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Water and Economy-Wide Policy Interventions[1]

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Contents

Abstract

Water is a limiting factor for sustainable economic growth and development in many countries. Its allocation has significant impacts on overall economic efficiency, particularly with growing physical scarcity in certain regions. Water also has become a strategic resource, involving conflicts among those who may be affected differently by various policies. This monograph reviews work that models various policy interventions aimed at improving water allocation decisions with an economy-wide context. It focuses on the "macro–micro linkage" framework that facilitates assessment of various linkages among policies and their impacts within individual sectors and the economy. Drawing on country-based studies in Morocco, South Africa, Turkey, and Mexico, the analysis reveals difficult tradeoffs among various policy objectives, including priorities placed on different sectors, regional advantages, and general economic efficiency gains versus broader social impacts. The comparison of policy impacts demonstrates how policy makers can use such information to rank the policy interventions according to the emphasis placed on their objectives. The monograph also compares approaches used in other economy-wide studies that apply computable general equilibrium models in various contexts of water, environment, and agriculture.

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1

Introduction

Water is a scarce resource in many arid and semi-arid regions, where economies are highly dependent on it. In many countries, due to climate and landscape conditions, water supply and demand nodes may be present in different geographical locations. Therefore, competition over and allocation of water involves serious policy considerations. The state faces difficult decisions regarding management and allocation of its water, as it is linked to land, environmental amenities, and development priorities.

Because of its central role in both developing and developed economies, water resources are the focus of many intervention policies. These policies have been aimed at achieving multiple objectives, including income transfer, food production security, environmental sustainability, and resource conservation. Since agriculture consumes the lion's share (70–90%) of annual renewable fresh water on earth it is a sufficient reason for policy makers to focus their efforts on improved performance of scarce water use in irrigated agriculture. While focusing on policies that target irrigated agriculture may lead to an immediate improvement in irrigation water use, still, other implications may negatively affect other water-using sectors, and indirectly also the agricultural sector. This system of cause and effect holds also for the urban water sector, as well as for the industrial and environmental sectors. The fact of the matter is that water, to a large extent, plays a central role as an intersectoral mechanism that has to be considered at the economy-wide level when being allocated among competing uses.

For quite some time, the economic literature analyzed impact of policy interventions by governments, using a plethora of policy interventions such as pricing, quotas, water right assignments, and development of water trading, but with focus only on a subset of water-using sectors [e.g., Johansson et al., 2002, Dinar and Saleth, 2005, Tsur et al., 2004a,b,c, Tiwari and Dinar, 2002]. Policy interventions could be water-directed (e.g., water regulations) or not water-directed (e.g., trade policies, labor policies, or other input policies). Another typology of policy intervention could be the level at which they are applied, namely as macro policies imposed on the state as a whole, or micro policies imposed on a region, on a sector, or on individuals (e.g., big farmers). But because interactions among sectors and factors of production are evident, the linkages between micro and macro policy interventions are far more important and allow policy makers to better assess the outcome of their interventions.

While policy interventions at the regional (micro) levels could lead to desirable results, local considerations may also lead to a suboptimal outcome, from a social point of view. This point is demonstrated in recent findings from works on economy-wide considerations and linkages [Roe et al., 2005a, Diao et al., 2008, Hassan et al., 2008, Cakmak et al., 2008, Yunez-Naude and Rojas Castro, 2008, Hassan and Thurlow, 2011]. It was found that reforms in sectors other than agriculture have major impacts on rural households' income, and that water reforms that are designed without taking into account reforms outside the major consumer of available water — irrigated agriculture — may lower overall productivity of irrigation water and have negative impact on the other sectors competing on that limited resource.

In recent years we have also witnessed increased globalization and climate change considerations, both of which strongly suggest that water policy is no longer a sectoral, or regional, but an economy-wide matter. Recognizing this trend gave rise to studies of an economy-wide nature [see review in Dudu and Chumi, 2008, Johansson, 2005]. While many economy-wide analyses (mainly Computable General Equilibrium — CGE — models) have been published in the economic literature on water, little can be generalized mainly because these studies use different assumptions and structures of the economy. For example, many CGE studies on water that have been reported in the literature treat irrigated agriculture as one sector/activity. Such structures are only appropriate in economies where physical (soil quality, water availability, etc.), economic, and social conditions (crop mixes, proximity to markets, farm size, water delivery costs, etc.) are identical or similar across regions. However, existing spatial variation within economies makes that assumption of little use for simulation of real-world policy interventions.

Recognizing the importance of having the ability to assess different policy-linkage and performance interactions, this monograph considers policy interventions aimed at improving water allocation decisions, and assessing the impact on regions and sectors, by including both macro and micro considerations in a unified analytical framework. The monograph draws upon a recently completed set of country-based case studies on water management policy interventions in Morocco, South Africa, Turkey, and Mexico, all using a similar macro–micro CGE framework [Roe et al., 2005a,b, Diao et al., 2008, Hassan et al., 2008, Cakmak et al., 2008, Yunez-Naude and Rojas Castro, 2008, Hassan and Thurlow, 2011]. The country studies allow, for the first time, a comparison of a variety of policy interventions across various economic, institutional and physical situations, and generalization to situations and conditions in other countries. The results of the analyses of the macro–micro linkage approach that was applied to Morocco, Mexico, South Africa, and Turkey are presented and contrasted so that the tradeoffs between different social allocation preferences are clearly identified in terms of their impact on sectoral productivity and welfare distribution, using economy-wide performance indicators. The monograph is concluded by identifying areas (e.g., climate change, globalization, food crisis, migration, distributional effects) in need for more research. It will provide a proposed framework for their inclusion in such analysis.

2

What is New? A Short Literature Update

Two extensive literature reviews on CGE and water can be found in Johansson [2005], and Dudu and Chumi [2008]. Annex 3 in Dinar [2012] provides an annotated bibliography of extensions to the above publications that include literature beyond what was reviewed there. The reader can also visit Annex 1 of this publication for a technical comparison of the various studies.

One can divide the body of works reviewed in Annex 1 into several groups. One distinction is the works dealing with global economy models (e.g., the various studies by Calzadilla et al. and Berrittella et al.) versus state-level economy models [e.g., van Heerden et al., 2008, Phuwanich and Tokrisna, 2007]. A couple of studies combined CGE with detailed hydrologic modeling [Dixon et al., 2005, Smajgl et al., 2006]. Another distinction is the studies that employed dynamic CGE [e.g., Briand, 2007, Schreider, 2009, Diao and Roe, 2000, 2003] versus static CGE frameworks (some of which have been already included in the typologies above). Several studies assess the impact of water market on various sectors and the economy as a whole [e.g., Gomezz et al., 2004, Tirado et al., 2010]. Interactions between irrigation and environment and the role of various policy interventions (taxes, subsidies) are reported [e.g., Dixon et al., 2011, Peterson et al., 2005]. Many of the studies report the effectiveness of water pricing with regard to improved water efficiency, economic development, and equity [van Heerden et al., 2008]. Many papers deal with the impact of climate change on the water sector and the economy [e.g., Juana et al., 2008, Kraybill, 2010]. And finally, a large number of studies are concerned with trade reforms and their impact on water allocation and economic development [Berrittella et al., 2005, 2007b].

The literature reviewed in Johansson [2005] and Dudu and Chumi [2008] and the review of the recent studies in this monograph points to the importance of distinguishing between types of policies, namely micro-level and macro-level policies. Special attention to this distinction has been provided in a set of studies conducted by the World Bank in Morocco, Mexico, South Africa, and Turkey [Cakmak et al., 2008, Diao et al., 2008, Dudu et al., 2010, Hassan et al., 2008, Hassan and Thurlow, 2011, Roe et al., 2005a,b], based on the macro–micro linkage framework that was developed for that purpose. In the following section the macro–micro linkage framework is presented with focus on the links between policies and their impact on the various sectors in the economy.

3

The Macro–Micro Linkage Framework

The macro–micro linkage framework was proposed to analyze policy interventions aimed at improving irrigation water allocation decisions by including both macro and micro considerations in the analytical framework, and thus, decisions related to other sectors. The approach is demonstrated by analyzing selected policy interventions and external shocks that affect the entire water sector directly and indirectly. Top-down and bottom-up policy interventions are part of the framework. Macro policies associated with removing various trade and domestic barriers to open up the economy are examples of top-down links affecting the irrigation sector indirectly, which were called "trade reform". Water management policies at the farm/perimeter/district level, such as assignment of water rights to farmers or different schemes to price irrigation water (e.g., per area, volumetric, market-based) are examples of bottom-up links that affect the irrigation sector directly. But after being adopted by a large number of farmers, such policies have indirect effects on the economy as a whole, which in turn feeds back (largely through factor markets) and affect the micro level; such policies are called "water reforms".

In addition to policy interventions one can also assess the impact on the economy of water projects (such as expanding areas under irrigation perimeters, constructing dams), shocks to available farm water supply (either due to weather or the growth of metropolitan areas). And finally, one can also claim that the sequence of introducing policy reforms (water reforms and trade reforms that are included in the analysis) can be critically important. For example, implementing water markets when policy protects, for example, irrigated sugar and wheat producers, can lead to a Pareto inferior outcome by causing water to move from non-protected to protected activities. The analytical framework can provide the sequence of reforms that lead to continually Pareto superior outcomes.

While the focus of the macro–micro approach is on irrigation water, the same line of argumentation regarding linkage holds for other sectors, such as the residential and industrial sectors, albeit, with much less impact on the economy. While not all countries have mechanisms to move water across sectors and/or regions, still the macro–micro framework allows testing of the value associated with having such mechanisms.

3.1 The building blocks

Begin by with outlining the micro (farm, perimeter, district) model and describing micro-level decisions and the economic environment in which they are made. The micro framework distinguishes between those variables that are exogenous to micro-level decisions and those that are endogenous. In this way feedback effects between the micro and macro levels are broken down into direct and indirect effects. Direct effects correspond to partial equilibrium effects (e.g., the effect of a *ceteris paribus* change in farm output prices on crop supply). Indirect effects are due to general equilibrium effects. The overall effect of a policy is the sum of direct and indirect effects. One additional point to be made is that partial equilibrium models do not capture the indirect impacts of the policy on other sectors. In addition, they incorrectly measure the direct effects, due to the fact that not all prices are able to adjust in partial equilibrium models. This conceptual approach has its analytical foundation in the LeChatelier principle (see for example Varian, 1992; p. 47), and has been applied in a number of studies (Binswanger, 1989 and in the studies directed by Krueger et al., 1991 on the political economy of agricultural price policy).

The basic decision-making unit in a water economy is an irrigated land farm operator (farmer). In the short run, farmers take the production technology, input prices, and output prices as given and decide on input allocation — including irrigation water — and consequently on output supply. The overall quantity of water demanded at different water prices constitutes the (aggregate) demand for irrigation water. The supply is represented by the marginal cost of water supply (the cost of supplying the next, marginal unit of water).

The economy consists of many sectors that interact at the marketplace to determine the prices of goods and services (including agricultural inputs and outputs). In addition, prices of traded inputs and outputs are set at the world market and are affected by domestic trade polices (quotas, tariffs, and other trade barriers). Irrigators compete for inputs (water, capital, labor) with other sectors and its overall supply of agricultural products affects their prices. The direction of the impacts, macro-to-micro and micro-to-macro, is important and is explained below.

3.1.1 Macro-to-Micro links

An obvious macro-to-micro link entails the prices of purchased inputs and outputs, which are determined at the macro level and taken as given by farmers. These prices are sensitive to government policies (taxes and subsidies) and affect the derived demand for irrigation water.

Trade policies (tariffs and other trade barriers) affect prices of traded agricultural inputs (fertilizer, pesticide, seeds) and outputs. Another important macro-to-micro link involves national or regional water projects (e.g., construction of dams), which affect water supply constraints and the cost of water supplied.

3.1.2 Micro-to-Macro links

These links include water allocation reforms at the micro level (perimeters, districts), such as changing water assignment rules, changing water pricing methods (e.g., from per area charges to volumetric pricing), or introducing institutions and mechanisms for trading water and water rights. Such reforms affect farmers' water (and other inputs) use and agricultural production. When applied in a number of regions these changes will affect input and output prices at the national level. The changing prices will then feedback, affecting the micro units (households, farms, perimeters).

3.2 The farm model

Here only the micro (farm)-level decision process is laid out and identifies the endogenous and exogenous variables.

There are a number of cultivable crops and farmers must decide the input allocation for each crop. These inputs include area planted, the monthly (or annual, if the model is an annual one) quantity of irrigation water, as well as fertilizer, machinery, pesticide, labor, and other inputs. The input allocation implies output supply for each crop through a production technology that assigns a particular output level for each input bundle. In their input allocation decisions, farmers take it as given the prices of purchased inputs (labor, machinery, fertilizer, pesticide) and output, the production technology, the quantity of irrigable land, and the supply of irrigation water according to the water authorities' assignment rules. If irrigation water is assigned by month and for each crop then the water restriction is per month and per corp. If water is assigned annually, then water restriction is per year only.

The input decisions are chosen so as to maximize profit, subject to the land and water constraints (and possibly other constraints such as crop rotation). The result is the restricted profit function, which is a function of all the exogenous variables — input and output prices, farm size, and water constraints. The shadow prices of water are defined as the derivatives (the marginal change) of the restricted profit function with respect to the respective water constraint. It is calculated as the Lagrange multipliers of the respective water constraint. By changing a particular water constraint, leaving all other constraints and exogenous variables unchanged, one obtains the derived demand for irrigation water associated with this constraint (e.g., demand for water at a particular month for a particular crop). As was explained above, the derived demands associated with the different water restrictions are essential ingredients in the procedure — and in any water pricing scheme for that matter.

A unique feature of the farm model is that its specification and calibration to data results in a solution that reproduces the farm plan exactly as depicted by the data. This greatly facilitates and makes its use much more practical for policy analysis.

