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WATER POLICY AND POVERTY REDUCTION IN RURAL AREA: A COMPARATIVE ECONOMYWIDE ANALYSIS FOR MOROCCO AND TUNISIA

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Abstract

Morocco and Tunisia are considered among the countries where the scarcity of water resources may cause a serious constraint to the development of their economies. During the past, huge efforts have been made by both governments in order to satisfy an escalating water demand expressed by all users. The main objective of this paper is to compare the impacts of alternative water policy management scenarios on Tunisia and Morocco. The fact that a same policy instrument applied to two different countries can have different impacts; represent the main motivation behind the adoption of a comparative analysis. A dynamic water CGE-model taking into account the particularities of both countries' economies in terms of agricultural production technologies has been implemented and used as a laboratory to explore the likely effects of water economic instruments. The results show that large public subsidies to water mobilization and distribution significantly affected the structure of agriculture production in both countries. The low cost of water has encouraged farmers to diversify their production towards more water-intensive activities. The combined effects have been a rise in farmers' incomes but also an efficient uses of a scarce resources such as water. Reducing public subsidies on water will affect directly farm income which is expected to drop by about 20 per cent in the short and medium terms. A reduction in the number of crops available for farming can also lead to greater technical and economic vulnerability of the agricultural sector in both Tunisia and Morocco. Employment is likely to be affected also in both countries. However, the reduction in farmers' incomes will be largely compensated by the saving in public expenditures but also in a better and more efficient uses of water resources. In the medium-long term, Tunisian and Moroccan farmers will adjust their activities to accommodate with the new public managements of water resources which will be manifested by a substitution among activities towards those that are more efficient in water uses.

JEL Classification: C68, H25, Q25, Q18

Keywords: agriculture, water pricing, CGE model, Tunisia and Morocco

ملخص

تعتبر كل من المغرب وتونس من بين البلدان التي يوجد بها ندرة في الموارد المائية والذي قد يسبب عائقا خطيرا لتنمية اقتصاداتها. بذلت هذه الدول جهودا كبيرة من أجل تلبية الطلب المتصاعد على المياه. الهدف الرئيسي من هذه الدراسة هو مقارنة آثار سيناريوهات إدارة السياسات المائية البديلة في تونس والمغرب. والحقيقة أن استخدام وتطبيق أدوات السياسة نفسها على بلدين مختلفين يمكن أن يكون لها تأثيرات مختلفة؛ وتمثل هذه الحقيقي الدافع الرئيسي وراء اعتماد التحليل المقارن. وقد تم تنفيذ نموذج ديناميكية المياه من قبل فريق من الخبراء الاستشاريين مع الأخذ بعين الاعتبار خصوصيات اقتصاد البلدين من حيث تقنيات الإنتاج الزراعي واستخدم هذا النموذج كمختبر لاستكشاف الآثار المحتملة للأدوات الاقتصادية للمياه. بينت النتائج أن الإعانات العامة الكبيرة لتعبئة وتوزيع المياه تتأثر بشكل كبير بهيكل الإنتاج الزراعي في كلا البلدين. وقد شجع انخفاض تكلفة المياه للمزارعين لتنويع إنتاجها نحو المزيد من الأنشطة كثيفة الاستخدام للمياه. وجدنا آثار مشتركة لارتفاع دخل المزارعين وأيضا لاستخدامات فعالة من الموارد النادرة مثل المياه. وخفض الإعانات العامة على المياه والتي تؤثر مباشرة على دخل المزارع والتي من المتوقع أن تنخفض بنحو 20 في المائة في الأجلين القصير والمتوسط. تخفيض عدد المحاصيل المتاحة للزراعة يمكن أن يؤدي أيضا إلى مزيد من الضعف التقني والاقتصادي للقطاع الزراعي في كل من تونس والمغرب. ومع ذلك، فمع الانخفاض في دخل المزارعين سيتم تعويضهم بشكل كبير من التوفير في النفقات العامة وأيضا باستخدامات أفضل وأكثر كفاءة للموارد المائية. وأما عن الأجل الطويل، فسيتمكن المزارعين التونسي والمغربي من ضبط أنشطتهم لاستيعاب الإدارات العامة الجديدة من الموارد المائية من خلال إجراء تبديل إلى الأنشطة الأكثر كفاءة في استخدامات المياه.

1. Introduction and Objectives

Water constitutes the main constraining factor of agricultural development in the Southern and Eastern Mediterranean and particularly in Tunisia and Morocco. According to the Blue Plan (2013) on the future of the Mediterranean basin, Morocco and Tunisia are among the countries where the pressure on water resources is strong with an index of exploitation of renewable natural resources between 50 and 75% indicating significant medium-term risks of structural stress. The available water resources per person in Tunisia were about 540 m^3 per year in 1990, compared to 1195 m^3 per year in Morocco. According to the Plan Bleu (2008) estimates, by 2025, per capita water resources will be 310 m^3/year in Tunisia and 600 m^3/year in Morocco. For both countries, this index would be less than 1000 m^3/year, deemed critical by various experts and indicator of chronic shortage. On the basis of this concept, Morocco and Tunisia are considered countries where the scarcity of water resources may cause a serious constraint to the development of their economies. It therefore becomes of critical importance that sustainable management of this resource should be based on an integrated approach aiming at better adequacy between supply and demand.

Water scarcity has led governments in Tunisia and Morocco to design and implement ambitious policies aimed at water resources improvement. The opportunity cost of water has raised economic concerns in water resources management. Public interventions also aim to improve the efficiency of water utilisation in agriculture, i.e. to intervene on the demand side. Water savings are expected to be transferred to other economic sectors, namely in those areas where competition is with urban expansion, tourism and manufacturing sectors, or to allow agricultural expansion. However, while the share of agriculture in total water demand is expected to diminish, overall demand is expected to rise, driven by both population growth and industrialization.

Models forecasting future water demand identify different types of growth for different types of demand: while population growth affects household demand, economic growth is expected to affect industrial demand, and agricultural demand growth depends on incentives to the extension of irrigated area. Simulation results by Rogers (1996) show that Tunisia is expected to go 14 percent over its water resources by 2025 if agricultural demand increases at a 3 percent annual rate. With no additional demand stemming from agriculture, Tunisia will be using 49 to 58 percent of its resource base in 2025 depending on the income elasticity of domestic water demand.

