peoples currently have social regulations and local institutions that define water access and rights for all who reside in their territory.

However, many of their community institutions and regulations are not legally recognized by the State and are carried out in a more informal manner. The different indigenous regions studied have self-management strategies to utilize water: from community labor for cleaning springs, to the assignment of water uses and distribution through collective meetings or assemblies. These regulations have led to social cohesion and conflict resolution at community and intra-community level. In some indigenous communities, during the low-water period (March–May) an assembly decides on the amount of water supply needed. This ensures at least a small volume for community survival at the most critical moments.

Basic Information on the Indigenous Population

Total population in Mexico (1999 Census)	97,483,412
Overall estimate of indigenous population (CONAPO-INI)	12,707,000
Localities with 40% or more of indigenous population	
Percentage of employed population who work in the primary sector	56.8
Percentage of employed population who do not earn income for their work	30.7
Percentage of employed population who earn 1 to 2 minimum wages	22.2
Percentage of houses with dirt floors	53.5
Percentage of houses without piped water	42.3
Percentage of houses without drainage	73.0
Percentage of houses without electricity	20.7
Percentage of houses without piped water, drainage, or electricity	13.0

Source: Serrano, Enrique, Arnulfo Ambriz, and Patricia Fernández, Indicadores socioeconómicos de los pueblos indígenas de México, INI, UNDP, CONAPO, Mexico, 2002.

The disassociation and omission of the sociocultural dimensions of water is a means of making vulnerable the bases for contemporary civilization and for indigenous peoples where there exists a culture of water use and management. It is also a way to generate conflicts over water and to upset the social mechanisms and forms of social management that have guaranteed collective access to and use of water.

Recognition of indigenous rights to water is essential to move forward with the construction of more sustainable and democratic societies. The National Water Law omits them, although Articles 2 and 27 of Mexico's Political Constitution open the

possibility for more innovative laws that recognize the cultural diversity and existence of indigenous peoples and do not reduce them to the simple connotation of water users.

In summary, the strategic location of indigenous peoples in regions with high levels of biodiversity and a wealth of natural resources, as well as in aquifer recharge zones, calls for the definition of policy options that value the ecosystem services (including water) they offer to other social and productive areas (cities, irrigation zones). Conversely, if policies of abandonment and looting of natural resources continue, the panorama of social conflicts will increase in the country. There are already examples in Mexico, such as the 1993 armed uprising of indigenous peoples in Chiapas and the emergence of the movement of Zapatista Women for the Defense of Water in the Mazahua zone. In other countries such as Bolivia there have been nationwide protests over the violation of indigenous water rights.

E. Main Policy Messages

The issues and findings discussed above form the basis for evaluating the impact of stylized policy interventions using the following analytical framework. First, a partial equilibrium, regional production model is used to assess the impact of such interventions in a given region (in this case, the Río Bravo Basin, which was selected on the basis of the consultative process mentioned above). Then, to introduce linkages between the local/regional economy and the national/international economy, a computable generalized equilibrium (CGE) model is used to evaluate the impact of macro-level policies such as trade, subsidies, taxes, and exchange rate on the water sector and the economy. The novel combination of these two models (i.e., the micro–macro linkage) allows policy makers to evaluate both the impact of interventions at the sector/local level on the regional/national economy, and the impact of national policy interventions on sector- and local-level actors.

Highlighted below are some of the main conclusions resulting from the application of the aforementioned models. However, it must be emphasized again that the objective of the current study is to develop a comprehensive analytical framework that can inform a policy dialogue and not to provide specific policy recommendations.

Reorienting Water Allocation for Agriculture

It seems unlikely that preserving current water allocations for agricultural uses could be sustained, in part due to the allocation of more water for agricultural uses relative to urban uses. As such, meeting urban demands would likely only require small reductions in available water for agriculture, leading to moderate reductions in total cultivated land and level of production. Moreover, some policy interventions to achieve this result have relatively lower negative impacts than others, so they are more politically feasible. An important caveat to this finding is that the analysis in the macro model did not address groundwater areas separately. Other studies suggest that in order to reverse the water level trend in overexploited aquifers and to account for environmental needs, drastic rather than small reductions in water supply to agriculture are needed.

Either way, farmers seem to be quantity responsive rather price (cost) responsive to both land and water. Simulating a 50 percent water price increase, for example, the water cost change is still below the unit value of water to users, so increasing the price of water

seems to be relatively ineffective. However, the economic profitability (due to crop subsidies) of some grain crops results in shifts from present cropping patterns to new ones. In other words, given current pricing and subsidy realities, policy alternatives that target irrigation water supply reduction (rather than irrigation water supply price [cost] increases) may be more likely to induce greater water use efficiency for agricultural purposes.