3.3 The macro model

First, the simplest possible general equilibrium open-economy analytical model is constructed to show the key linkages between macroeconomic reform as illustrated by trade reform, and sectoral changes as illustrated by water reform. Then, this model is generalized by simply stating the key reduced form analytical equations that are necessary to link the macro (economy-wide) and micro (farm) analyses.

This analytical approach illustrates how the macro and micro empirical framework interlinks and will be used in the analysis. Agricultural goods are produced by two sectors (could be crops, farm types, regions), using labor and an assignment of water allotted by a water authority that exhausts total water supply. Commodity markets clear at given (world) prices, and the labor market clears at an endogenously determined wage rate. In this structure, the shadow price of water in each sector is unambiguously determined as the profits per unit of water used in each sector. Each sector's profits (or shadow price of water) are a function of the sectors output price, and wages. Wages in turn are a function of the economy's resource endowments, i.e., the amount of water assigned to each sector and the world prices. Thus, by considering trade reform one can trace the impacts through the effects on wages, and the shadow price of water. By changing the sectoral allocation of water, wages change and so does the shadow price of water. A drought, for example, leads to a decrease in the total quantity of available water, which impacts wages and again, the shadow prices of water in each sector. It was shown that the magnitude and direction of change in the shadow price of water depends upon the initial water assignment, and the relative factor intensity of labor and water in each sector's production function. These features are critically important to explain the "behavior" of the large empirical model [Roe et al., 2005b].

The effect of trade distortions on the shadow prices of water. Consider the case of a tariff imposed on an import competing good. A policy that changes (or lifts) the tariff will directly change the relative output prices and will indirectly affect demand for — hence prices of — inputs. The changes in input demand include irrigation water, hence the shadow price of water is likely to change too. As shown in Empirical Results section after the trade reform, producers of one good can be made worse off in the sense that the total returns to their water assignment (i.e., their profits) may decline. If, however, prior to the trade reform a water market were introduced (say, between rural and urban users), then this would equate the shadow prices of water between the two sectors and the economy could be made better off. The key implication is that the sequencing of economic reform in a water economy can, as predicted by the theory of the second best, be critically important.

The effect of water market reforms on the shadow prices of water. Water market reform can have dramatic effects on the shadow prices of water. Consider the introduction of water markets within a system in which water is assigned for each crop at each month. If farmers can only relocate water between crops, the water market would equilibrate the shadow prices of water between crops. If farmers can also trade water between months or seasons, it will further equilibrate the monthly shadow prices of water. It was shown that, depending on the importance of water relative to other inputs of production (or relative factor intensity), a market that equilibrates the marginal value product of water among its various uses can cause the shadow price of water to fall, remain unchanged, or rise. The prices of all other factor inputs, such as labor, are also likely to change. If a water market reallocates water to labor-intensive crops, then wages rise, thus benefiting the poor whose income depends on rural labor opportunities.

The basic features of the simple analytical model developed above are easily generalized to a multi-sector and multi-factor small and open economy as will be demonstrated in the Morocco case.

3.4 Feedback links

The macro-to-micro linkage is shown first by considering an economy-wide reform illustrated by a trade reform. Then, we turn to focus on the direct effect on farm profits from a crop's water assignments, and the indirect feedback effect when water assignments are changed for all farms. These two reforms are also considered in the empirical analysis for Morocco.

Macroeconomic reform, macro-to-micro linkages. As noted above, farmers take as given input and output prices. Any change in these prices will affect farmers input allocation decisions and the ensuing output supply. The direct effect associated with a trade reform corresponds to these changes in input allocation. But at the culmination of changes in input demand and output supply, as all farmers adjust to the macro reform, has an economy-wide effect on other prices, e.g., the price of labor and the price of capital. As these prices re-equilibrate factor demand and supply, such (indirect) changes in turn also effect farmers' decision. Often, these indirect effects have the opposite impact on incentives than do the direct effects. The overall effect of a trade reform is the sum of direct and indirect effect.

Microeconomic reform, micro-to-macro linkages. The illustration uses a change in a farmer's water assignment. The farm model shows how the farmer responds by changing the level of crop and livestock production, changes in purchased input levels, and changes in the shadow prices to farm-specific resources including the water assignment. This is the direct effect. However, since all available water is allocated, this change induces additional changes in water assignments among other farmers in the perimeter. This causes a re-equilibration of factor market demand and supply, with shifts in final demand due to corresponding changes in income earned. This "feedback" effect alters the broader economy, and provides incentives for farmers to also respond to these changes by, again, changing their farm plan. This indirect effect can be surprisingly large. Together, the direct and indirect effects equal the total effect of a change in water assignments.

3.5 How other sectors are linked and modeled

The main sectors in addition to irrigated agriculture that is modeled are the urban sector and the government. The urban sector is represented by one or more household types, broken into income-level groups. Households are linked with the economic system in various ways. Households receive income in payment for producers' use of their factors of production. Households pay direct taxes to government (based on fixed tax rates), save (based on marginal propensities to save), and make transfers to the rest of the world. Households use their income to consume commodities under a linear expenditure system (LES) of demand. The government receives revenues from imposing activity, sales and direct taxes and import tariffs, and then makes transfers to households, enterprises, and the rest of the world.

4

Description of the Policy Issues

To put things in perspective, this section details and compares the policies used in the studies of the four countries (Morocco, Mexico, South Africa, and Turkey) that are the focus of this monograph. While each of the four countries practices different policy interventions, and thus, different outcomes, still there are several policies that, at least nominally, are similar across these countries. The policies will be presented very briefly in the following (the features of the evaluated policies by country can be found in Annex 2).

4.1 Mexico

The joint strategy of the Government of Mexico and the World Bank for 2004–2006, under the framework of the Country Partnership Strategy, identified four priorities with regard to challenges for development. These are reduction of poverty and inequality; increased competitiveness; strengthening of institutions; and promotion of sustainable development. Under the latter, the water sector has received special attention, with four priority aspects in need to be addressed: overexploitation of surface and groundwater; minimization of the use of scarce water for crops with low added value; difficulty to reach strategic consensus among key actors due to institutional complexities that impede efficient coordination among key actors; inadequate management of water rights; and high subsidies for the pumping of surface and groundwater and inadequate water prices (see Table 4.1).

4.2 Morocco

The potential trade arrangements of Morocco with the EU are likely to increase competition for cereals while increasing opportunities for the export of fruits and vegetable products. Domestic policies support directly and indirectly the production of other commodities such as sugar, bananas, livestock, and vegetable oils. Other policy barriers include adjustment in capital markets to encourage foreign direct investment, particularly in those sectors for which Morocco can compete in international markets. Irrigated fruit and vegetable products are among these sectors.

Closely linked to the macro economic issues is the question of a policy to better allocate water within and among irrigated perimeters to maximize the returns to this scarce re-source. This entails a reconsideration of how water is priced and allocated to farmers, concerns with the equity of this process and poverty reduction. Moreover, due to the uncertain temporal and spatial effects of weather, policy must also take into consideration the mechanisms by which these uncertainties can be managed, and particularly so in an environment of a continuing growth in nonfarm water demand (see Table 4.1).

4.3 South Africa

Over the past few years agriculture in South Africa (SA) has seen major structural adjustments in response to a number of critical macro and sector level policy changes. Broad macroeconomic (fiscal and monetary) reforms that led to major changes in managing the foreign exchange and capital markets coupled with wide liberalization of agricultural marketing and trade regimes have exposed the agricultural sector in SA to shifts in relative world commodity and factor prices

Table 4.1: Selected policy and policy linkages used in the four analyzed countries.

Key policy issues affecting the use and productivity of irrigation water		Likely impacts	
Macro policies	Micro policies	Macro-to-micro linkage	Micro-to-macro linkage
		Mexico	
1. NAFTA liberalization.	1. Water transfer from Rio Bravo Basin to close by regions.	1. Possible impact will be on reduction in maize price and processed maize, and significant increase in export of fruits and vegetables. Regions neighboring with the Rio Bravo and the border with the US will benefit the most. Water use for producing noncompetitive crops will decline but and rises for fruits and vegetables in all regions. Rural and urban household incomes increase in all regions as well.	1. A transfer of water in the RBB to the North and Central regions will counterbalance several of the negative impacts associated with reduction in water supply to the irrigation sector in each region. Land rents will decrease, and water shadow value increase. Impact on rural and urban wages is positive as manufacturing of durable goods increases.

(Continued)

Table 4.1: (*Continued*)

Key policy issues affecting the use and productivity of irrigation water		Likely impacts	
Macro policies	Micro policies	Macro-to-micro linkage	Micro-to-macro linkage
2. NAFTA + elimination of the PROCAMPO subsidies for staple food.	2. Significant (50%) reduction in water supply.	2. This simulation combines the effect of NAFTA trade liberalization with eliminating PROCAMPO income transfers to maize producers by 10% of the gross value of their maize production. While the impact of a combined NAFTA and removal of ProCAMPO subsidies are similar in general, the only important difference is reflected in rural households' income drop when PROCAMPO is simulated. The drop in rural households' income is more or less equally distributed across household types (poor, medium, rich), but not across regions. The RBB region suffers the least and the North and Center regions suffer the most. In contrast urban household incomes increase across all regions and household types.	2. A 50% decrease in water supply will affect water use in all regions. Rich households will be significantly affected in all regions. Prices of food commodities increase, other durable and services increase due to decrease in domestic supply of all foodstuffs, exports of raw and processed foodstuff is reduced and replaced by imports for most items. Dryland rent increases, irrigated land rent decreases, wages in ag. decrease and water shadow values increase.

(*Continued*)

Table 4.1: (*Continued*)

Key policy issues affecting the use and productivity of irrigation water		Likely impacts	
Macro policies	Micro policies	Macro-to-micro linkage	Micro-to-macro linkage
		Morocco	
1. Modification of policies (both Moroccan and European based) to allow Morocco better access to the EU market.	1. Change in farm level and regional water policy: institutions, water entitlements, and water pricing.	1. The possible trade arrangements are likely to increase competition for cereals while increasing opportunities for the export of fruits and vegetable products.	1. Improved equity among small and large farms.
2. Free trade agreement with the US on access to agricultural markets.	2. Agricultural development policy: expansion in irrigation area, investment in water conveyanceinfrastructure, investment in farm-level irrigation technology/management, fertilizers and other input pricing.	2. Better interregional allocation of water to address regional relative advantages.	

(*Continued*)

Table 4.1: (*Continued*)

Key Policy Issues affecting the use and productivity of irrigation water		Likely Impacts	
Macro policies	Micro policies	Macro to micro linkage	Micro to macro linkage
		South Africa	
1. Adjustments in the rate of foreign exchange as the value of the SA currency continues to fluctuate toward more stable equilibrium levels.	1. Movement toward full recovery of water supply costs in water charges.	1. Competitiveness of agricultural exports significantly affected with the removal of various forms of protection, interest rate and export subsidies and substantial currency devaluations.	1. Efficiency of water use. Gradual reductions in the high subsidies enjoyed by irrigation farmers. Switch of land and water resources out of low value field crops such as maize to high value horticultural products for export and shifts to use more efficient irrigation technologies.
2.Negotiations on trade agreements between SA and its main trade partner, the EU.	2. Regulation of the rural labor market through introduction of a minimum wage rate for farm workers and regulation of dismissals.	2. Change in the land allocated to international market crops.	2. Reduced employment in agriculture and expected to continue affecting factor intensities of farming toward less labor-intensive operations.
3. Future regional economic cooperation within the Southern African Development Community (SADC) on strategic food commodities.	3. The new water act provide for allocation of higher shares of water at subsidized prices to small holder farmers and basic human need.	3. Possible increase in corn production.	3. Impact on the productivity of irrigated agriculture, rural poverty and food security.
	4. Protection of the ecological demand and basic human need for water.		4. Reduced availability of water with large reallocations away from agriculture to meet such demands.

(*Continued*)

Table 4.1: (*Continued*)

Key Policy Issues affecting the use and productivity of irrigation water		Likely Impacts	
Macro policies	Micro policies	Macro to micro linkage	Micro to macro linkage
		Turkey	
1. Bilateral trade liberalization in agricultural products with EU.	1. Changes in water pricing methods and assignments of water rights.	1. Help in setting the priorities of public investment and increase the competitiveness of the agricultural sector, and may ease the transition toward the EU membership.	1. More effective use of existing water resources.
	2. Targeted direct income support to farmers.	2. The shift toward more market-oriented agricultural policies accompanied by decoupled transfers to farmers represents a major policy change in agriculture. The effects of this change on the regional (including rainfed and irrigated) production pattern may have implications about the level and distribution of income.	2. Targeting of safety net program will affect equity distribution.

(international terms of trade). Particularly, competitiveness of agricultural exports has been significantly affected with the removal of various forms of protection, interest rate and export subsidies, and substantial currency devaluations. At the same time, a number of other reforms in domestic policies governing the distribution of and access to key resources such as land and water among others have been introduced to address the social and economic inequity of the past.

Although the agricultural sector has already undergone significant changes as a result, adjustment is far from complete and the effects of many of these reforms, some only recently implemented, will be felt for years to come (see Table 4.1).

4.4 Turkey

Turkey embarked on an ongoing structural adjustment and stabilization program toward the end of 1999. Agriculture has been selected to undergo heavy adjustment due to the ineffective set of policies and its increasing burden on government expenditures in the last decade. Another important factor is the rural-to-urban migration and the increased demand for urban water. A policy reform has been started encompassing both the channels and organization of agricultural support, without any change in the major policy objectives: increases in production and productivity, targeting mainly import substitution, with a special concern for farm income.

The major objectives of the reform are to decrease the distortions and the financial burden of government support to the sector. The reform includes removal of the input (especially fertilizer and credit) subsidies to decrease the state procurement activities, privatization of state enterprises, and restructuring of the cooperatives sales. An important new policy tool involves farm income support based on the cultivated area with limited targeting (see Table 4.1).

5

The Empirical Framework

The empirical framework is described first in the context of Morocco and then applied to the case of Mexico, South Africa, and Turkey.