An economy wide analysis of water policies in Tunisia and Morocco will permit addressing the allocation and distribution issues of water resource management facing policy makers. Those issues have high policy relevance as part of the effort of policy makers to manage water resources in the long term and to reduce poverty in rural areas. More precisely, the objective of the study is to explore the impacts of alternative domestic water policies in the form of a cut in irrigation water subsidies and/or increases in public expenditures on water mobilization needed to fulfill the expected water needs escalation by different users.

Although strategy for the agricultural sector is not as growth oriented as those for the industry and service sectors, agriculture is still considered the basis of both national economies and is targeted to grow considerably over the next ten years. This growth will permit achieving policy goals such as food security, production flexibility to meet changing world market conditions, and stabilization of rural incomes, which will also help to slow rural to urban migration. Agricultural sustainable growth in this context will probably entail the extension of irrigated areas. Agricultural growth and crop mix are likely to be affected by several policy reforms notwithstanding investment subsidies and water pricing policies. The ranking of crops according to economic profitability should depend on the shadow price of water and relative irrigation intensities.

This paper is organized in four sections. Section 1 describes the background relative to water resources balances as well as water policies and the main remaining issues of water management in Morocco and Tunisia. The second section reviews the main water-CGE models used in MENA countries and elsewhere followed by the main characteristics of the proposed CGE model and the structure of the two SAMs. The third section explores the likely effects of alternative scenarios of water policy in Tunisia and Morocco. The last section summarizes the policy implications and concludes.

2. Main Features and Challenges of Water Management in Morocco and Tunisia

Over the last two decades, Morocco and Tunisia experienced relatively steady economic growth based on a development strategy focused on economic diversification and export promotion. The growth of the agricultural sector has increased the pressure on natural resources in general and more particularly on water. Furthermore, the increase in the share of GDP accounted for by the nonfarm sector implies an increase in residential water demand as well as manufacturing and service sectors. If production growth in the non-farm sectors requires a proportional increase in water demand, then water can be a major constraint to economic growth in these countries.

2.1 Importance of agriculture and recent features of water balance

Agriculture is considered one of the main pillars of the **Moroccan** economy. Its contribution to the GDP lies between 12 to 17% (15.4% in 2010). Agriculture has an important and growing multiplying effect on the rest of the economy (Global Forum on Agricultural Research 2012). Regarding the employment rate, agriculture constitutes the main force for absorbing considerable amounts of workforce in Morocco. Indeed, almost half (46 percent) of the active population works in the agricultural sector.

The total agricultural area is about 9 million hectares of which nearly 83% are cultivated in a rainfed production system. The remaining area is irrigated and contributes on average to 45% of the value added of the agricultural sector.

Agriculture can be divided in three major sectors: (1) Modern, private, irrigated, highly capitalized, and export oriented farms producing mostly fruits and vegetables, (2) Agriculture within reorganized large scale dams has irrigated perimeters producing mostly dairy, sugar crops, seeds, fruits and vegetables mostly for the local market, and (3) Rainfed agriculture with more favorable land in the Northwest (growing mostly grains, olives, pulses, red meat and dairy) and less favorable land in the South and East (growing mostly grains and non-intensive sheep production).

Given the high rate of rural population in Morocco, which is around 43%, agriculture is a significant contributor also to social cohesion. How agriculture evolves will determine the stability and well being of rural society and of the country as a whole.

Morocco is ranked among the poorest countries in water resources worldwide, with a potential estimated at 22 billion m^3 per year. Scarce and unevenly distributed, rainfall has made water a key economic and social development issue in Morocco. The annual average rainfall is 340 mm, but varies from more than 450 mm in the north, where rainfed agriculture is possible to less than 150 mm towards the southeast, where irrigation is absolutely necessary. Hence, surface water is characterized by important variability given its dependence to rainfall whereas ground water is characterized by its regularity, reduced cost of mobilization and good spatial repartition. It is also less vulnerable to climatic risks and pollution.

Since its independence, Morocco has made considerable efforts in water supply consolidation, particularly through the construction of 130 major dams and hydro-agricultural extension networks by 2011 with a capacity of more than 17.5 billion of cubic meters.

Significant results have been realized with the completion of 13 water transfer structures with a total length of nearly 785 km. These achievements allowed the country to have an irrigated area of 1.5 million hectares, of which the Moroccan government equips two-thirds. In contrast, potable water demand has begun to receive the prominence it deserves at the mid-1990s with the promulgation of the Water Act 1995(Act 10-95). This law among others, created water basin agencies and introduced financial mechanisms to protect and maintain water resources for the consolidation of integrated management, participative and decentralized water resources. It stipulates that water belongs to the State and introduces explicit user and polluter pays principles. It underlines also the recognition of the social, economic and environmental value of water. The increased access to safe drinking water is one of the major achievements of the act. Indeed, access to potable water in urban areas has been generalized and secured (100%) and in rural areas it is currently estimated at 92%.

To cope with the threats of the scarcity of water resources, a new strategy for strengthening water policy was established in April 2009. This was realized through partnership between the government and 16 regions with the objective of rationalizing water utilities based on three strategies. The first consists of achieving the ambitious goals related to water consumption and supporting the socioeconomic development of the country. The aims of the second strategy are to radically change water use and management behavior. Finally, the third strategy looks to implement a "truly sustainable water management".

The planned investment for the implementation of these strategies is estimated at 82 billion dirham over the period of 2009-2030 (around 10 billion USD). Currently, three types of programs are encouraged by the government to improve the recovery of irrigation water over the next ten years. The first program is aimed at increasing the share of land irrigated by water saving systems (such as drip irrigation) to 50% of the total irrigated area. The second objective is the extension of 110,000 ha of land affected by large hydro-projects. The third concerns the privatization of water management irrigation in the major irrigated areas under the scheme of the Agricultural Development Offices of public - private partnership.

Regarding drinking water supply, the strategy aims at connecting people nationwide to an effective supply management scheme both quantitatively and qualitatively. Moreover, the National Office of Drinking Water has launched projects for the benefit of both rural and suburban areas. Such activity is considered as part of a large government program costing around 1.6 billion USD for 2008-09.