Moreover, many negative impacts that may result from reducing irrigation water supply can be offset by allowing water user associations (WUAs) to retain revenues from water charge collection, and locally reinvest the proceeds in water productivity improvement technologies. It is important to note that this is possible when the WUA can increase the rate per unit of water to match the value of water to the farmers (shadow value) that results from a reduction in irrigation water supply.

Decoupling the Tarifa 09 Subsidy

The overexploitation of many of Mexico's groundwater aquifers, associated with Tarifa 09, is considered a national crisis. In addition to sustainability of the resource and its quality, the overexploitation also brings about equity issues in terms of access and cost of extraction to small/poor farmers. Eliminating the electricity subsidy may not be effective or politically feasible. However, policy options that convert the subsidy into a direct income transfer, decoupling it from the resource (groundwater), could still provide farmers with incentives to make rational use of water and electricity, while keeping irrigation technology, crops, and the entire production process efficient. Considering past experiences in Mexico, this will necessitate that a multitude of aspects be considered, including farmers' and stakeholders' participation; clarifying the present water right system and the overconcession of water, including surface water; changes in economic incentives; and making technological innovation available to farmers.

Developing Water Markets

Improving water productivity could also be addressed by introducing policies that promote the development of water markets. For example, a simulated transfer of 40 percent of the irrigation water in the RBB to the north and central regions suggests that the water transfer could offset several of the negative impacts associated with a 50 percent reduction in water supply to the irrigation sector in each region. However, the present legal and regulatory framework under the general purview of National Water Commission (CONAGUA) would require modification to allow farmers to trade their water quotas. Such modifications might be considered for their pros and cons, as well as the political economy that may arise when they are implemented.

Localization

For many issues, a variety of conditions must be addressed simultaneously. In addition, there are variations in the effectiveness of a number of policy interventions. For example, climate change is expected to affect different regions of Mexico to varying degrees. Simulating differential water availability in five regions generally indicates that crop yields and production areas decline while crop prices increase. However, rainfed agricultural production (presently more prevalent in the southern parts of Mexico)

increasingly replaces irrigated crops. Therefore, localized and focused policies (at the regional or sectoral level) seem appropriate to address the fact that impacts from changing water availability vary across regions, households, sectors, and cultural groups.

F. FINAL NOTES

The main issues and findings of this study and the background papers corroborate lessons learned from international experience: there is a need for a comprehensive and well-coordinated set of interventions that address issues of sustainability, equity, and economic efficiency (or constraints to growth). For example:

- The economic value of water analysis demonstrates substantial differences in water productivity across various agricultural products, among different economic sectors, and in different areas within a region. This imbalance implies that distortions remain in terms of productivity, efficiency, and equity for the regional economy as a whole. Improving crop production techniques could address much of that distortion, in terms of both water savings and increased physical output. Improvement, diversion, or substitution of forage and grain crops (i.e., alfalfa, sorghum, and pastures) may lead to similar favorable results if adequate infrastructure and markets are in place.
- Similarly, the review of the cost of providing and the willingness to pay for water suggests that improving the performance of utilities could lead to increased water savings, as well as better delivery of water supply and sanitation services (including those for the most vulnerable). The municipal and industrial water use analysis highlights the scope for such improvements, which would lead to better sustainability of water use by reducing water losses in the system. Policy interventions regarding pricing, bill collection, leak-and-detect management, and performance-based incentives for utilities require greater consideration.
- Transferring water among crops, water rights holders, and basins could also lead to more equitable and economically efficient water allocation. However, such transfers would require that an adequate legal, institutional, and regulatory framework be in place. Findings from the comparative analysis of water-related policies suggest that such a framework may need to be strengthened to assure that trading of water rights is feasible, viable (i.e., the associated transactions costs are not prohibitive), and transparent. Otherwise, purely informal water markets may remain relatively marginalized and localized and/or may lead to inefficient and inequitable results.
- Other important limitations to efficient, equitable, and sustainable water allocation include pricing and subsidy distortions. The analyses of farm types and groundwater pumping subsidies demonstrate, in particular, that the Tarifa 09 subsidy for electricity negatively impacts both the agricultural sector and the entire economy. Moreover, the main beneficiaries are farmers who have irrigation systems, i.e., only about 30 percent of all farmers in Mexico. With the cost of the subsidy reaching nearly US$700 million in 2004, this sort of distortion can no longer be overlooked. However, simply eliminating the subsidy would not likely be politically feasible, nor would it be particularly efficient in the context of

existing institutions in Mexico. On the other hand, several alternative policy interventions may be more or less politically neutral, as well as efficient and equitable. These include the following options: (i) *"decoupling"* so that each farmer receives the average subsidy; (ii) allocation based on *historical consumption;* (iii) assigning subsidy benefits only to *water concession holders*, thereby stimulating a more efficient and legal use of water and electricity; and (iv) a combination of one of the preceding options with a *payment per hectare* approach to further target the subsidy. Each of these options has political economy consequences that would need to be considered in the context of the policy dialogue which the present study is intended to inform, but none of the options would be as politically charged as eliminating the subsidy altogether.