5.1 Features for Morocco

Agriculture accounts for about 15% of Morocco's gross domestic product, and employs about 40% of the country's labor force. Agricultural products account for 19% of the country's total imports and about 18% of total exports. Of the 9.2 million hectares of arable land, 10% is irrigated but the products from irrigated agriculture account for 75% of total primary and processed agricultural exports. Agriculture is a key sector in the domestic economy, and it is a major trade sector and thus prone to macroeconomic shocks and to the trade policies of the country's major trading partner, the European Union.

The irrigation sector consumes about 85% of the country's total available water supplies. Per capita annual renewable water resources are estimated at 800 m^3, implying that Morocco is already a water-stressed country. Morocco has invested heavily in developing its water resources, and approaches the physical limits of water availability from ground and surface sources (snow melt in the Atlas Mountains). The management of this critical resource for irrigation is carried out by nine administrative authorities (ORMVAs) in each of nine large-scale irrigation schemes (regions), seven of which account for over 90% of the total irrigation water managed by the public authority. The investment in and development of these irrigation districts has contributed in major ways to sustaining the income of rural areas, and employment opportunities. It is generally recognized that both economy-wide and farm-level policies are needed to increase water use efficiency.

Special features of the empirical framework include: (1) spatial identification of irrigation districts and the perimeters within each district, (2) linking the micro, farm-level model to the macro model within the irrigation district(s), (3) disaggregating the macroeconomic policy instruments, by separating the country's trade pattern between the EU — Morocco's major trading partner — and the rest of the world,[1] and (4) modeling architecture designed to accommodate the availability of data depending upon the country to which it is applied. This architecture will allow application to other countries but will not be carried out here.

The spatial identification is particularly important because of the spatial heterogeneity of irrigated agriculture, the proximity of major metropolitan areas to some water districts whose growth affects the scarcity of water in some regions relative to others, and the obstacles of transporting water over space and elevation.

5.1.1 The basic structure of the macro–micro model for Morocco

The Moroccan economy is disaggregated in the CGE model into 88 production activities, which produce 49 commodities and employ eight primary input including intermediate inputs produced in own and other sectors. On the demand side, there are five private household groups and one public group. The nonagricultural component of

[1] This is also the structure in the case of Turkey and South Africa. For Mexico, it is the NAFTA agreement.

the economy is captured by six activities or sub-sectors. Since the European Union (EU) is a major trading partner, as mentioned above, Morocco's trade patterns between the rest of the world and the EU are identified separately.

Since two of the nine ORMVAs are isolated and barely involved in the economy the modeling framework refers to the remaining seven ORMVAs. Among the 82 agricultural and agriculture-related production activities, 66 are in crop production, five in livestock, and 11 in processing agriculture, both up and downstream from the farm firm. To capture the spatial nature of irrigated agriculture, 66 crop production activities are further distinguished according to whether they are within or outside the seven ORMVAs. Among the 33 activities within the water authority perimeters, 21 are irrigated crop production and 11 are rainfed. Because water is either costly or presently impossible to transport between perimeters, the seven ORMVAs are further subdivided into 20 perimeters.

The data are organized into a social accounting matrix (SAM). The data include perimeter-level information on water charge fees, cropping mix, water and land allocation by crop and area, employment of labor and capital, and intermediate input use by crop. National-level data on employment, trade, nonfarm production, and resource flows are also entered into the SAM. These data are used to calculate the parameters of the model.

Unlike a standard SAM that often includes only national-level data, the Morocco SAM (and that of all three countries) in this study is multidimensional, taking into account crop production activities. A schematic presentation of the major features of the macro framework is presented in Figure 5.1.

Data for the farm model ("micro" model) are from the same data source as those for perimeters in the "macro" model, i.e., each perimeter is aggregated from farm-level data. For this reason, the production activities in the farm model are compatible with the "macro" CGE model. For the analysis preformed here, the representative farm is chosen from the irrigated area, and hence, only irrigated crops are included in the farm model.

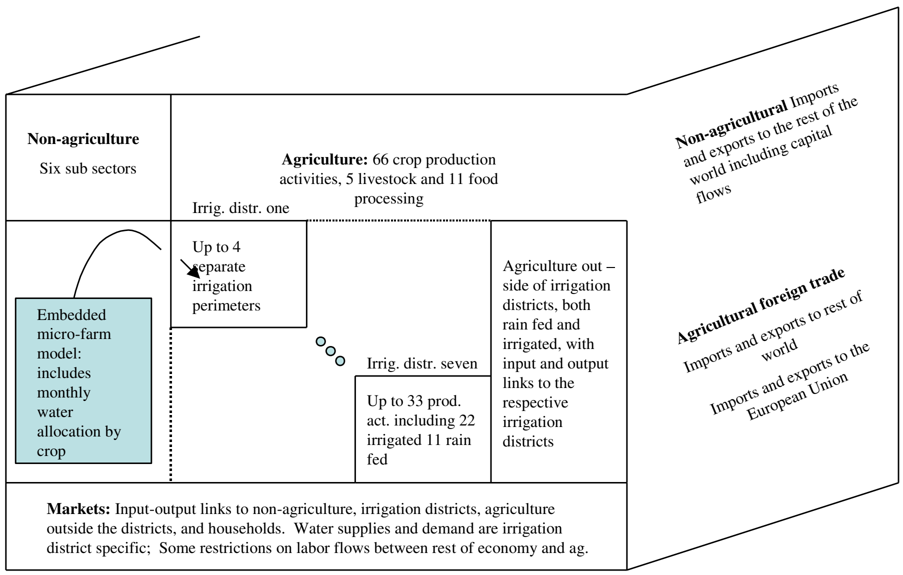

Figure 5.1: Depiction of the major features of the general equilibrium model including sectoral and spatial disaggregation and embedded farm model.
Source: Roe et al. [2005b].

Note: A similar structure, except for the sectoral specifications was used also for Turkey, South Africa, and Mexico.
Note for Morocco: Households: six groups, four in agriculture, one non-agriculture and public group. Structure of Production: 88 activities; 49 commodities; up to eight primary factor inputs plus intermediate factors of production for each activity. Policy instruments: taxes, subsidies, tariffs, water charges, and quotas by region.

The farm model accounts for monthly water allocation by crop. Typically, the representative farm only grows some of the crops produced in the perimeter. Only a number of crops (10) are included in the farm model. Just as the case with the CGE model, the farm model is calibrated to the data in such a way that the solution of the farm model for the base period reproduces the observed farm data exactly.

While the farm model only captures farmer's decision-making in production activities, the CGE model, as a general equilibrium model, captures intersectoral interactions of the decision-making process in the economy. For this reason, prices, including prices for output and factors

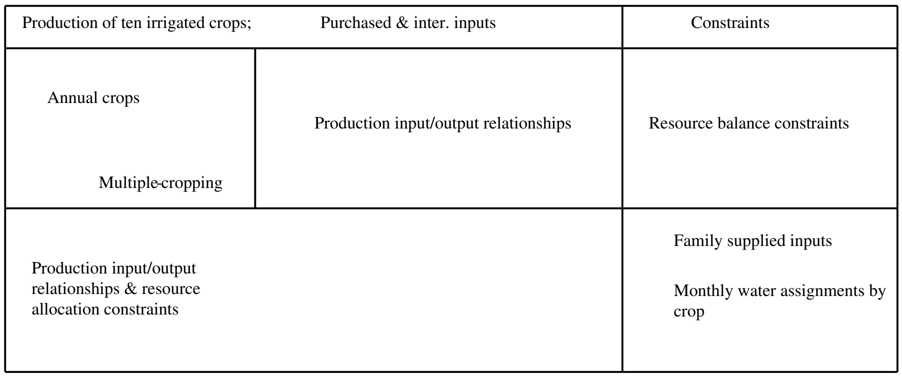

Figure 5.2: Illustration of the major features of farm level model.
Source: Roe et al. [2005a].

Note: Similar structure was used also for the case of Turkey, South Africa, and Mexico.

of production, are endogenously determined by the CGE model. Factor markets clear such that total available supplies of land, capital, and labor have to equal their respective demand. In the farm model, the representative farmer faces given prices for output and factors. The farm model treats the supply of land and monthly supplies of water as constraints. Otherwise, the farmer can hire labor, employ capital, and use intermediate inputs at exogenously (to the farmer) given prices without supply-side constraints. But these prices are endogenously determined in the economy-wide markets. A schematic presentation of the major features of the farm model is given in Figure 5.2.

In principle, the farm model can be handled in two ways: full linkage, i.e., embedding the farm model into the CGE model, or top-down (stand-alone) linkage. The full linkage treats the representative farm as a small part of the economy included in one of the perimeters. In the top-down linkage, the prices that are exogenous to the farm model are determined by the CGE model. When shocking the CGE model and when prices change through this linkage, the farmers (in the farm model), facing different prices, adjust their production decision to maximize profits. These effects are separated into direct, indirect, and total effects.

5.1.2 Empirical results for Morocco

Two sets of policy analysis were used to illustrate how the macro–micro linkage framework works for the case of Morocco. The first set of policies is at the macro level, and trade reform is chosen to illustrate the macro-to-micro analysis. The second set of policies is at the micro level, and water reform is chosen. The results are reported in Tables 5.1–5.7 in Roe et al. [2005b]. A qualitative description of the links and impacts is provided in Figures 5.3–5.6.

Macro-to-micro effects of a trade reform. A full trade liberalization scenario is used as an illustration of a macroeconomic reform, and focuses on the macro–micro linkage effects due to liberalizing both agriculture and non-agriculture sectors. The trade reform (removing tariffs on the imports of all commodities, agricultural and nonagricultural) scenario is first conducted in the economy-wide (CGE) model. Removing trade protection causes all endogenous variables to change and the economy moves to a new equilibrium. Table 5.1 [Roe et al., 2005b] summarizes selected aggregate/macroeconomic variables and their change. As predicted by the trade theory, the country as a whole benefits from the trade reform. Real GDP increases by 1.54% from its pre-reform level, and total consumption increases by 1.51%. A depreciation of the real exchange rate causes exports to increase. The resulting total exports to the EU, Morocco's major trade partner, increases by 11.26% and the agricultural component of exports increase by 38.93%. Morocco's agricultural import competing commodities, such as wheat, sugar, and other industrial crops, are highly protected. Removing protection increases the imports of these commodities.

Table 5.2 [in Roe et al., 2005b] also reports the aggregate effect on agricultural production within and out-side the irrigation perimeters. Due to data constraints, livestock production within perimeters has to be ignored (and is included in the outside perimeter agriculture). Total crop production within perimeters accounts for about 25% of national crop production. Due to the decline in the production of the protected crops (wheat, sugar, and other industrial crops), total agricultural output within the perimeters declines by 2.3%. Crop production outside of the perimeters (mostly rainfed agriculture) also declines, but only

Table 5.1: Policy Intervention/shock-NAFTA liberalization using the CGE model simulation results for Mexico.

Impact on	North	Central	Southwest	Southeast	Rio Bravo
Water use for grains	⇓	⇓	⇓	⇓	⇓
Water use for fruits and vegetables	⇑	⇑	⇑	⇑	⇑
Water shadow value	↓	⇑	↓	⇑	⇑
Comments	To simulate agricultural and food processing trade liberalization as part of NAFTA, the price of composite commodity maize and beans was reduced by 20% and 10%, respectively, dairy products by 5%, and price of vegetables and fruits was increased by 5%. The most significant impact is the reduction in maize price (9%) and processed maize (1.4%), and significant increase in export of fruits and vegetables (12%). Maize and beans imports have increased by 27% and 16%, respectively. Changes in returns to factors of production suggest that the distribution of benefits from the trade liberalization reflects closeness to the border, with the Rio Bravo and the North regions benefiting the most. Water use for producing noncompetitive crops declines and rises for fruits and vegetables. In all regions. Rural and urban household incomes increase in all regions as well.				

Source: Dinar and Asad [2006].
Note: The following symbols are used to compare impacts:

- ⇑, ⇓ Significantly positive or negative impact on the said variable through all range of policy intervention values.
- ↑, ↓ Positive or negative impact on the said variable through all range of policy intervention values.
- ↔ No consistent, but small, impact on the said variable (by crops and by regions for the farm models and for the CGE model, respectively) through all range of policy intervention values.
- ⇔, No consistent, but large, impact on the said variable (by crops and by regions for the farm models and for the CGE model, respectively) through all range of policy intervention values.
- ⊗ No significant impact of the policy on the said variable.

Table 5.2: Policy intervention/shock-NAFTA liberalization + elimination of PROCAMPO using the CGE model simulation results for Mexico.

Impact on	North	Central	Southwest	Southeast	Rio Bravo
Household income (urban)	↑	↑	↑	↑	↑
Household income (rural)	↓	↓	↓	↓	↓
Comments	This simulation combines the effect of NAFTA trade liberalization with eliminating PROCAMPO income transfers to maize producers by 10% of the gross value of their maize production. While the impact of a combined NAFTA and removal of ProCAMPO subsidies are similar in general, the only important difference is reflected in rural households' income drop when PROCAMPO is simulated. The drop in rural households' income is more or less equally distributed across household types (poor, medium, rich), but not across regions. The RBB region suffers the least and the North and Center regions suffer the most. In contrast urban household incomes increase across all regions and household types.				

Source: Dinar and Asad [2006].

Note: See note to Table 2.

by 1%. However, these aggregate changes mask increases in the output of fruits and vegetables.

Trade reform generally results in more efficient allocation of resources. As output and input markets re-equilibrate following macroeconomic reform, one can observe changes in output and factor prices (not presented). Most of the commodities for which prices have fallen received some form of trade protection. Tables 5.3 and 5.4 [Roe et al., 2005b] report changes in factor prices (wages and capital). In the CGE model, labor is an economy-wide factor, but capital is fixed at the perimeter level, i.e., capital can only move within a perimeter. The slight decline in rural wages suggests that trade policy tended to protect those sectors of agriculture that are relatively labor intensive. This finding bears some important implications related to the debate on "self-sufficiency" policies of developing countries. Trade protection and

Table 5.3: Policy intervention/shock-NAFTA + reduction of 50% in water supply for irrigation Using the CGE model simulation results for Mexico.