At the same time, the function of water distribution is given over to the private sector, including multinationals, which are currently engaged in the supply of urban areas with drinking water, sanitation, sewage and household waste collection based on delegated management.

Despite large public programs for efficient water management, sectors in Morocco are still experiencing multiple challenges: (i) limited potential of water resource with an increasing demand of the different users and overexploitation of the groundwater, (ii) increase of extreme climate events as a result of climate change, (iii) low valorization of water in use especially in the agricultural sector, (iv) concerns related to water quality, and (v) soil erosion and dams siltation

To face these challenges, the Moroccan authorities have developed the National Water Strategy with the general objectives of securing water resources for the need of the country development and at the same time ensuring integrated and sustainable management of water and natural resources. The National Water Strategy is based on three axes:

I. Demand management and water efficiency:
    - Demand reduction of 2.5 billion m^3/year

- Saving water in irrigation: conversion to drip irrigation (50 000 ha/year)
- Catch up on the hydro farm equipment delay (150 000 ha)
- Program for the conservation of drinking, industrial and tourism water

II. Management and supply development:
- Mobilization of 2.5 billion m^3/year
- Mobilization of conventional water resources (60 dams) and small dams
- Rain water harvesting
- Desalination of sea water: 400 Millions of m^3/year
- The reuse of treated wastewater: 300 m^3/year

III. Preservation and protection of water resources and the environment
- Preservation of groundwater resources
- Program of the protection of water resources quality and the fight against pollution
- Preservation of sensitive areas: watersheds, wetlands and oasis, coast.

This strategy is inscribed within the Green Morocco Plan (GMP), implemented by Morocco since 2008, as a major tool to reduce poverty and to improve competitiveness.

In **Tunisia**, while declining through time, the agriculture and forestry sectors continue to play significant roles in the economy, both at the macro and micro levels. At the macroeconomic level, the contribution of the agriculture sector has been around 12% over the past decade. Despite the relative downsizing of agricultural activities and the variability of their outputs, agriculture continues to play a significant positive role in the overall socioeconomic activities of the country. In addition to the classical role of providing food for a population that has about quadrupled over the last five decades, no significant food shortages were experienced either in global terms or at the level of specific commodities. Moreover, agriculture and rural areas continue to provide a livelihood for about 35 to 40% of the population. Agriculture also provides employment for around 16% of the labor force and contributes around 10% of the country's total commodities exports. It absorbs about 10% of total investment and is increasingly feeding an agro-food industry with the required primary commodities thus enabling this sector to grow rapidly, providing increasing value added and hence contributing to economic growth. That sector represents today about 25 to 30% of Agricultural GDP.

The historical relative slowdown feature of the agriculture sector does not however imply stagnation of the agricultural economy but rather that other sectors of the economy are rapidly rising. Moreover, the sign of apparent salient strength that agriculture has shown since the political change that occurred in the country since the beginning of the year 2011 has turned out to be a stabilizing factor of the overall economy in view of the revealed greater fragility that the nonagricultural sectors have exhibited, particularly those dependent on foreign investment.

In view of all of these considerations, agriculture has constantly been the target of numerous and discontinuous set of policies, particularly those related to water which is considered as one of the most limiting factors of the country's economic development.

Tunisia is a middle-income country endowed with moderate water resources compared to its neighbors. The rainfall pattern is irregular in space and time. The annual average rainfall is 230 mm. It is around 594 mm in the North, 289 mm in the Center, and 156 mm in the South; it varies between a maximum of 1500 mm in the Northwest and a minimum of 50 mm in the South. Furthermore, the rainfall is concentrated in the winter months. Policies towards natural resources have concerned both soil and water. Hence most of the public investment in agricultural sector (over 50%) has been in the hydraulic infrastructure so as to mobilize as much of the available and potential water resources as possible (Table 1).

In 2012, the government invested 308 Million Tunisian Dinars (MTD) on irrigation projects followed by forestry and water conservation (84 MTD) and soil conservation (79 MTD). These investments have been financed by the public budget (76%), foreign investments (22.5%) and the rest (1.5%) by bank credits. In that spirit, 27 large dams, more than 182 hill dams and around 700 artificial lakes were constructed in the country over the 5 past decades. The general balance in terms of water mobilization, confronted to the estimated potential, is shown in Table 2.

Such water mobilization policy has enabled the development of near 450000 Ha of irrigable land, corresponding to about 7 to 8% of Tunisia's total arable land. It accounts for 35% of the value of agricultural production, 20% of agricultural exports and 27% of the labor force in agriculture. Irrigated perimeters, contribute to 95% of the vegetable production, 70% of fruits and 30% of the dairy output. The overall ratio of water resources to water demand appears worrying and is further compounded by high salinity of groundwater resources, erratic nature of rainfall, and uneven geographical distribution of resources. Chronic water shortages affect the supply-demand balance and forecasting models show that Tunisia's fragile hydrological situation is likely to deteriorate with increasing demand.

2.2 The challenges of water management

The established fact is that water resources in Morocco and Tunisia are scarce and their quality is degrading. Consequently, the authorities of both countries at different levels have made several interventions. The first level, which still absorbs important resources, is the investment in hydraulic infrastructure and the construction of dams in order to meet a rising demand by increasing water supply. The second level of intervention is the implementation of rationalization measures aimed at controlling a steadily increasing demand using water-pricing instruments. The third level concerns the institutional organization reform towards more decentralized water management.

In the near past, the management of water **in Tunisia** was under the direct responsibility of the Ministry of Agriculture. Currently, two regimes of management in the irrigated areas are the private regime secured by individuals and the collective regime secured by Water User's Associations (WUAs):

- Private management applies to 40% of the total irrigated area. It relates to areas irrigated by small hydraulic machines using mainly groundwater. Farmers in these areas are responsible for the investment and operation costs of their individual water systems.

- Collective management concerns areas that are managed by WUAs. Collective irrigation networks are set up through public funds but their management is delegated to the WUA, which fixes the water fees and is responsible for their collection. The WUA also assumes responsibility for investment and the development of irrigation in its areas.