- Inequitable water allocation also seems to arise from centralized water policy and investment decision making that inherently marginalizes certain elements of the overall society. For example, the analysis of water management policies in indigenous communities indicates that omission of the sociocultural dimensions of water not only makes contemporary indigenous civilizations vulnerable, but also negatively impacts overall water resources management. Many indigenous communities have evolved cost-effective and sustainable water management practices. However, these communities remain marginalized from water sector policy and investment decision making. Such marginalization inevitably generates conflicts over water and leads to various negative impacts that upset the overall fabric of society at large. Ironically, indigenous communities are often strategically located in regions with high levels of biodiversity and natural resources, as well as aquifer recharge zones, precisely those areas that require greater attention under the current "water crisis" circumstances. However, public resources allocated to improve basic needs in indigenous regions remain far below the millennium development goal of US$550 per capita needed to resolve drinking water and sanitation deficits in these regions.

In the context of the comprehensive analytical framework that the present study seeks to develop as a policy dialogue tool, the above findings provide the basis for evaluating the economic impact of selected policy interventions. Applying the analytical models (regional production and CGE) developed as part of the overall study yields a number of relevant conclusions that further validate and/or extend the findings indicated above. These conclusions are highlighted below. However, the objective of the current study is to develop a comprehensive analytical framework that can inform a policy dialogue. In keeping with that focus, the results of the current study also include a strategy for ongoing consultations and dissemination among various relevant stakeholders.

- Considering the overexploitation of aquifers nationally and in the Río Bravo Basin, combined with rapid urban growth, it seems unlikely that preserving current water allocations for agricultural uses can be sustained. Part of the complication arises from allocating much more water for agricultural uses relative to urban uses. As such, meeting urban demands would likely only require small reductions in available water for agriculture, leading to moderate reductions in total cultivated land and level of production. Moreover, some policy interventions

to achieve this result have relatively lower negative impacts than others, so they are more politically feasible.

- Many farmers seem to be quantity responsive rather than price (cost) responsive to both land and water. In other words, given current pricing and subsidy realities, policy alternatives that target irrigation water supply reduction (rather than irrigation water supply price increases) may be more likely to induce greater water use efficiency for agricultural purposes. Moreover, reducing water supply can be implemented more equitably, and would therefore be more politically viable, compared to policies that focus on eliminating energy subsidies for pumping groundwater. As compared to poor and medium-income rural households, rich Mexican rural households (especially those in the north and in the RBB) are the ones that are most affected when water availability is reduced and when water costs increase.
- Many negative impacts that may result from reducing irrigation water supply can be offset by WUAs to retain revenues from water charge collections and locally reinvest the proceeds raised by charging fully according to the value of water in water-productivity improvement technologies.
- Policy changes that imply more resources to the WUAs and to the government could improve government finances and be used for redistributive purposes; for example, by promoting a more efficient crop production of poor rural households. The above is particularly important for the portion of poor rural households that are indigenous, that is, for the poorest of Mexico's poor.
- Free trade policies may facilitate many of the policy alternatives discussed above. For example, the negative impacts from restricting water supply for irrigation would be relatively low compared to the positive impacts from agricultural trade liberalization. These impacts may offset negative consequences to richer rural households whose incomes are the most affected when water availability is reduced and/or water costs increase. The same holds when a value-added tax on foodstuffs are introduced and/or when agricultural subsidies to certain crops are eliminated. For example, reductions on water supply for irrigation in a context of free trade are less harmful to rural households than the elimination of PROCAMPO.
- Climate change is likely to affect Mexico with differential impacts by regions. The high reduction of water availability for irrigation in northern Mexico and in the Río Bravo Basin caused by lack of rainfall, negatively affects crop production all over the country and household real incomes. Rich rural households are the ones suffering the highest income reductions, especially in the north and in the Río Bravo Basin agricultural regions. Such differential impacts call for localized policies.
- Localized policies seem appropriate to address the fact that impacts from changing water availability vary across regions, households, and cultural groups.

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