Impact on	North	Central	Southwest	Southeast	Rio Bravo
Land use (fruits and vegetables)	⇑	⇑	⇑	⇑	⇑
Land value (other crops)	⇓	↓	⇓	↓	⇓
Household income	⇓	↓	↓	↓	⇓
Comments	This simulation addresses the issue of compensation of trade openness for water scarcity. The impact is the same as when just NAFTA is simulated. However, the magnitudes of the impacts slightly differ. Drops in crop prices is more moderate and increase in crop and other commodities prices more moderate in the case of combined NAFTA and water supply reduction. The combined policy results in reduction in price of fruits and vegetables (1.5%) compared to increase (5%) in price in the case of NAFTA alone. Employment increases in fruits and vegetables and decreased for maize across all regions. In other crops the impact is differential.				

Source: Dinar and Asad [2006].

Note: See note to Table 2.

water assignments are partially designed to encourage the production of staple crops in-house, and to secure jobs for the poor. The analysis shows that the first objective comes at the expense of the second and policy makers need to consider the tradeoff between the two.

Trade reform affects the shadow prices of water (i.e., the productivity of the authorities' water assignment), by crop and perimeter. For the protected crops, trade reform tends to lower the shadow price of water assigned by the respective ORMVA to these crops. As other input and home goods' prices re-equilibrate to this adjustment, the shadow prices adjust accordingly. In general for most perimeters, the shadow prices of the formerly protected crops are lower. However, since input prices faced by farmers are also generally somewhat lower after the trade reform (as is discussed in the following), the shadow price of water allocated to non-trade protected crops tends to rise.

Table 5.4: Policy intervention/shock: Climate change regional differential impact on rainfall and water supply using the CGE model simulation results for Mexico.

Impact on	North	Central	Southwest	Southeast	Rio Bravo
Land value (dry)	↓	⇑	⇑	↑	↑
Land value (irrig.)	⇓	⊗	↑	↓	⇓
Employment (rural)	⇓	↑	↑	↑	↓
Household income (rural, all classes)	⇓	↓	↑	↓	⇓
Comments	Climate change is expected to affect different regions of Mexico in a different force. A differential water availability change was imposed on the five regions, namely reduction of 50%, 50%, 4%, and 6.5% on RBB, North, Center and Southeast, respectively, and an increase of 33% in Southwest. Most crop yields and area are reduced and crop prices are increased, diary and livestock prices are reduced as well as other durable commodities and services. More cropping under rainfed replace irrigated crops. Urban real wages drop and the same holds for rural wages in the North and in the RBB. Irrigated lands rents also drop for the North, the RBB, and the Southeast.				

Since farmers only pay a nominal water charge, changes in the shadow price of water translate directly into changes in farm profits. Equity implications in irrigated areas are also apparent. Farmers producing bananas, for example, tend to be of larger scale with relatively capital-intensive operations. These producers experience a decline in returns to water that is assigned by the water authority to these protected crops, while the smaller scale unprotected fruit and vegetable crop producers experience a rise in the shadow price of water assigned to their crops.

Farm-level direct and indirect effects of changes in output prices. To capture the full effect of changes in output prices the model allows prices for both crop outputs and purchased inputs (including

Table 5.5: Impact matrix of simulated policy scenarios in South Africa.

Policy impacts	Policy scenarios: Liberalize regional irrigation water markets	Liberalize national irrigation water markets	Water-restricted competition from higher urbanization	Water-liberalized competition from higher urbanization
Irrigation water use	⊗	⊗	⊗	⇓
Non-agriculture	⊗	⊗	↑	⇑
Irrigation water	⇓	↓	↑	⇑
Total GDP	↑	↑	↑	↑
Agricultural GDP	⇑	⇑	⇓	⇓
Non-agriculture	↓	↓	↑	↑
Absorption	↑	↑	↑	↑
Production of food crops	↓	↓	↑	↑
Price of food crops	↑	↑	↓	↓
Exchange rate	↑	↑	↑	↑
Consumer prices	↑	↑	↓	↓
Rural incomes	↑	↑	↓	⇓
Urban incomes	↓	↓	↑	↑
Total employment	↑	↑	⇓	⇓
Rural employment	⇑	⇑	⇓	⇓

(*Continued*)

Table 5.5: (*Continued*)

Policy impacts	Policy scenarios			
	Liberalize regional irrigation water markets	Liberalize national irrigation water markets	Water-restricted competition from higher urbanization	Water-liberalized competition from higher urbanization
Non-agriculture	↑	↑	↑	↑
Total exports empl.	↑	↑	↑	↑
Agricultural exports	⇑	⇑	↓	⇓
Non-agriculture	↓	↓	↑	↑
Total imports	↑	↑	↓	↓
Agricultural imports	⇑	⇑	⇓	⇓
Non-agriculture	↑	↑	↑	↑

Source: Hassan et al. [2008].

Note: For notation see note in Table 2.

intermediate inputs, labor, and capital) to change according to the results of the CGE model (see Tables 5.3–5.4 in Roe et al., 2005b). In general, the indirect effect from declines in factor and intermediate input prices work in opposite direction to the direct effects discussed above. That is, the decline in some input prices help to countervail the decline in output prices due to the reform's direct effects. Thus, it can be observed that the decline in sugarcane production falls less (−5.4%, Table 5.4) under the total effect scenario, and change in soft wheat production actually increases (+2.1%). However, for the other small crops, the total change in output is larger than (i.e., dominate) the direct effect. The decline in purchased input prices (intermediate inputs, labor, and capital) benefit farmer's production, and hence, induce the farmer to increase (or reduce less) each crop's production after the

Table 5.6: Impact matrix of simulated policy scenarios in Turkey.

	Scenario[a]					
Variable	1	2a	2b	3a	3b	3c
Absorption	↓	↑	↓	⇓	⇓⇓	⇓
Household consumption	↓	↑	↑	⇓	⇓	⇓
Investment	⇓	↓	⇓	⇓⇓	⇓⇓	⇓⇓
Government consumption	↓	↑	↑	⇓⇓	⇓⇓	⇓
GDP at market prices	↓	↑	↓	⇓	⇓⇓	⇓
Net income tax	⇓	↓	↓	⇓	⇓	⇓
GDP at factor costs	↓	↑	↓	⇓	⇓⇓	⇓
Total exports	↓	↓	↓	⇓⇓	⇓⇓	⇓⇓
Total imports	↓	↓	↓	⇓⇓	⇓⇓	⇓⇓
Agricultural exports	⇑⇑	⇓	⇓⇓	⇓⇓	⇓⇓	⇓⇓
Agricultural imports	⇓⇓	↑	⇑	⇑⇑	⇑⇑	⇑⇑

Source: Cakmak et al. [2008].

[a]Scenario 1: World price increase; Scenario 2: Rural-to-urban water transfer in West Region (2a–30% of irrigation water transferred; 2b–50% of irrigation water transferred) Scenario 3: Climate change (3a–30% reduction in rainfed crop yield; 3b–10% reduction in irrigated crop yield; 3c-0-30% reduction in all crop yield depending on crop and region);. Upward and downward arrows indicate the level of the positive or negative impact with longer arrows larger higher impact.

Note: Symbols in the table correspond to Note under Table 5.1. ⇑⇑ and ⇓⇓ mean extremely positive or negative impact on the said variable through all range of policy intervention values.

reform. Interestingly, due to differences in input intensity among crops, the demand for labor and capital, as well as land reallocation change differentially in response to reform interventions (Table 5.4). This analysis then shows clearly the importance of linking and identifying the separate macro–micro effects on farm decisions.

Since farmers are heterogeneous, their supply response to the trade reform will also vary. For this reason, it is necessary for policy makers to distinguish between the aggregate (all farms) effect of trade reform on

Table 5.7: Comparison of the policy interventions and economy structure used in the Mexico, Morocco, South Africa, and Turkey analyses.

Country	Mexico	Morocco	South Africa	Turkey
Intervention/shock				
Rural-to-urban migration and water allocation from rural-to-urban centers	√	√	√	√
International trade liberalization	√	√	√	
Reduction in water supply for irrigation	√	√	√	
Climate Change	√	√	√	√
Trade in water within and among sectors		√	√	
Conjunctive use of GW and SW		√		
World agricultural price shocks				√
Economy structure				
Rural/urban distinction	√	√	√	√
Household types	√	√		
Farm types	√	√		
Irrigation/rainfed	√	√	√	√
Regional differentiation	√	√	√	√

agricultural production and the distribution effect across farm types. This analysis can be done by using the economy-wide (CGE) model, in which not only the macro economic variables can be obtained, but also sector-level (agriculture by crops) variables, such as changes in total supply of each crop, can be observed.

Due to the differential effect on crop production, crop and input prices and land holdings, trade reform impacts on farm incomes vary with farm size. Table 5.5 [Roe et al., 2005b], reports the income effect of trade reform by household groups in the CGE model. Due to our

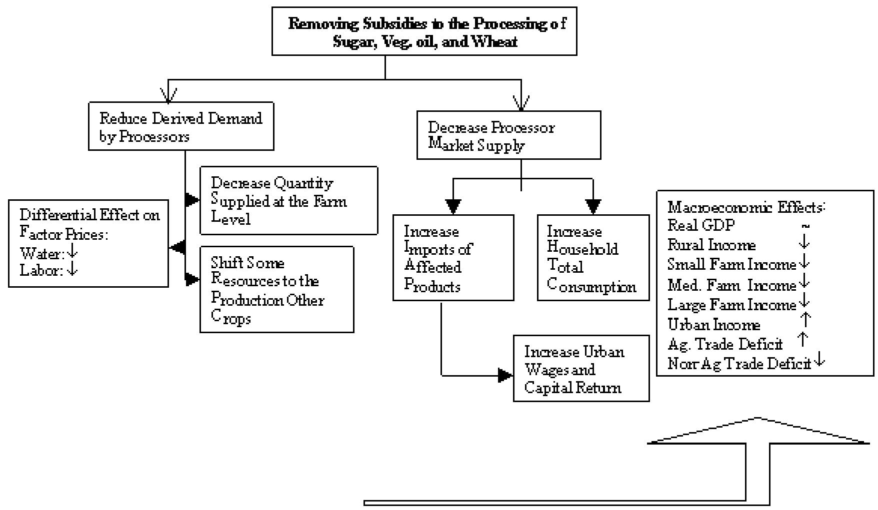

Figure 5.3: The macro–micro linkage effects of removing subsidies to processing of sugar, oil, and wheat in Morocco.
Source: Roe et al. (interim reports to the World Bank during 2003–2005).

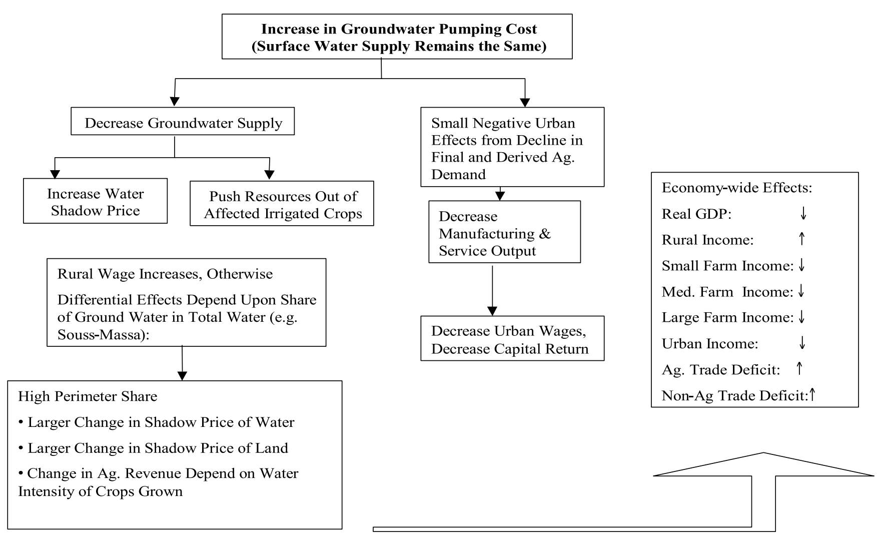

Figure 5.4: The macro–micro linkage effects of increase in groundwater pumping cost in Morocco.
Source: Roe et al. (interim reports to the World Bank during 2003–2005).

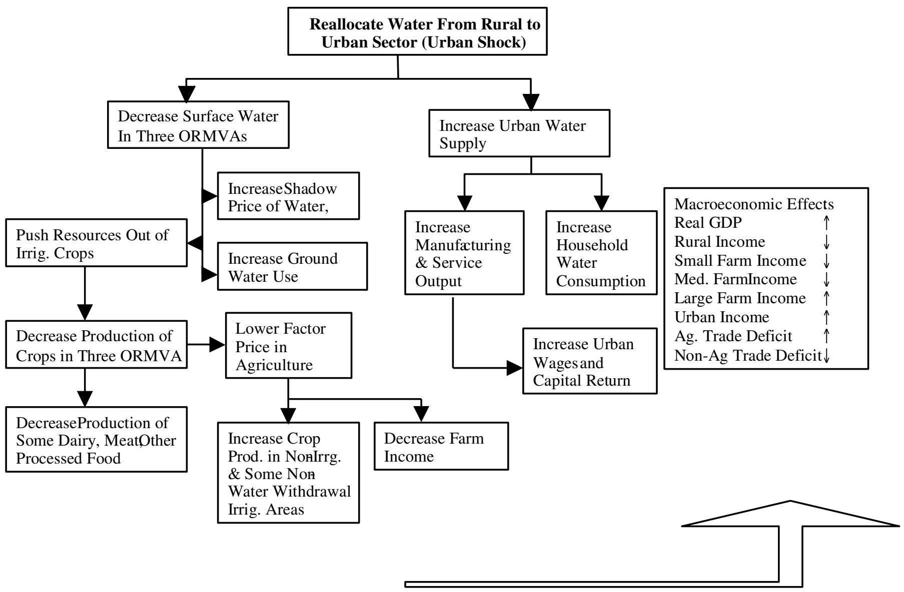

Figure 5.5: The macro–micro linkage effects of reallocation of water from rural-to-urban uses in Morocco.
Source: Roe et al. (interim reports to the World Bank during 2003–2005).

current data constraints, this income grouping does not distinguish between farmers in or outside the perimeters. The results show that small farmers incur the largest income loss due to the trade reform. As a group, small farmers' income declines by 17%. The urban household group benefits from the reform, and its income increases by 8.6%. These results reflect the fact that the nonfarm sector of the economy is also negatively impacted by the country's current trade policy.