The Tunisian public policies with regard to water face two main challenges. First, not all irrigable land has been put into actual irrigation as around 80 000 ha of equipped areas (about one fifth) have not been put to use. A variety of reasons could explain that situation. Chief among these are the concerns about possible price decreases if supplies were to increase too rapidly, along with other potential marketing difficulties on the input or output sides.

Second, efforts were made to push farmers to devote about a third of their irrigable land to cereal cultivation, as part of the national policy to bring about food security. This encountered resistance as well for the simple reason that farmers find it more profitable to allocate irrigable land to other crops.

Furthermore, the emphasis on the development of irrigated agriculture has had unexpected results in the form of soil salinity, as irrigation water in a number of areas of Tunisia has a high salt content. In other rainy areas of the north east of the country, cases of aquifer nitrate and other chemical pollution resulting from the excessive use of those products have been registered. Hence the general public perception is that near all potential water resources will soon be exhausted and severe shortages could occur. In this eventuality, particularly if present water policies continue to underprice the resource, this will increase the likelihood of severe water shortages and could even shorten its horizon. However, if policies were to be revised to value the resource at its true cost and/or discourage water waste, prospects can be perhaps less gloomy.

In view of the aridity of the Tunisian climate, natural resource (soil and water) preservation will certainly continue to be at the centre of future policies, as it has been in the past. Hitherto conservation programs and their corresponding budgets have been geared towards water mobilization through dams and hill reservoirs construction, in the case of water, and erosion breaks and brakes, in the case of soil. Efficiency considerations, along with maintenance problems of these conservation projects and limited budget resources, are raising new questions as to their economic and environmental relevance. Alternative techniques of resource conservation based on relative soil immobilization through reduced tillage, or absence thereof, are being contemplated and experimented with.

In reality, past policies have indirectly contributed to the achievement of those objectives only partially or not at all. Take the example of agricultural mechanization which has been encouraged first through subsidized fuel and nowadays via direct subsidies of as much as 25% or 40% on the purchase [1]. As a result, most farmland cultivation has shifted into the mechanical mode, including small-scale farms with difficult and hilly landscapes, and has eliminated the use of animal traction on Tunisian farms. The excessive mechanical cultivation has resulted in devastating soil erosion and organic matter impoverishment.

In the livestock sector, public subsidies allocated to animal feed have incentivized otherwise non livestock raisers to develop local feed independent livestock activities even in urban areas. In a number of cases, the incentives pushed animal raisers to increase herd numbers irrespective of grazing potential. This has resulted in overgrazing and a rapid destruction of vegetation on graze land and in some cases forestland as well.

Another example, which reflects the difficulties encountered by the Tunisian public authorities in the management of water resources, is water pricing. Indeed, conscious of the importance of economic instruments in reducing water consumption, several increases in water prices have been implemented since the beginning of the Structural Adjustment Program in 1986. The aim of this water tariff hike was also to make farmers pay the total cost of producing and delivering water to their farms. However, a study conducted by the Tunisian Ministry of Agriculture (2006) concluded that farmer’s response to an increase in water prices was very weak and that farmer’s behavior is mostly influenced by climatic conditions and results from a combination of other variables. This means that water prices are still below their marginal benefits. The same study also revealed a recovery rate varying from 186% in the governorate of Nabeul to 56% in Bizerte. This recovery rate was calculated on the basis of an average cost during the period 2000-2004 covering a dry year in 2002, a rainy year in 2004, and a medium year in 2003. However, the cost of water production and delivery doesn’t take into account investment costs related to dams and hydraulic infrastructure.

In their study of water pricing in Tunisia, Thabet and Chebil (2006) expressed doubts about the accuracy of the amount of subsidies to irrigation water. By examining the cost structure of

[1]The percentage varies according to the subsidy requester, an individual farmer, or a society.

delivered irrigation water published by the Ministry of Agriculture and crosschecking it with the declared invoiced volume of irrigation water, some inconsistencies have been found. These inconsistencies were considered problematic since that the rate of subsidy on irrigation water depends on the water volume consumed by the agricultural sector. Furthermore, when data is not consistent, the establishment of a water-pricing scheme becomes difficult since the rate of subsidy is not clearly determined. On the other side, the water authority does not have accurate information on water productivity at the farm level. Thus, the water "market" in Tunisia is characterized by asymmetric information on the side of the authorities as well as on the side of the farmers.

The authors concluded that, for a successful reform of the irrigation water pricing policy, some conditions have to precede: (i) a reform of the public accounts integrating the capital depreciation and an analytical approach behind invoicing; (ii) assess the farmers' ability and willingness to pay for irrigation water; and (iii) a definition of the priority goals assigned with the irrigation water pricing policy.

In **Morocco** the institutional reform concerns the privatization of water management irrigation in the major irrigated areas under the scheme of the Agricultural Development Offices *through* a public - private partnership. Regarding water pricing issue, since 1969 a "Code of Agricultural Investment" has been advanced by the government in which, it is indicated that farmers have to repay the state 40% of the investment costs and 100% of Operation and Maintenance (O&M) costs through a land improvement tax and volumetric water charges.

For non-agricultural sectors, an increasing block rate structure for potable water has been used in order to limit urban waste and to finance part of subsidies and costs. This system results in cross-subsidization between users. However, implicit subsidies to potable water use should also be taken into account since all investment-related undertakings implemented in rural areas are subsidized by the central budget.

3. Methodology

The main objective of this study is to evaluate the implications of alternative water policy management scenarios with a focus on inter-sectoral water allocation and their distributional impact. The evaluation of alternative policies will be conducted on a comparison basis between Tunisia and Morocco. The fact that even a same policy instrument applied to two different countries can have different impacts; represents the main motivation behind the adoption of a comparative analysis. In fact, heterogeneous socioeconomic structures, different market features and economic policies, various levels of endowment in natural resources and access to factors of production, are among the reasons that explain the different impacts of same policies across countries. Not only patterns of water demand are specific to each user, but water supply also stems from different sources and is managed and priced by different water entities. However, it appears important for planning purposes to treat water as a unitary resource in a comprehensive framework. This should permit deriving the opportunity cost of water and its evolution over time.