Micro-to-macro links of water reforms. We analyze how a water policy reform at the farm level has direct effects on the farm firm, how these effects affect the broader economy when adopted in all perimeters, and then, how these adjustments feedback (indirect effects) to affect the economy of the firm. In terms of the simple theoretical model, extending the reform of water policy from the firm to the national level is considered in terms of trades in water user rights. This type of national level reform will equate shadow prices within each perimeter. The results appear in Tables 5.2–5.5 in Roe et al. [2005b].

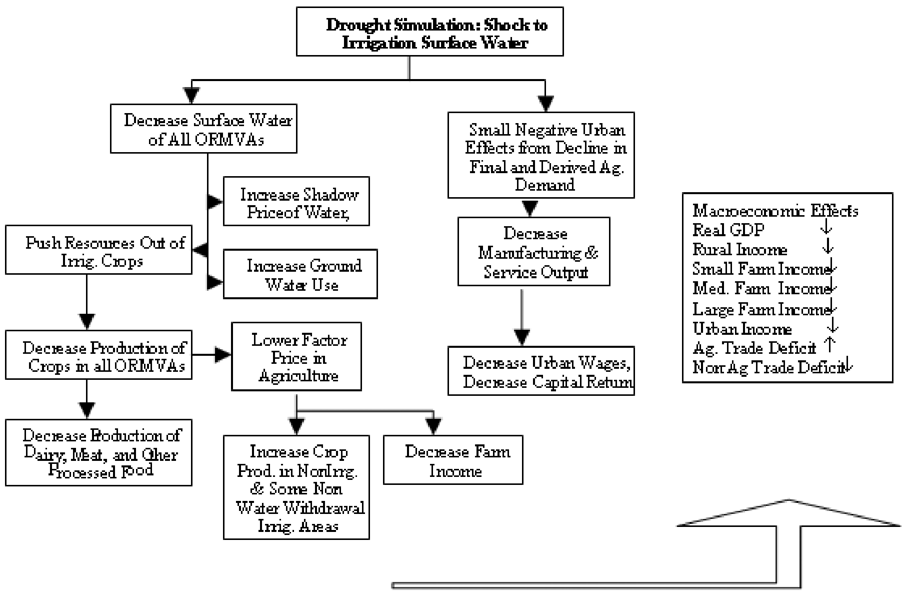

Figure 5.6: The macro–micro linkage effects of drought resulting in reduction of surface water available for irrigation in Morocco.
Source: Roe et al. (interim reports to the World Bank during 2003–2005).

Farm-level direct effects of water reforms. Starting at the micro level, the reform analyzed is to relax the water authority's water assignment rule, which is the respective ORMVA's assignment of water by crop and month. To model such policy reform, one has to start from the farm model, and allow the farmer to equate the marginal cost of water across crops (by month) to maximize their production profit. Without considering the possible effect on other economic factors (i.e., holding all exogenous variables in the farm model constant), the farmer responds by reallocating water more efficiently, according to the marginal-value product-of-water rule. Thus, water moves out of the crop production in which the government has assigned an amount of water that causes the marginal value product of water in this crop to lie below that of other crops. Hence, the shadow prices (opportunity cost) of water for growing such crops (such as soft wheat and sugarcane) are lower than for those crops receiving a lower water assignment (e.g., strawberries and water melon).

The direct effect of reform at the farm level (results not shown) is to cause water allocated to the production of soft wheat and sugarcane to decline by 36.6% and by 3.7%, respectively. The water released from wheat and sugarcane is allocated to other crops. Except for the late peanuts, water allocation increases in all other crops. Water reallocation is accompanied by the reallocation of land as well as labor and capital (not shown). Moreover, although the direction of change in the reallocation of land and other inputs is consistent with water reallocation, due to the relative factor intensity of the resource employed in each crop and the water–land ratio, the magnitude of the changes in the other inputs is not in direct proportion to water reallocation.

Finally, notice that the magnitude of the output change due to water reform is often larger than the change due to trade reform, indicating the importance of water policy to farmers' production decision.

Farm-level direct and indirect effects of water reforms. If many farmers in a region (e.g., a perimeter or an ORMVA) participate in a water reform, the allocation of a perimeter's total disposable water supplies among crops and farm types is most likely to depart substantially from those of the water assignments. If, for example, the government were to grant to farmers the user rights to the ORMVA's previous assignment of water, some farmers may have the incentive to rent out some of their water to other farmers, or to rent in from others. In this case, a different combination of crops could be produced and different combinations and levels of resources could be employed at the farm level. These changes in turn will cause factor markets for labor and other purchased inputs to re-equilibrate. For this reason, the economy-wide model (CGE) is used to simulate a similar water reform policy that might be carried out on a national basis.

Assume that this policy is adopted for each perimeter in each of the seven ORMVAs. This policy will cause the economy to re-equilibrate, with new prices for labor and goods that are not traded in world markets (including some purchased inputs).

Table 5.3 in Roe et al. [2005b] report the change in wage due to such a water reform, while Table 5.4 in Roe et al. [2005b] presents changes in factor prices, which the farm takes as given. The difference between the total and direct effects yields the indirect effects of water reform. These results are reported in Table 5.4. In most cases, the indirect effects are of opposite sign to the direct effects.

Effects on the shadow prices of water. The total effect of water reform on the productivity of water in each of the seven ORMVAs, by perimeter, is reported in Table 5.6 in Roe et al. [2005b]. The values shown are the change in the shadow price due to the provision of water user rights that farmers may trade among themselves as a percent of the shadow price of water (as estimated by the model when calibrated to data) associated with water assignments in each perimeter of each ORMVA, by crop. The trading in water rights should equalize the shadow price of water. In an analytical model with multiple factor inputs, the change in the shadow prices of water is indeterminate.

Of the 20 perimeters, only four experienced a decrease in the shadow price of water due to water trade reform. The intuition explaining this result is that (a) given the initial water assignments, and (b) the reallocation of water among crops and farmers in all ORMVAs, together caused an increase in the prices of other factor inputs that the crops in these four perimeters employ relatively intensively. This caused the new shadow prices for the crops grown in these four perimeters to fall. In the case of Doukkala perimeter 1, sugar beets account for over 10% of total output, melons for about 8% and other tree crops for 12%. The allocation of water out of sugar beets, and the increase in other input prices simple caused the productivity water in the perimeter to fall in marginal value relative to the base as the prices of other inputs increased.

The other 16 perimeters experienced an increase in the shadow price of water relative to base. The largest increase, about 52%, occurred in perimeter 2 of the Haouz ORMVA [Table 5.7 in Roe et al., 2005b]. This increase occurred as water was allocated out of cereals and fodder production and into crops that are relatively more water intensive such as vegetables. This reallocation released more non-water resources from cereals and fodder production than could be profitability employed in other crop production and the pre-reform resource prices. The result was an increase in the shadow price of water in this perimeter.

The effect of reforming water policy on the macro economy and income distribution of household groups is shown in Table 5.2, (4th column) [Roe et al., 2005b]. Total agricultural output in the seven ORMVAs increases by 7.54% due to the water reform. This is a substantial increase in output that is obtained without the additional net use of resources. It can be seen that change in most other aggregate or economy-wide variables is modest. Such modest effects are due, in part, to restricting reform to the perimeter level, and holding urban demand for water constant. It must also be kept in mind that irrigated agriculture is a relatively small share of the total economy, although it employs a disproportionately larger share of the nation's rural work force.

Farm-level effect due to combined trade and water reforms. The overall effects of the two policy reforms on farmer's total revenue and net profit are used to represent the possible welfare gains/losses of the policy reforms for the modeled farm, recognizing that farms of different types and enterprises may experience different effects. The results show that for this specific farmer who is heavily dependent on income from growing sugarcane and soft wheat, the trade reform leads to relatively large decline in output revenues and farm profits (defined as total production revenue minus all purchased inputs, thus equaling returns to farm-specific resources). The direct effects of reform cause total production revenue and net profits fall by 15.7% and 50.7%, respectively. The indirect effects compensate the direct negative effects only marginally, by a positive 1% on revenue and 10% on profits. Thus, the total effect of trade reform for this particular farm is a decline in revenue of 14.7% and a decline in profits of about 40.3%.

On the other hand, the farmer benefits from the water reform. In this case, the indirect effects are larger than the direct effects, and more importantly they operate in the same direction. The direct effect of the water reform is to increase revenue by 3.7% and profit by 16.5%. The total effect is a 9.6% or 35.6% increase on revenue or profit, respectively.

Putting the two, trade and water reforms, together, the particular farm modeled is still made worse off (35.6–40.3%), but the water reform can almost totally compensate the farmer for the losses incurred by the trade reform. This result illuminates the importance of taking a broader view on reforms. It also suggests that the chronological order at which the reforms are implemented is important. Farmers will be more agreeable of a combined trade and water reform when they know that the water reform will compensate some or all of their losses due to the trade reform.

5.2 Features for Mexico

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 been greater (by internal migration) in the semi-arid and arid north, northwest, and central regions, which are the regions with greater economic activity and where water is scarcest. The resulting increased demand for water, combined with more intensive use of water has led to insufficient water availability to support natural ecosystems, and seriously constrains growth in many areas.

Nearly 75% of Mexico's available water resources are used for irrigation. Roughly speaking, Mexico can be divided into two parts; the country's four southern regions are more water endowed than the nine northwestern, northern, and central regions. Irrigation systems in Mexico can be grouped into two major categories: small- and medium-scale (100 to 3,000 ha) and large-scale systems (>3,000 ha). While industry uses 10% of the water in Mexico, it has an important role, both affecting and being affected by the water sector. Several issues are worth mentioning. Mexico's industrial sector pays water extraction charges that are relatively higher than in other sectors. With over allocation of existing water rights, new industrial entrepreneurships are constrained in many of the most attractive locations for certain industries. At the same time the industrial sector is said to be a significant polluter, creating emissions of organic water pollutants. Water resources availability and poor quality are increasingly becoming constraints to economic development and growth in important northern and central parts of the country.

In the study of Mexico a regional agricultural production model and a macroeconomic (CGE) model were developed.[2] Both models focus on the Río Bravo Basin, but the CGE model also incorporates additional regions and sectors, comprising the entire Mexican economy. The detailed and technical description can be found in Dinar and Asad [2006], Yunez-Naude and Rojas Castro [2008], and Howitt and Medelin-Azuara [2008].

5.2.1 The regional farm production model

The regional production model is linked to a hydrological model[3] of the Río Bravo Basin (http://www.crwr.utexas.edu/riogrande.shtml). The regional agricultural model is based on production models of representative farm types. The production models were calibrated to small (area < 10 ha), medium ($10 >$ area < 50 ha) and large farms (area > 50 ha), based on the farm sample that was used by FAO. Then, using CONAGUA statistics on farm distribution in the study area, the farm models were extrapolated to construct the regional model that represents the agricultural sector in the four Rio Bravo Riparian states: Chihuahua, Coahila, Nuevo Leon, and Tampaulipas. Several sets of policy interventions were simulated. The production model, a partial equilibrium framework, distinguishes between farm types and is used to assess the impact of the following policy issues: (1) reduced water availability, (2) increased water cost, (3) smaller elasticity of crop supply (to reflect "water secured" crops with lower sensitivity to changes in crop prices) + change in water availability, (4) smaller elasticity of grain crop supply + increased water cost, (5) reduced labor availability, (8) increased labor cost, and (6) changes in crop price support programs.

[2]See "Regional and Macroeconomic Analysis of Policy Interventions in the Water and other Related Sectors in Mexico" authored by a team from Colegio de México (COLMEX) and led by Antonio Yunez-Naude, as part of Dinar and Asad [2006].

[3]The study team collaborates with the bilateral Mexico-USA project that has been initiated between the University of Austin Texas and several research institutes in Mexico, including IMTA.

While specific policy intervention results are discussed in Dinar and Asad [2006], and to a greater detail in Howitt and Medellin-Azuara (2008, Tables 1–17) for the farm level model, and in Yunez-Naude and Rojas Castro (2008, Tables 1–25) for the macro model, several general observations are worth presenting here. The policy simulations suggest that the farming sector is more responsive to policy interventions that affect level of the resource that is available to the farmers rather than to policies that affect the cost to the farmers of using that resource. In other words, using economic terminology, farmers in the Rio Bravo Basin are quantity rather than price rationed. Both the reasons for that and the general policy implications will be discussed later.

Another general observation is that the various farm types respond differently to the policy interventions. It should be emphasized again that the differences among farm types are the result not only of size, but also of technology, access to credit, markets, and knowhow — all of which affect the crop mix and productivity levels. While this is an obvious observation that may not be ground breaking, the ability to quantify the impacts and to identify the magnitudes is of importance.

Eight crops were included in the farm model, that in total capture the majority of the cultivated land in the Rio Bravo Basin (Alfalfa, Wheat, Maize, Cotton, Melon, Sweet Potato, Beans, and Sorghum). Three of these crops, Alfalfa, Maize, and Sorghum, are grown by all farm types. Therefore, these crops will be used to test crop-related policy interventions.

5.2.2 Policy intervention simulations

The starting point to consider for the policy interventions simulations is that there are significant differences among the farm types that will probably affect their response to the various interventions. First, cropping patterns of small farms include also melons and beans, which are not grown by medium and large farms. Second, there is a reciprocal trend of applied water per unit of land with farm size, for all crops. On average, medium farms use 10% more water per unit of land than large farms, and small farms use 100% more water per unit of land than large farms (these significant differences are not necessarily the case when specific crops are compared). With farm size distribution in the basin, the policymaker has already a pre-stated priority as to where the problems are and the efforts should be focused.

To save space only a handful of policies that were applied are discussed. A more comprehensive discussion can be found in Dinar and Asad (2006).

Reduction of water availability for irrigation by up to 40% (reduction from 100% to 60%) suggests an important economic term — the opportunity (shadow) value of water to the farm, which indicates the economic value of an incremental unit of water to that farm. This policy intervention could represent either an external water availability shock, or a shift in allocation policy, if politically allowed. Shadow values are quite similar for large and medium farms but about 25–50% lower, for similar levels of water reductions, in small farms. Shadow values demonstrate a steep increase, for all farm types, as water becomes less available, indicating inelastic demand function for all farms. However, small farms' demand functions are relatively more elastic than those of the medium and large farms.

Increasing irrigation water cost to farms by up to 50% may reflect change in water charges, or electricity subsidy removal policies. One immediate observation of this policy intervention results is the lesser impact on farms compared with reduction of water availability. Generally, under this intervention, reduction in irrigated area reached not more than 10% when water cost increased by 50%. The derived conclusion is that in order to achieve a larger decrease in area (and probably also in water use), a more substantial increase in water cost is necessary, which may bring in additional political considerations. But it is clearly the present behavior of the farms that suggests that the value of water is much higher than its cost (price) to the irrigators.

Specific area reduction results suggest that small farms are again, affected the most by this policy for the same reasons indicated earlier. Specific water use-intensity results suggest that for the range or water cost increases, very little effect has been made on all parameters, namely area irrigated, cropping patterns (switching to more water value crops), and reduced water per land area. Focusing only on the water application per land, for the three crops grown by all three farm types, it is clear that farmers are not price responsive at all. Increase of 50% in water cost yielded 10–13% reduction in water application per land unit for all farm types and crops with the exception of maize in small farms that was associated with a reduction of 42% reduction in water application.

Changing labor availability and its cost reflect policies that increase off-farm employment, increase in urban migration, or increased demand due to international trade. A general observation is that none of the crops grown on any of the farm types exhibited a significant change in water use intensity. The biggest change was in the case of small farms, where maize and sweet potato took a cut in water per hectare of 14% and 11%, respectively. One can conclude therefore that water is not a substitute for labor in this region. Farmers just reduce irrigated area as labor becomes scarce or more expensive, and this is how the irrigation water demand is affected. Small farms were also most hit by this policy intervention.

5.2.3 The macro model

The regional-CGE framework is used to assess the impact of the following set of policy issues: (1) progressive increase in water supply, (2) progressive reduction in water supply, (3) reduction of 50% in water supply for irrigation; (4) reduction of 50% in water supply for irrigation + investment of fee (based on shadow water value) collection in improved productivity by WUA, (5) water transfer from Rio Bravo Basin to close by regions (North, Central), (6) NAFTA liberalization; (7) NAFTA liberalization + elimination of PROCAMPO, (8) NAFTA liberalization + reduction of 50% in water supply for irrigation, (9) application of 15% VAT on foodstuff + reduction of 50% in water supply, (10) elimination of agricultural subsidies, and (11) climate change regional differential impact on rainfall and water supply.

5.2.4 Results of the macro model simulations

Cropping patterns in Mexican agriculture are clearly more sensitive to factor availability than to factor price (or total cost increments). So, in regards to surface water for irrigation in the RBB, policies aimed to increase total cost of water for agriculture may not substantially change behavior of farmers as they are reflected in current cropping patterns and usage of other factors. A similar result was obtained using the macroeconomic model. That is, reductions in water supply for irrigation have much stronger effects on irrigated agriculture (and on the remaining of the Mexican economy) than changes in water costs to users. This finding is explained in part by the fact that in Mexico, total surface water costs are just a composite of water fees paid to the Water Users Associations (WUAs, i.e., water is not fully valued and its opportunity cost is extremely low). In addition, dryland and irrigated land rents respond differently, as demand for dryland increases.

The positive general equilibrium effects of agricultural trade liberalization on rural households' income do not disappear when one adds water restrictions on addition to instituting free trade. By contrast, and under free trade, the elimination of PROCAMPO income transfers to maize producers reduces rural households' incomes.

Agricultural trade liberalization plus a value-added tax (VAT) to foods and a 50% decrement in water supply for irrigated agriculture counterbalances the positive effects of agricultural free trade in the rural economy. However, the VAT has a positive impact on public resources that can be used for investment.

Climate change impact on water availability will be differential across the river basins of Mexico. The macro model was able to capture this variable impact and assess the regional and macro economy consequences. Except for the Southwest, all regions will suffer mild to significant reduction in rainfall quantity. Most crop yields and area will be reduced and crop prices will be increased, diary and livestock prices will be reduced as well as other durable commodities and services. More cropping under rainfed will replace irrigated crops. Urban real wages will drop and the same holds for rural wages in the North and in the RBB. Irrigated lands rents will also drop for the North, the RBB, and the Southeast.

Finally, the elimination of subsidies (mainly granted to crop production under irrigation) also has negative consequences on Mexican agriculture, as well as on Mexico's rural and urban households, especially so for rich rural households. As in the VAT policy intervention, the positive effect of this policy is that public resources increase.

A linkage and interaction of impact channels of a trade liberalization policy alone, on the various sectors and factors of production is shown in Figure 5.7. And the linkage and interaction of impact channels of a water supply reduction to irrigation, charging by shadow value and investment of proceeds by WUA, on the various sectors and factors of production is shown in Figure 5.8. A more detailed impact description by region and explanation of the linkages is provided in Tables 5.1–5.4 for selected macro policy intervention and external shocks.

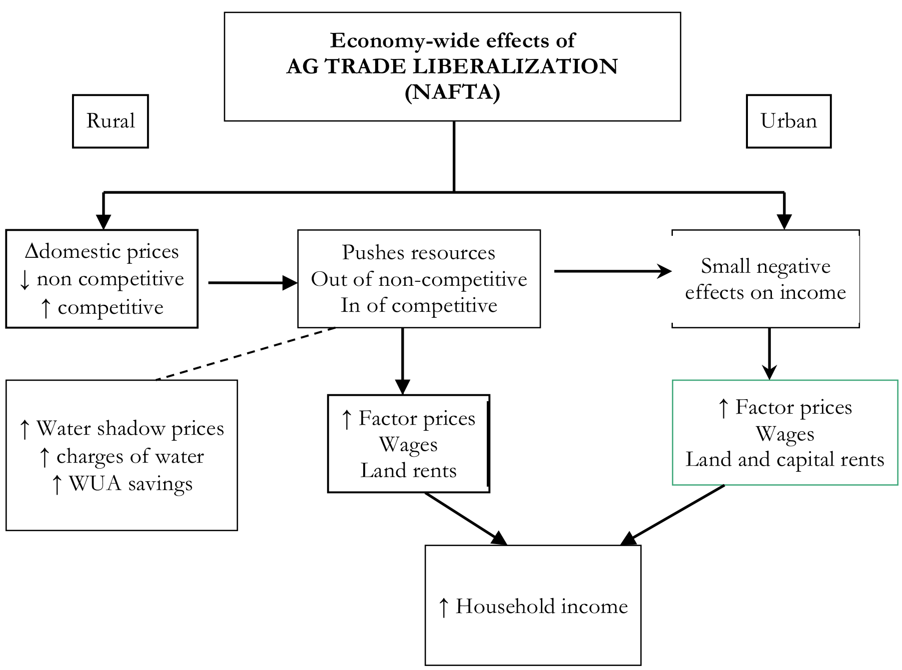

Figure 5.7: Channels of impact and interaction in the CGE model of a trade liberalization policy in Mexico.
Source: Yunez-Naude (interim reports submitted to the World Bank during 2005–2006).

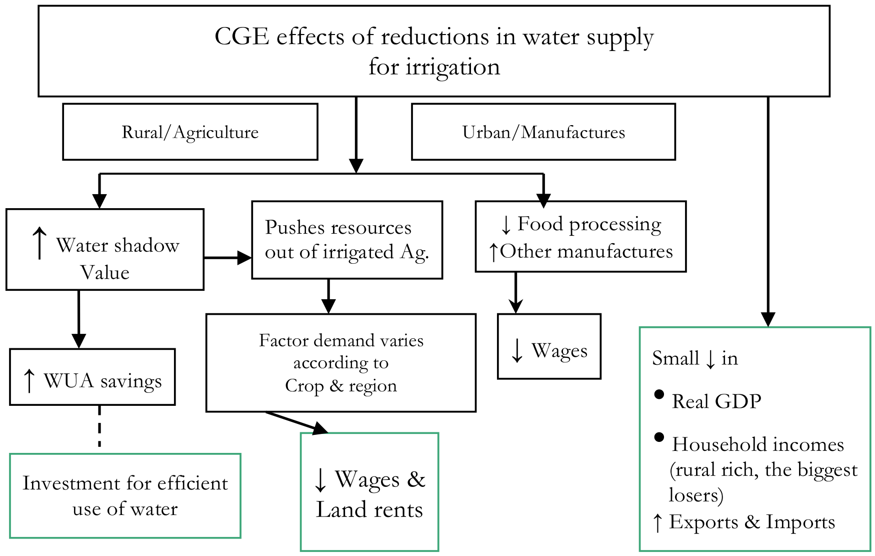

Figure 5.8: Channels of impact and interaction in the CGE model of a water supply reduction to irrigation, charging by shadow value and investment of proceeds by WUA in Mexico.
Source: Yunez-Naude (interim reports submitted to the World Bank during 2005–2006).

5.3 Features for South Africa

The total potential irrigable land in SA is estimated at 1.57 million ha (NDA, 1996). Most of the irrigated land is used for large-scale commercial farming of horticultural crops (grapes, fruit, and vegetables), grains and pastures, and forages. Less than 4% of the irrigated area is under smallholder farms growing various combinations of these crops within a number of irrigation schemes (WRC, 1996).

Agriculture contributes a small and declining share of total economic output but relatively higher shares in total export (including secondary value-adding processing) earnings and employment. Nevertheless, the agricultural sector draws 75% of the country's water resources. Recent trends also indicate increased competition for water from other use sectors and developmental needs and hence a declining share and availability of water for irrigation activities.

Over the past few years SA agriculture experienced major structural adjustments following a number of critical macro and sector-level policy changes, including major changes in managing the foreign exchange and capital markets coupled with wide liberalization of agricultural marketing and trade regimes. All of that led to the exposure of the agricultural sector to shifts in relative world commodity and factor prices. Particularly, the competitiveness of the South Africa's agricultural exports has been affected with the removal of various forms of protection, change in interest rate and export subsidies and substantial currency devaluations [Hassan et al., 2008]. In parallel, a number of domestic policy changes mainly in the allocation of and access to key resources such as land and water were implemented.

The key water sector (micro) policy changes stemming mainly from implementation of the National Water Act (NWA) are expected to have important direct and indirect implications for future water use and allocation and associated macroeconomic consequences. The NWA introduced measures to enhance future equity in access to water resources, and promotion of efficiency in water use and allocation among competing sectors such as irrigation, mining, manufacturing, and services.

One immediate response to the initial move toward economic efficiency following increased water charges was a switch of land and water from low value field crops such as maize to high value horticultural products for export and shifts to use more efficient irrigation technologies [Hassan et al., 2008]. The NWA also promotes trade in water leading to efficiency gains in water use in some areas [Hassan et al., 2008]. In addition, the NWA secures ecological demand and basic human needs for water. This by itself affects water availability for economic activities.

5.3.1 Policy considerations

Some of the main macroeconomic changes that are expected to have important influences on water use and allocation and overall economic wellbeing include: (1) strategic plans promoted by the government to increase rates of economic growth in the future, while providing water basic needs; (2) rapid urbanization fostered by recent major shifts away from primary production, affecting competition for water particularly between domestic and other uses; (3) policy changes with implications for the performance of irrigated agricultural exports, such as adjustments in the rate of foreign exchange, allocation of larger shares of water at subsidized prices to small holder farmers and for basic human need, trade protocols with SA's major trade partner, the European Union (EU); and (4) future regional economic policies, and global climate change.

The impact of these policies on the productivity of irrigated agriculture, rural poverty, and food security in South Africa will be simulated by focusing on the impacts of a selected set of four policy interventions: (1) removal of major non-price restrictions that constrain reallocation of water between activities, sectors, and regions; (2) allowing trade in water among various users (i.e., allocation of water on the basis of economic efficiency through a water-like market); (3) water-restricted competition from higher urbanization; and (4) water-liberalized competition from higher urbanization.

5.3.2 The structure of the CGE model for South Africa

Apart from its treatment of water, the model contains detailed information on production, trade, and consumption. The model uses a new structure for highly disaggregated agricultural sector activities.

The model contains 40 sectors/commodities, including 17 agricultural and 15 industrial sectors. Agricultural production is divided into field crops (summer cereals, winter cereals, oil crops and legumes, fodder crops, cotton and tobacco, and sugarcane), horticultural crops (vegetables, citrus fruit, subtropical fruit, deciduous fruit and viticulture, and other horticulture), livestock (livestock sales, dairy, poultry, and other livestock products) and fishing and forestry. Field crops are further separated into irrigated and rainfed, whereas all horticultural production is assumed irrigated. Together, these agricultural sub-sectors account for 4.3% of national gross domestic product (GDP) — making agriculture a relatively small part of the South African economy [Hassan et al., 2008, p. 13]. The model introduces for the first time a breakdown by water management areas (WMAs), which are delineated by, more or less, the river basin borders. This has important relevance to policy in South Africa as the government agencies and WMAs are in charge of allocation of water and other resources within these borders.

Agricultural and nonagricultural production in the CGE model is therefore disaggregated across each of the 19 WMAs. In total there are 874 representative producers in the model (each of the 19 WMAs contain 40 sectors, with the six field crops further disaggregated into irrigated and rainfed). Thus, while the regional dis-aggregation of the model is motivated by WMAs, it also captures the varying importance of agriculture and other sectors in different parts of the country.