Given the importance of the issue at the country and regional levels, few studies were done on the management of water resources in the MENA region in the recent past. Country level studies were focused on sectoral issues while forecasting models of demand for MENA countries were implemented to assess water stress at the country level (see Rogers 1996). These models typically use very simple frameworks, not meant to address efficiency and equity issues. Two main tools are often used for this type of analysis: partial and general equilibrium models.

Partial equilibrium analysis may be the best approach for analyzing economic impacts for small changes in water attributes (supply, prices) that are unlikely to affect prices of other goods and services throughout the economy in an appreciable manner. Partial equilibrium approaches hold other prices and markets constant, while focusing on a specific water use. These methods include the hedonic property value method, stated and revealed preference, non-market valuation of the value of water to recreation and ecosystem services, estimation of production functions or demand functions, the residual method (subtracting all other input costs from total revenue), and linear programming input-output models where prices are fixed (Young 2005). However, for non-marginal changes in water supplied or pricing associated with many types of water policies, the direct and secondary influences on other commodity and factor markets may be of consequence throughout an economy. Partial equilibrium approaches cannot account for secondary effects, and therefore estimates of changes in water demand and prices from partial equilibrium approaches could lead to over- or under-estimates of changes in water values, depending on the extent and type of linkages in the affected economy. Potential changes in prices in other commodity and factor markets in turn also affect incomes and can have fiscal impacts on governments and water suppliers.

CGE models are specifically built to represent these interrelationships among markets and sectors in regional economies, where water pricing and supply can affect multiple markets and sectors in non-marginal ways. CGE models are simulations meant to represent the economies of well-defined countries so that analysis of the impact of changes in any one, or combination of, sectors can be traced through to predict changes that will result throughout the entire regional economy.

A CGE modeling approach allows for complete exploration of complex feedbacks throughout the economy, so that the modeler can experiment and isolate the effects of many variables and identify the linkages between them with regard to water shadow prices in industry. The CGE approach breaks down the net effect of a shock to the system (the 'value' of an increase or decrease in the supply of water, for example) into individual changes in prices, outputs and incomes by each affected industrial sector, so that a complete set of gainers and losers are identified, along with the measurements of change. To illustrate the difference between partial and general equilibrium approaches, we consider the application of each approach to the case of water as input to production. Consider, as an example, the case that water fees are set administratively, and are unlikely to be equal to what would be the market clearing price for water in a country. The value of the marginal product (VMP) of water to producers may be either less or more than the administratively set fee rate for its delivery. If more water is demanded than is available at the given administrative fee, then water is a binding constraint and the value of an additional unit of water is indicated by a shadow price for water, which exceeds the administrative price (Diao and Roe 2000). If, on the other hand, the producer has more water than he can profitably use, the VMP for water is zero for that producer. In the case of an administratively set fee that is not a market clearing price for water, water purchases and uses across industrial sectors may be distorted from what is socially optimal. The analyst may wish to determine the welfare loss associated with constraints to water trading. We can consider the problem of determining the social cost associated with non-optimal water pricing by considering the counterfactual, where well-functioning markets for water purchases and sales exist. Assuming there are no additional distortions in the economy, the equilibrium market clearing price of water would be equalized over all producers and will be the socially optimal price. In either case, that of administratively set fees or market clearing prices for water, we can assume that producers who use water as a variable input to their production processes choose how much to purchase depending on the marginal value of that input to the value of outputs.

The key difference between partial and general equilibrium analysis is that all else will not be held constant in a general equilibrium approach. All prices in all markets adjust supply and demand to clear the market. The water input to production is reallocated elsewhere to another consumer or producer. In a general equilibrium approach, all prices and all quantities are allowed to adjust to a new equilibrium when any other price or quantity changes anywhere in the entire system. Other prices in the market are no longer considered to be parameters. Wherever trading is allowed, water prices will equilibrate, and all other markets that are affected through incomes, prices of competing or substitute inputs and outputs, government revenues, and investments are all potentially affected. Thus the net effect of a given change is modeled to include primary and secondary effects in all related activity in the economy. A second example is related to the reduction of public investments in water mobilization and distribution, which could change the availability of water in a given economy. A policy maker would want to know what the value of water would be to a particular sector (agriculture) under these new conditions of public spending. Widespread these changes could increase the market price of agricultural products. The increase in the price of agricultural products could attract more labor to agricultural sectors. As the share of household income spent on food increases, the share spent on other types of goods could fall, causing firms in non-agricultural sectors to lay-off workers. Higher unemployment could change consumer demands. All of these changes in other markets for factors and goods ultimately affect the value of water in agriculture. It is in taking into account this cascade of indirect effects that a general equilibrium model is better than a partial equilibrium model.

3.1 The water CGE model

The literature includes many examples of CGE models that have been used to examine the economic consequences of alternative water projects, allocations, or prices, as well as the effects of increasing scarcity. The existing literature on water CGE models gives examples of the types of general equilibrium effects that cannot be accounted for in partial equilibrium methods. A good example of how a CGE can identify secondary effects is described by Hassan and Thurlow (2011), who use a multi-regional CGE model of South Africa to compare water pricing policies.

The types of economic problems concerning the value of water resources that lend themselves to CGE approaches tend to include the following elements: (1) the value of water as an input to one or more industrial sectors in a well-defined economy is a relatively high proportion of the total value of the output of those sectors, (2) those sectors are integrated into the rest of the economy, so that secondary effects in other markets are likely as a result of changes in sectors that rely directly on water resources, (3) the economy to be modeled is well defined in terms of water use, such as a hydrological basin, a watershed, a water utility district, or river shed, (4) there is sufficient use for a water CGE model (in developing simulation scenarios that are policy-relevant) to justify the investment in designing, developing and calibrating it.

Several water CGE models have been built for Morocco and Tunisia and used in the analysis of water policy reforms. We find seven published studies, based on CGE models that assess changes in water policy for Morocco and Tunisia. These CGE models differ at several levels. Goldin and Roland-Holst (1994) consider water as a primary production factor and assume the existence of a perfectly elastic water supply in the Moroccan economy. Their model was used to examine the relationships between international trade, macroeconomic policies and the sustainable management of water resources. These relationships have been established and confirmed using a CGE in which the agricultural sector has been disaggregated into two subsectors: irrigated and rainfed.