5.3.3 Results for South Africa

The South Africa Water CGE model examines a number of water-related issues in SA and the economy-wide (micro and macro) impacts of the following policy scenarios have been evaluated. They include [Hassan et al., 2008] (I) intraregional irrigated-water-market liberalization to examine the impact of liberalizing local water allocation among crops so as to equalize the shadow price of irrigation water across crops within each WMA. It is called Regional Irrigation Market.

Regional Irrigation Market. Since the trade is allowed only within each WMAs, some shadow price values may rise or fall by lager magnitudes relative to the base than others. Therefore, the initial shadow values only provide a partial prediction of the direction of the final result. This scenario leads to estimation of general equilibrium shadow process for irrigated water for various WMAs; (II) changes in inter-regional transfers of water for irrigation use based on existing water transfer schemes in addition to liberalizing regional (within WMA) irrigation water markets (as in I). Water allocation between agricultural and nonagricultural use remains unchanged in this scenario which liberalizes national irrigation water trade. It is called *National Irrigation Market.* This scenario equalizes irrigation water shadow process both within and between all WMAs and thus establishes a national general equilibrium SP; (III) Introducing increased competition for water from predicted expansions in nonagricultural uses and rapid urbanization through rural-to-urban migration. Under this scenario there is no liberalization of water markets. It assumes that urbanization and industrial expansions will greatly increase urban water demand in the future. It is called *Water-Restricted-Urbanization*; and finally, (IV) Liberalizing water markets allowing for market-based water transfers out of irrigated agriculture to municipal areas to meet the growth in demand for domestic and industrial uses introduced under scenario III. It is expected to transfer significant amounts of water out of irrigation agriculture leading to declines in agricultural GDP, rural employment, and incomes. This scenario is called *Water-Liberalized Urbanization.*

The quantitative results can be found in Hassan et al. [2008, Tables 1–21]. In Table 5.6 the reader can find the impact matrix of the four simulated policy scenarios in South Africa on major variable. The interesting finding is that some of the policies such as those that favor urbanization further polarize the competition between the rural and the urban sector in the country, which will be discussed in the conclusion section.

5.4 Features for Turkey

Turkey has about 25 million hectares of irrigable land. Nearly 20% of the cultivated area is irrigated. Because of the climatic conditions, rainfed agriculture is very limited, and irrigation plays an important role in the agricultural sector.

The sources of irrigation water and irrigation systems display both interregional and intraregional! diversity. Over half of the land in the Aegean, Southeastern, and Mediterranean regions, constituting nearly 50% of the irrigated land in the country, is irrigated from dams and artificial lakes, and thus benefits more from subsidized water (SIS, 2003). Equity issues are at the heart of needed policy intervention in Turkey. Small farmers (<5 hectare), which make up 70% of the farmers, own slightly over 20% of the land. The larger farmers (>20 hectare) constitute 5% of the holdings and own 35% of the land. Larger lands tend to be irrigated from dams and reservoirs constructed and subsidized by government, whereas smaller farms are more likely to derive irrigation water from local wells at the farmers' expense.

5.4.1 Structure of the CGE Model for Turkey

The Turkish CGE model includes the three main sectors in the Turkish economy, namely the production activities, the institutions, and the foreign sector. The model disaggregates the economy into 20 agricultural and nine nonagricultural activities. Agricultural activities are categorized by field crops, livestock, fishing, and forestry (classified as "other agriculture"). Nonagricultural activities include mining, consumer manufacturing, food manufacturing, intermediates and capital goods, electricity and gas, water, construction, private services, and government services.

Of the agricultural activities, field crops and livestock are further disaggregated into production in four main regions and one micro region of the country: West, East, Central, Southeastern, and the microregion, LSCB (Lower Seyhan–Ceyhan Basin). Fishing, forestry and nonagricultural activities remain at the national level. The institutions sector includes households, the government and the Water User Associations (WUAs). Households are disaggregated into rural and urban households. Rural households are further disaggregated according to their geographical location. The model includes five rural households and one urban household type. Import, export, and tariffs concerning the 25 EU countries and the rest of the world constitute the foreign sector of the model.

According to Cakmak et al. [2008, p. 29], "Production technology in each activity is defined by a CES function of value added and aggregate intermediate input use. The value added in each activity is given by a CES production function of factors used (labor, capital, irrigated land, rainfed land, and water, if applicable). Aggregate domestic output is distributed among domestic use and exports (EU and rest of the world). All producers take factor and commodity prices as given, and are all profit maximizers. Urban and rural household types in each region have a simple consumption pattern in the sense that they devote a fixed share of expenditures on each consumption item. Each household type has a different consumption pattern depending on household income and savings. Implicitly in this structure, households are assumed to minimize expenditures on consumption, taking as given the price of each commodity. Urban households earn income from labor services and capital rent, whereas each rural household earns income from services of labor and capital, as well as land rents (irrigated and rainfed) and income from the WUAs via transfers from government.

The government also has a fixed consumption pattern in the sense that it devotes a fixed share of expenditures on each commodity. The government derives income from various types of taxes (import, export, production, sales, etc.) and also saves. The government in this model also acts as an intermediary between the WUAs and the rural households in the sense that the water charges collected from agricultural producers by the WUAs are then distributed to rural households in their respective regions by the government."

Water demand in agriculture (which uses about 80% of available water in Turkey) is estimated, using the concept of shadow prices in order to derive the water demand. The shadow prices are derived from a programming model for each of the various rural household types that face different levels of available water quantity. In this setup the shadow price for the water constraint is the value of the marginal product of irrigation water. In order to get the derived demand for irrigation water, one should change the water constraint starting from zero when irrigation water is not binding [Tsur et al., 2004a,b, p. 6].

5.4.2 Linkage between the farm model and the CGE

The farm model is used to estimate the shadow value of water in agricultural production. In this setup, shadow rent is the difference between the farmers' surplus and the price at the level of consumption of water. It was estimated that the shadow rent for water is twice the actual payment made to water. Under these findings this shadow rent was added to the payments made to irrigation water as a factor of production in the CGE model.

5.4.3 Results for Turkey

Qualitative results of the policy intervention simulations for Turkey are presented in Table 5.7. The first set of simulations involve the effects of changes in world agricultural prices; the second set of simulations examine the impacts of rural-to-urban water reallocation within each region; and the third set of simulations evaluates the impact of climate change on agriculture. Following are highlights of main results.

Introducing world agricultural price shocks has two primary effects. First, agricultural imports and exports change significantly. Increasing demand for exports changes the equilibrium price and quantities in the goods market. Price changes are higher for maize, pulses, and other animal products. These products have a relatively higher share in agricultural exports and lower elasticities implying a lower substitutability of domestic and imported goods. Domestic production increased significantly in almost all activities. Non-farm households are adversely affected by increasing food prices. Demand for the factors used by agriculture is likely to increase, whereas factor demand by industrial sectors is expected to decline. Land and water use in maize also increases significantly, at the cost of employment of these factors in the other sectors.

The overall conclusion for this simulation is that change in world prices has significant welfare implications that vary between urban and rural households. A change in prices brings about a decline in import demand while increasing the export supply. Consequently, domestic prices increase and adversely affect the urban households while increasing the income of rural households. Agricultural world price increase negatively affects industrial sector due to the direct competition for factors of production with agriculture, and in intermediate demand for agricultural products that are now relatively more costly. This further suppresses urban households purchasing power income.

Urban migration in Turkey is affected by various factors such as a “high population growth rate, industrialization, mechanization of agricultural production, shifts in land ownership, inadequate education and health services, a desire to break away from traditional social pressures and feuds in rural areas, as well as increased transportation and communication facilities” (Kahraman et al., 2002, cited in

Cakmak et al., 2008, p. 43). But, increase in urbanization rate will lead to increase in rural-urban competition for water within each region. Increased urbanization and water demand is simulated by increased water supply in urban areas in the West region and reduced irrigation water availability for agriculture by the same share (rural-to-urban and industrial water allocation) in the West region. Two sub-scenarios were considered: increasing urban water supply by 30% (Scenario 2.a) and 50% (Scenario 2.b) with a similar reduction in water irrigation water. Both sub-scenarios have the same direction of effects with corresponding magnitudes.

The results indicate a decline in overall production (the sum of both irrigated and rainfed lands) for all crops. The drop in production in irrigated agriculture releases factors of production that are re-allocated to rainfed activities, leading to increase in production in rainfed activities. However, the productivity of rainfed agriculture does not compensate for the loss of irrigated productivity. As a result, prices of all agricultural commodities increase at varying rates, whereas prices in national nonagricultural activities (except for food manufacturing, electricity, gas, and government services) fall at varying rates. The price of water as an urban commodity by falls drastically following the increased available quantity in the West region.

This scenario also changes labor use patterns, as labor is released from irrigated agriculture, but wages paid to labor slightly increase as a result of the decrease in irrigation water in the West region. Water shadow value in irrigated agriculture increases dramatically. Rainfed land rent increases in the West Region because rainfed agriculture enjoys the increase in prices without bearing the cost for increasing water prices. The decrease in agricultural production and the corresponding domestic price increases lead imports to increase and exports to decrease in these activities.

Climate change is expected to reduce precipitation in most regions of Turkey. Climate change is expected to lead to severe adverse effects on rainfed agriculture, increase in irrigated agricultural demand for water as a result of reduced precipitation and increased evapotranspiration, and increase in the urban demand. All of that will mount pressure on water resources. The effects of the anticipated climate change are simulated by shocking the yields of various crops. The following section presents the aggregate results for the scenarios. A thorough discussion on the design of the scenarios together with the obtained results can be found in Cakmak et al. [2008] and Dudu and Cakmak (2011).

Three sub-scenarios are considered: a reduction in rainfed crops' yield of 30% (Scenario 3.a); a reduction in irrigated crops' yield by 10% (Scenario 3.b); and a differential reduction in all crops' yield ranging from 0 to 30%, depending on the region and whether the crop is rainfed or irrigated. All three scenarios have the same direction of impact and similar range of impact on the various variables, as can be seen in Table 5.6.

6

Conclusion

The analysis conducted in the four countries demonstrated similarity in impact directions and linkages between policy interventions. However, explanations and interpretations of the magnitudes are unique to the conditions in each country and will be discussed separately.

6.1 Mexico

In the context of the comprehensive analytical framework 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, again, 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 Rio 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 affected the most when water availability is reduced and water costs increase.

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 collections, and locally reinvest the proceeds raised by charging fully according to the value of water in water-productivity improvement technologies.

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 foodstuff is introduced and/or when agricultural subsidies to certain crops are eliminated. For example, reductions in 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 in water availability for irrigation in Northern Mexico and in the Rio Bravo Basin caused by lack of rainfall negatively affects crop production all over Mexico and Mexico's household real incomes. Rich rural households are the ones suffering the highest income reductions, especially so in the North and in the Rio 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 [Dinar and Asad, 2006].

6.2 Morocco

The top-down (macro-to-micro) links considered in our analysis for Morocco are of a trade reform type. The bottom-up (micro-to-macro) links pertain to changes in farm water assignments and the possibility of water trading. For each policy the direct, indirect, and total effects are analyzed. It was found that the productivity of water is strongly influenced by these policies, with direct effects modified by general equilibrium, indirect effects and sometimes even reversed by them.

It is expected that the basic forces will also be present in the other countries, but their magnitudes and possible direction of change will of course vary by country-specific situations, with important policy implications.

The impacts of the two reforms that were assessed were found to be different, with trade reform having an absolute impact of a higher magnitude than the water reform. It is expected to find both differences in relative and absolute magnitudes in the other three countries, based on institutional, economic, and physical conditions.

The importance of packaging and sequencing reforms is an issue that deserves further research. Our analysis of the Moroccan economy reveals that this is an important factor, affecting a successful implementation of any reform. The model developed here can be used to evaluate policy reforms in other situations, pending appropriate data, and is therefore of wide application. The three countries considered here are of varying degrees of initial conditions and relative effectiveness of policy interventions. Applying the analysis to other countries will allow testing the hypotheses related to reform packaging and sequencing under different circumstances [Roe et al., 2005b].

6.3 South Africa

SA is a water-stressed country. The pressure on existing water resources is predicted to worsen with planned growth strategies, observed recent demographic changes, ongoing radical water sector reforms which aim to correct for previous social injustices and economic inefficiencies in water use and allocation and unfavorable global climatic and economic conditions. The fact that many of these changes and policy reforms serve conflicting objectives and often work in opposite directions necessitates adoption of an economy-wide approach to properly evaluate their net impacts on rural livelihoods and economy at large.

Liberalized regional irrigation water markets improve the efficiency of water allocation within each WMA. It also expands agricultural production and exports, and creates additional employment for farm laborers. This is especially important for lower-income rural households employed mainly on farm. However, regional water market liberalization would also increase the price of cereals, thus increasing SA's dependence on imported grains and raising concerns for urban consumers.

Liberalized interregional irrigation water markets to equalize water shadow prices within irrigated agriculture across all WMAs will allow market-based transfer between crops and WMAs. This policy will lead to more production of higher value crops and regions with positive macroeconomic impacts and improves employment and income levels for low-income households, so increasing agricultural GDP. However, such policy favors also greater production of high-value crops (citrus fruits) at the expense of cereals and other field crops. This raises the price of these crops, which leads to the same final impacts as in the case of liberalized regional irrigation water markets.

Water-restricted competition from higher urbanization policy introduced competition for water from non-agriculture urban uses with irrigated agriculture. This leads to much higher competition and higher water shadow prices for irrigation water with reduced income and employment benefits to rural households and higher gains for nonagricultural households.

Water-liberalized competition from higher urbanization considers competition from industrial expansion and urbanization but transferred water from irrigated agriculture to domestic use to maintain the national water price unchanged. This has major negative consequences on the agricultural economy and may not be politically acceptable [Hassan et al., 2008].