Löfgren et al. (1996) assume the existence of a fixed amount of water available in the Moroccan economy. They explore issues pertinent to the formulation of a Moroccan rural development strategy. More particularly, they show that, while improving the fiscal position of the government, raising water tariffs sufficiently to cover operation and maintenance costs of the hydraulic infrastructure has a strong negative impact on the incomes of farmers in irrigated areas. However, if the option of allowing irrigated farmers to sell water is introduced, the negative impact of the tariff hike is cushioned or reversed while significant quantities of water are diverted to other uses.

Decaluwé et al. (1999) model explicitly water supply using different technologies according to the fact that water is extracted from dams or the ground. They have implemented a standard CGE model with special features that allows for comparative analysis of different pricing schemes. In this context, Boiteux-Ramsey Pricing (BRP), Marginal Cost Pricing (MCP) as well as an arbitrary water pricing increase for agriculture sectors have been simulated. Their results show that the choice of applying one policy over another can rely on water management authority (or government) objectives. Considering welfare criteria and water conservation objectives, BRP seems to be the best alternative and becomes more advantageous the more rigid small capacities to substitute water for other inputs become. The economy and the efficiency of MCP decrease as the economy becomes more rigid.

Diao et al. (2005) present a detailed inter-temporal CGE model for Morocco and their simulations show that water markets are likely to increase the agricultural output significantly in Morocco.

Tsur et al. (2004) and Roe et al. (2005) investigate the effects of trade reform at the macro level on agricultural water use, as well as instigating water trading or other water policy reforms at the farm level. They find that while both reforms can improve water allocation decisions, the order in which the reforms are carried out is quite important. If water policy reforms such as a water trading scheme are carried out before protectionist policies are removed, water use for the protected crops may increase. This could mean the adjustment process when trade policies are liberalized will be even more wrenching.

Hassan et al. (2008) is another extension of the research of Diao et al. (2005) and analyzes the groundwater resources in a general equilibrium framework. In this model, ground water is modeled as an input for the agricultural production. The authors conclude that groundwater is important in lessening the severity of the economic and climatic shocks.

Thabet et al. (1999) developed a static CGE model for the Tunisian economy in order to examine the issues of an exogenous increase of water needs by the non-agricultural sectors with and without water reform policy. They found that water pricing reform helps better adjustments of the resources within the Tunisian economy. Regarding the impact on households' welfare, the situation will be largely improved with water pricing reform than the situation where no government intervention is made, keeping the pressure on water unsustainable.

The same model has been used by Thabet et al. (2005) to compare in terms of efficiency and equity different second best methods of water pricing namely average cost pricing, two tiers pricing, and a two part pricing where a fixed subscription is applied on the irrigated land. Their results show that average cost pricing is recommended when saving water is the primary objective of the government whereas the two part tariff with a subscription applied on land will be more suitable when equity concerns are considered more important.

Other applications include the analysis of the economic effects of drought (Wittwer and Griffith 2011), interaction of water pricing liberalization with trade tariffs on agricultural goods (Robinson and Gehlhar 1995); taxation of water prices (Berritella et al. 2008, Letsoalo et al. 2007, van Heerden et al. 2008), or used more productively (Calzadilla et al. 2011). Many, but not all of these models are used to find a price or shadow price for water in agriculture or for municipal water. CGE models built for that purpose differ in many ways. Robinson and Gehlhar (1995) consider water as a fixed production factor that is incorporated in the production technology through various functional forms (activity analysis or more traditional well-behaved nested neoclassical functions), while Dixon (1990) consider water producing sectors. On the demand side, some models consider only the demand stemming from agriculture (Robinson and Gehlhar 1995, Löfgren*et al.* 1996), or from households in urban areas (Dixon 1990), while Decaluwé*et al.* (1999) model three types of demand (agricultural, industrial and domestic). Many applications focus almost solely on water use and policy in the agricultural sector. Most use the CGE model to experiment with different government policies thought to bring about a more rational and efficient use of water. For a synthesis of these models, see Fadali et al. (2012). In addition, other studies provide more details on alternative CGE modeling of water policies and their interactions on other economic instruments on one side and with the rest of the economy on the other. The list includes among other Renzetti (2005), Berk et al. (1991), Young (2005), Schreider (2009) and Sung et al. (2000). Lastly, the models have treated time in three alternative frameworks: comparative statics, recursive dynamics, or dynamics with inter-temporal optimization.

The model used here is based directly on the prototype developed by the OECD Development Centre (Beghin, Dessus, Roland-Holst and van der Mensbrugghe, 1996), which has been applied to many developing countries, including Tunisia (Chemingui and Dessus 1999; Chemingui and Thabet 2001).

Additional features have been incorporated in the original model for the purpose of this specific study. In what follows, the main features of the present water CGE model are described. The backbone of any water CGE specification is usually the production function. A particular feature of water CGE models is that land or water or both are usually included as a factor of production in the specification. In the present model, water is entered as a factor of production (like physical capital or labor or land). The production block in the water CGE model follows the typical specification observed in many other types of CGE models. One of the important features of a CGE production function is that functional forms are generally chosen that allow for substitution between various factors of production such as labor, capital, land and water. The model focuses more on production than on private demand, given the predominance of agricultural water uses.

Typically, government and investment demands are not a major focus of interest in CGE models. However, and given the importance of public investments in water mobilization and distribution, (Horridge et al. 2005), government and investment spending shares are assumed to be exogenous to the model. This assumption is a key feature for this study mostly when simulations on alternative public investment plans will be performed.

Wages, rents and returns to factor supplies are determined endogenously. The interplay of the producing sectors' demands for factors such as water and land and the owner's household supplies of these factors will determine price so that the market clears. Factor mobility decisions, often referred to as 'closures', are very influential in CGE simulation results. The mobility of factors is critical to determining the value of water in production. The degree of inter-sectoral mobility of labor and capital, as well as of water as a factor of production, is an important dimension of the model. In particular, when the issue involves water trading between urban and rural groups, assumptions regarding labor mobility may be quite important. A high degree of mobility may mean workers leave an agricultural area if agricultural water use decreases, while a lack of mobility may mitigate negative rural economic impacts from reduced agricultural activity when the worker remains and is employed in a non-agricultural sector (Seung et al. 1998). Inclusion of non-irrigated agricultural activities may also allow alternative employment of labor, land and capital as water prices rise, and factors are often modeled as perfectly or partially mobile between irrigated and non-irrigated agricultural sectors.

The mobility of land and water across activities is also typically an important issue. In the present model, water is perfectly mobile across agricultural activities. However, in modeling water trade between rural and urban activities, we assume that water is not mobile between the agricultural sectors and the drinking water supply sector (see Goodman 2000). Accordingly, sectors, which do not have mobility of water between them, will be separate markets with separate equilibrium prices.

The water CGE model determines prices endogenously by equating supply and demand in a Walrasian general equilibrium framework. This process assumes a perfectly competitive market, but it is often the case that observed water prices reflect government policies rather than the workings of a marketplace. In Tunisia and Morocco, water is available to agricultural sectors at a lower level than market price. In a competitive market without any distortions, the shadow price will be equal to the market price, but this is not the typical case for water in most countries and particularly in the two cases selected here. The model developed here already specifies a market for water as a factor of production whether there is an existing market or not. However, two alternative approaches exist and will be tested for both Tunisia and Morocco. The first one consists in deducing the sectoral rents related to water ownership from the gross operating surpluses provided by the SAMs of the two countries. Water rights sales prices can be annualized for this purpose. Sometimes the difference in productivity between dry land and irrigated land is used to proxy water rents. In other cases a short-term market does exist and average lease price can be used (Goodman 2000, Watson and Davies 2011). The second alternative is to not be concerned with a market value or shadow price for water but rather model changes in administratively set prices. The aim is to assess or analyze how changes in water tariffs can bring about a triple dividend of reduced water use, reduced overall tax distortion and increase in income for poor households; thus, the price of water is a tariff imposed by the government and the water factor is a non-market commodity.

Production is modeled using nested CES functions, which describe the substitution and complement relations among the various inputs. Producers are cost-minimizes and constant return to scale is assumed. In the first place, products are broken down into two aggregates, intermediate consumption excluding water, and value added plus water consumed. The value-added and water components are decomposed into two parts: aggregate labor and capital plus water. Labor demand is broken down into three categories, skilled paid workers, unskilled paid workers and farmers. Within each segment, labor is totally mobile and completely employed. The composite capital/water factor is disaggregated into capital and water. Demand for physical capital makes a distinction between "old" capital and "new" capital. The model thus integrates the notion of vintage capital in order to make a distinction between the process of allocating capital existing at the beginning of the period, or which is already in place, from that resulting from contemporary investment (that is, a production function of putty/semi-putty type). "New" capital can be allocated more flexibly than already installed or "old" capital. It substitutes for other types of capital more easily (land, natural resources) than does old capital. Accelerating investment therefore strengthens the capacity for adjustment of the productive sector to match changes in relative prices. Finally, the water aggregate comprises two types of water, urban and rural, which are targeted by distinct, substitutable demands: municipal versus agricultural. Figure 1 illustrates the process whereby successive decisions are taken in the process of choosing production factors. Substitution elasticities reflect the possibilities for adjustment of demand for production factors to match movements in their relative pricing. Their values are based on those used in the previous CGE model built for Tunisia.

Income from labor is allocated between the various households using a standardized fixed-coefficient distribution matrix. Income from capital is allocated in the same way between households, companies and foreign investors. Companies pay tax on this income to the government and save the remainder. Household demand is derived from a program for maximizing the utility function (following the ELES system developed by Lluch 1973), specific to each household, subject to the constraints of available income and consumer price vector. Household utility is a positive function of consumption of the various products and savings. Income elasticities are differentiated by product and by household. The calibration of the model determines a per capita subsistence minimum for each product, whose aggregate consumption grows with population, while the remaining demand is derived through an optimization process. The share of the various products in government demand and investment demand is fixed once the aggregate levels of these have been defined.

The model assumes imperfect substitution among goods originating from different geographical areas. Import demand results from a CES aggregation function of domestic and imported goods (Armingto 1969). Export supply is symmetrically modeled as a Constant Elasticity of Transformation (CET) function. Producers allocate their output to domestic or foreign markets in response to relative prices. The small country assumption holds for Tunisia and Morocco being unable to influence world prices; thus, their imports and exports prices are exogenous. Capital transfers are exogenous as well, and determine the trade balance.

The equilibrium condition on the balance of payments is combined with other closure conditions so that the model can be solved for each period. First consider the government budget. Its surplus / deficit is exogenous and the household income tax schedule shifts in order to achieve the predetermined net government position. Second, investment is savings-driven, the latter originating from households, enterprises, government and abroad. The sequential dynamic path of the model results from this closure rule. A change in savings influences capital accumulation in the following period. Finally, exogenously determined growth rates are assumed for other factors that affect the growth path of the economy, such as population and labor supply and (in the baseline scenario) the total factor productivity. Agents are assumed to be myopic and to base their decisions on static expectations about prices and quantities.

The model considers a large set of policy instruments, some of which have been mentioned above: production subsidies (by type of activity), consumption subsidies (by product), value added taxes (by activity), other indirect taxes (by activity), tariff barriers (by imported product), direct taxes (by household), and taxes on corporate profits. The modeling of these different policy instruments is conventional. It defines each instrument as a tax on the relevant resource. For example, a production subsidy is modeled as a negative tax on production price.

3.2 The data

Water CGE models require the same data as traditional CGE models, but need water data in addition to the standard social accounting matrix. Moreover, CGE models, including water CGE models, are calibrated by using the baseline data to find parameters and by searching the literature for existing parameters that may fit the current model. The assumption that the baseline SAM represents the economy at an equilibrium point allows many of the parameters to be calculated from baseline SAM data, depending on the functional forms chosen for production functions and the utility function. In addition to the water intensity factors previously discussed, an important consideration for water CGE models is the elasticity of substitution between water and other factors of production. For agricultural sectors, these are typically assumed to be low because water is a vital input for which there are limited substitutes. Three categories of data are required for the calibration of the two countries water-CGE model: the social accounting matrix (SAM)[2], the different elasticities, and the trend in exogenous variables.