6.4 Turkey

Turkey has a very heterogeneous landscape and spatial water distribution. Therefore, the used in the study yielded opposed impacts across sectors, and subsectors, and across regions.

The highest effects on major macroeconomic indicators occurs in the climate change simulations. Nominal GDP declines drastically, but the real impact is limited. The changes are relatively smaller in the world price increase scenario when compared to all climate simulations. The results indicate that Turkey is very sensitive to climate change impact on the performance of the overall economy. It is obvious that the impact of the climate change will not only be confined to the agricultural sector.

Irrigation is the most important adaptation measure to ease the negative impact of climate change, especially on farmers' income. While adaptation to climate change was not addressed in this study, still adaptation policies that include pricing of water, subsidies for technology adoption, crop diversification, etc. the model allows us to evaluate them in detail.

The increase in the world prices led to decrease in all selected macroeconomic indicators, except the agricultural exports. Increasing world prices hampers nonagricultural sectors as well, which then dissipates to suppress the income of rural households.

As a result of the rural-to-urban water transfer, overall production of all agricultural crops declines. The decrease in the agricultural production, coupled with the domestic price increase, is further reflected in the net trade. Agricultural imports increase with a higher decline in agricultural exports.

The over exploitation of groundwater in some regions and the increased scarcity of surface water in other regions has already started to affect also quality of the available water, with severe environmental impacts, and hamper agricultural production. One of the conclusions of the study is that a policy response of building additional infrastructure to store water and ease water availability constraint raises serious doubts as a sustainable policy for the irrigation sector [Cakmak et al., 2008].

6.5 A word on the value of macro–micro linkage CGE approach

By linking macro- and micro-level policies with micro-level decision-making into one analytical framework, the analyst is able to better capture direct, indirect, and total effects of either policy interventions or external shocks. The macro–micro linkage framework allows the analyst to address not only efficiency aspects of policy interventions, but also equity/distributional implications of the interventions and the shocks. The discussion in the previous sections suggests that given the uneven distribution of natural resources (e.g., land and water) across the landscape of a country, and given the different endowments and abilities of various households in each of these regions, policy interventions would have different impacts across regions and types of households. Because the macro–micro linkage allows us to differentiate between macro and micro policies, and between direct, total, and indirect effects, the analyst is capable of evaluating the tradeoff between social objectives and how each policy intervention/external shock impacts such tradeoffs.

Annex 1: Recent published CGE model applications related to water issues (includes and expands beyond Dudu and Chumi, 2008).

Source	Background	Aim	Modeling approach
Berrittella et al. [2005]	GTAP [Hertel, 1997]; GTAP-E [Burniaux and Truong, 2002]	Assesing the role of water resources and water scarcity in the context of international trade.	Multiregion world static CGE model.
Berrittella et al. [2005]		Assessing a series of water tax policies.	
Beritella et al. [2006]		To estimate the impacts of the North–South water transfer project on the economy of China and the rest of the world.	
Berrittella et al. [2008a]	Yunez-Naude and Rojas Castro [2008]	Comparison of pricing schemes in a multiregion, multisector economy.	Static GTAP model.
Berrittella et al. [2007a]		Estimates the impact of the South to North Water Transfer project on China's Economy and that of the world.	Static global GTAP model.
Berrittella et al. [2008b]	Roe et al. [2005a,b]	Evaluating the impact of trade liberalization of ag products on water use in a global setting.	Static GTAP model of international trade and water relationships.
Berrittella et al. [2008c]		Impact of water tax policies on movements of water in international markets for agricultural products via trade as virtual water.	Multiregion multisector GTAP model.
Blignaut and van Heerden [2009]		Analyzing possible future disruption in water supply to some regions in South Africa.	Country-level CGE model.

(*Continued*)

Annex 1: (*Continued*)

Source	Background	Aim	Modeling approach
Blignaut and van Heerden [2008]		Addressing the question of alternative sectoral water allocation in South Africa to allow growth under increased water scarcity.	Static sectoral CGE.
Boccanfuso et al. [2005]	extends Decaluwe [2001] by introducing water utilities	Investigating the distributional impact of privatization of the water utility and to isolate winners and losers of following privatization in Senegal.	Integrated multi-household.
Briand [2007]		Estimating the effect of marginal cost and average cost pricing on water availability under CC scenarios.	Dynamic CGE model for Senegal.
Briand [2004]		Estimating the production and employment impacts of water policy pricing on the development of both formal and informal water distribution segments.	Static CGE.
Calzadilla et al. [2011a]		Assessment of the potential impact of climate change and CO_2 fertilization on global agriculture and trade liberalization.	Static global CGE model.
Calzadilla et al. [2010]		Assessing the value of green (rainfall) and blue (irrigation) water resources in agriculture and the role of international trade. Tradeoff between economic welfare and environmental sustainability.	Static global GTAP-W model.
Calzadilla et al. [2011b]		Analyze the effect of improved irrigation efficiency on water saving and welfare, worldwide.	Global GTAP-W

(*Continued*)

Annex 1: (*Continued*)

Source	Background	Aim	Modeling approach
Diao and Roe [2000], Diao [2002]		Assessing the linkage between water and trade policies in Morocco.	Intertemporal CGE model
Diao et al. [2004]		Analyzing gains to the economy from allocation mechanisms for surface irrigation water in Morocco.	Static CGE multisectoral, state model
Diao et al. [2005]	Diao and Roe [2000, 2003]	Economy-wide gains from the allocation of surface irrigation water decentralized mechanism for achieving this result in a spatially heterogeneous environment.	Intertemporal CGE.
Dixon et al. [2005]		Investigate economy-wide issues as a result of climate change and other intervention policies.	A dynamic hydrology-economic-CGE multisectoral model at state level.
Dixon et al. [2011]	Berrittella et al. [2007a,b], Peterson et al. [2005]	Analyze the effect of the Australian government program of buying backwater from irrigators.	Dynamic multiregional CGE.
Dwyer et al. [2005]	Peterson et al. [2004]	Extends the analysis of Peterson et al. [2004] to investigate the effects of expanding irrigation-to-urban water trade to include both irrigators and urban water users.	Regional CGE model.
Finoff [2004]		Effects of stochastic changes in salinity levels and an initial shock to species population levels on the ecological and economic variables.	Bioeconomic model

(*Continued*)

Annex 1: (*Continued*)

Source	Background	Aim	Modeling approach
Gill and Punt [2010]		Assessing the efficacy of increased irrigation water charges in the Western Cape Province, South Africa.	Static provincial CGE.
Gomezz et al. [2004]	Goodman [2000]	Analyzing welfare gains from improving allocation of water rights and decentralization.	Static CGE model.
Goodman [2000]	Gomezz et al. [2004]	Compares investment in storage versus water transfer used for addressing water scarcity in Arkansas, USA.	Static country-level CGE model.
Hassan and Thurlow [2011]	Hassan et al. [2008]	Examine the economy-wide impact of macro and water-related policy reforms on water allocation and use and rural economy.	Static country-level CGE.
He et al. [2007]		Estimation of the shadow price of water in China between 1949 and 2050.	Dynamic CGE of state economy.
Juana et al. [2008]		Assess the impact of predicted reduction in freshwater availability by 2050 on household welfare.	Static South Africa level CGE.
Kaliba et al. [2007]		Estimate the effect of aquaculture expansion impact on poverty reduction in Ghana, Kenya, and Tanzania.	Three country-level static CGE models.
Kohn [2003]			Heckscher–Ohlin–Samuelson model
Kraybill [2010]	Berrittella et al. [2007a,b]	Introducing virtual water in order to explain role of water scarcity, international trade in food and fiber.	Global static CGE.

(*Continued*)

Annex 1: (*Continued*)

Source	Background	Aim	Modeling approach
Kraybill et al. [2002]	Yunez-Naude and Rojas Castro [2008], Roe et al. [2005a,b]	Interaction between food safety and resource subsidization in the Dominican Republic, using water and trade taxes.	Static state-level CGE
Kunimitsu [2011]		Evaluation of the impact of management of the stock of irrigation and drainage facilities on Japan economy.	Dynamic sectoral CGE.
Lennox and Diukanova [2011]		Analysis of changes in water allocation between instream and irrigation Canterbury, New Zealand.	Regional CGE model.
Letsoalo et al. [2005]	ORANI-G [Harrison and Pearson, 1996]	Assessing water consumption charges (in irrigation, mining, forestry) impact on releasing water for alternative uses and raising funds for poverty alleviation in South Africa.	Static state-level CGE
Letsoalo et al. [2007]		Estimating the impact of water pricing in South Africa on reduced water use, faster economic growth and more equal income distribution.	Static state-level CGE.
Luckmann et al. [2011]		Analysis of the economy-wide effects of increased use of various water resources, including fresh water reclaimed water, brackish water and desalinated seawater.	Static CGE model of various water resources.
Malik [2007]		Estimating multiplier effect of dam project on the basin economy.	Static regional CGE.
Peterson et al. [2005]	Dixon et al. [2011]	Examine the regional effects of expanding the trade in irrigation water.	Regional-level static CGE.

(*Continued*)

Annex 1: (*Continued*)

Source	Background	Aim	Modeling approach
Peterson et al [2004]	ORANI [Dixon et al., 1982]; TERM Model [Horridge et al., 2003]	The long-run effects of trade under reductions in water availability and short-run reductions based on observed allocations.	Large-scale, standard CGE.
Phuwanich and Tokrisna [2007]		Explore the economy-wide impact of irrigation water supply management and demand management policies to deal with scarcity in Thailand.	Sectoral static CGE.
Roe et al. [2005b]		Analyzing the effects of top-down and bottom-up reforms on irrigation water allocation.	Combines a CGE model with a farm model
Rose and Liao [2005]		Disaster impact analysis. Modeling response to input shortage.	Static CGE of a metropolitan area.
Schreider [2009]		Evaluation of water markets performance in Australia under recent drought conditions.	CGE + weekly stochastic model of water prices.
Seung et al. [2000]		Analysis of temporal effects of reallocating water from agriculture to recreational uses in Nevada, USA.	County-level dynamic CGE model with a recreation demand module.
Smajgl [2006]		Examines water use benefits within an integrated multidisciplinary focus.	Static regional CGE model for Australia.
Smajgl et al. [2006]		Assessing the impacts of water reform in an irrigation area in Queensland, Australia.	Regional applied general equilibrium model with hydrology component.

(*Continued*)

Annex 1: (*Continued*)

Source	Background	Aim	Modeling approach
Smajgl et al. [2005]		Showing that while CGEs allow the quantification of tradeoffs between economic sectors, catchments, and values, agent-based models make land use decisions spatially explicit.	A computable general equilibrium (CGE) model and an agent-based model (ABM) for integrated policy impact assessment.
Smajgl et al. [2009]		Integrated policy impact assessment for the Reef Water Quality Plan in Australia.	Static CGE and an agent-based model.
Strzepek et al. [2008]		Estimating the value of the Aswan Dam to the Egyptian economy.	A static CGE of the state economy.
Tirado et al. [2010]		Estimate the effect of an agricultural water market on the farming sector.	Static CGE model for the Balearic Islands.
Tirado et al. [2006]		Assessing the impact of increasing the technical efficiency of water use on the tourism sector in the Balearic Islands.	Sectoral static CGE.
Tirado et al. [2004]		Analyze the welfare gains associated with an improvement in the allocation of water rights through voluntary water exchanges (mainly between the agriculture and urban sectors).	
Tirado et al. [2005]	Tirado et al. [2004]	Provide information on water management options under Water Framework Directive.	
van Heerden et al. [2008]		Compare impact of water taxes in irrigated agriculture and forestry in South Africa on environment, equity, and the economy.	Static South Africa level CGE.

(*Continued*)

Annex 1: (*Continued*)

Source	Background	Aim	Modeling approach
Velázquez et al. [2005]		Analyzes the impact of water charges on allocation of water (virtual water) across sectors in the Andalusia region of Spain.	Static sectoral CGE.
Velazquez et al. [2007]	Cardenete and Sancho [2003], André et al. [2005]	To analyze the effects of an increase in the price of the water delivered to the agriculture sector on the efficiency of the water consumption and the possible reallocation of water to the remaining sectors.	Standard static CGE

Annex 2: Features of the policy interventions and shocks in the four analyzed countries.

Top-down and external shocks (macro)	Bottom-up (micro)
	Morocco
Removal of trade barriers	Pricing of irrigation water
Labor	Pollution taxes
Fiscal	Ag. input taxes
Regional preferences	Subsidies for water saving technologies
Electricity Subsidy removal	Investment regulations
Food processing subsidy removal	GW regulations
Inter-regional Water transfer	Water rights
Climate change	Pricing of irrigation water
Population growth	Pollution taxes
	Mexico
Progressive increase in water supply	Reduction of 50% in water supply for irrigation
Progressive reduction in water supply	Reduction of 50% in water supply for irrigation + investment of fee (based on shadow water value) collection in improved productivity by WUA.
NAFTA liberalization	Water transfer from Rio Bravo Basin to close by regions (North, Central)
NAFTA liberalization + elimination of PROCAMPO	Elimination of agricultural subsidies
NAFTA liberalization + reduction of 50% in water supply for irrigation	
Application of 15% VAT on foodstuff + reduction of 50% in water supply	
Return of Rio Bravo Basin water debt to the USA	
Climate change regional differential impact on rainfall and water supply	

(*Continued*)

Annex 2: (*Continued*)

Top-down and external shocks (macro)	Bottom-up (micro)
South Africa	
Trade policies with the USA and EU	Policies addressing equity in water allocation, both in agriculture and in the peri-urban areas.
Labor policies preventing labor transfer between SA and its neighbors	Policies to secure and value water–environment relationships
Trade policies with the USA and EU	Institutions to allow water trades within and between sectors
Turkey	
Trade policies and protection removal, both in the framework of future WTO agreement on agriculture and EU membership.	Policies for prioritizing investment between irrigation and other sectors
Policy changes due to the adjustments to comply with EU water directives and the shift to volumetric pricing in irrigated agriculture	
Subsidization reform, including changes in the structure of the budgetary transfers to farmers	

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