Both SAMs for Morocco and Tunisia have the same structure and reflects the economic situations that prevailed in both countries. The SAMs contains 15 productive sectors and their 15 corresponding commodities, 3 types of work (farmers, paid-skilled workers and paid-unskilled workers), 5 types of capital (physical capital, two types of lands and two types of water), 2 household categories (by areas) and one trade partner (the Rest of the World). The full dimension of both SAMs is the following:

Sectors/Commodities: (1) Wheat and barley, (2) other cereals, (3) Citrus, (4) Olive, (5) other fruits, (6) Tomato, (7) other vegetables, (8) Livestock, (9) forestry, (10) food processing, (11) other manufacturing industries, (12) non-manufacturing industries, (13) public administration, (14) services of water distribution, and (15) other services.

Production Factors: (1) urban water, (2) rural water, (3) irrigated land, (4) dry land, (5) physical capital, (6) paid unskilled workers, (7) paid skilled workers, and (8) farmers.

Institutions: (1) rural households, (2) urban households, (3) government, and (4) rest of the world.

Policy instruments: (1) VAT, (2) tariffs on imports, (3) taxes on income and profits, (4) subsidies on water mobilization, (5) subsidies on water distribution, (6) other subsidies on production, (7) other subsidies on consumption, (8) private investment on water mobilization, (9) public investment on water mobilization, (10) public investment on water distribution, (11) other private investments, and (12) other public investments.

Other accounts: (1) saving-investment, and (2) stock variation

4. The Water Sector in the Absence of Economic Reforms: The Baseline

4.1 Tunisian case

4.1.1 Main assumptions

Taking real values of 2005, a baseline scenario has been generated for Tunisia once the model was fully calibrated and solved. The so-called baseline scenario assumes observed growth rates for both GDP and government consumption in 2006-12. It also projects a marked GDP growth deceleration in 2012 owing mostly to the political crisis and, subsequently, a recovery of GDP at a rate of 5.5% per annum by the end of the simulation period (2020). The baseline scenario also shows that economic growth was already on the decline since 2008 when the global economic crisis erupted but this crisis barely affected the sector of mobilization of water resources during 2008-9 because public spending grew on average by 4.6% and 7%. The scenario, then, includes the effects of the global economic and political crises.

[2] A SAM may be viewed as an input-output table that has been extended to cover the full circular flow of incomes, linking the GDP on the supply side, represented by incomes accruing to factors and the government (indirect taxes net of subsidies), to the GDP on the demand side, defined as the sum of domestic and foreign final demands for the nation's outputs net of imports. Thus, the SAM includes comprehensive budgets for domestic institutions and the rest of the world. In addition, compared to what is implied by the IO structure, a SAM typically has a more disaggregated treatment of factors, domestic non-government institutions (households and enterprises), indirect taxes, and subsidies. For each institution, these budgets cover all current revenues and expenditures, including savings.

Notice that both real GDP growth and real government consumption growth are being imposed in the baseline scenario. Real GDP growth is merely imposed through a calibration procedure, adjusting productivity, but GDP is fully endogenous in the model.[3] This means that for the baseline scenario, we are simply assuming that the effects of the political crisis take place through productivity losses, without exogenously updating any other parameter. Productivity losses affect the level of production and, as a result, factor employment and household income and consumption per capita. In the case of government spending, it is assumed that consumption and other components of recurrent spending grow at a given rate per annum, which is part of the closure rules of the model. Government investment spending depends on the demand for capital in the public services sector and this, in turn, depends on government consumption.

Other macroeconomic closure rules used to generate the baseline scenario are as follows. Government investment spending is covered through current savings and fixed levels of borrowing (domestic and external) and tax rates. Any remaining imbalances are covered by foreign transfers from abroad (i.e., foreign aid) which basically assume their true value as the calibration of the model entailed imposing observed trends for the levels of borrowing and tax revenues. The real exchange rate adjusts to clear the current account of the balance of payments. Private savings rates adjust such that private investment equals total savings given a fixed ratio of private investment to GDP.

The model distinguishes three types of workers: those who have not completed secondary education (unskilled), those with at least completed secondary education (semi-skilled), and those who have completed some degree in tertiary education (skilled). If the unemployment rate by type of worker exceeds a minimum unemployment rate, the real wage (with respect to the consumer price index) is equivalent to a "reservation wage" such that the market reaches equilibrium through adjustments in the unemployment rate (or, by the same token, through changes in the level of employment). Alternatively, if the unemployment is at the minimum rate, the labor market reaches equilibrium through adjustments in the real wage. Meanwhile, the capital market reaches equilibrium through adjustments in the price of capital under the assumption of fixed unemployment of capital.

The baseline scenarios reflect the actual aggregate functioning of the Tunisian economy and the government accounts remain in realistic territory—based on existing data available for the preparation of this paper. The real exchange rate appreciates on average by 0.6% per annum in the baseline, consistent with more spending on non-tradables (clearly, government consumption), though it is worth mentioning that the actual trend of the real exchange rate is not being reproduced, as world prices are not updated due to lack of information. As a result, the real exchange rate appreciates, exports fall as a percentage of GDP whereas imports remain on the increase—such that foreign savings turned larger relative to GDP. In consistency with past trends, government debts decline over time.

Table 4 indicates the additional public spending required to keep the price of water constant over the period 2005-2020. In Tunisia, maintaining the current level of water price requires 0.8 percentage point of GDP additional public spending by 2020 compared with 1.1 percentage point of GDP in Morocco.

[3] The aggregate growth trajectory is imposed through the production function. The model is first run assuming that the quantity of value added (that is, real GDP at factor cost) is exogenous while the exogenous component of the efficiency parameter temporarily becomes endogenous. In this run, the observed trajectory of real GDP is imposed on the quantity of value added and this is achieved by proportionally scaling the efficiency parameter for all production activities. This run becomes the starting point to solve the model again and generate the baseline scenario, assuming that the quantity of value added is endogenous and the exogenous component of the efficiency parameter remains exogenous, though this is exogenously set to vary yearly to enable reproduction of the observed trajectory of aggregate real GDP growth.

5. Alternative Scenarios of Water Management

Three alternative scenarios have been tested:

- Cutting subsidies on water price by 50%
- Doubling public spending on water mobilization progressively over the period 2014-2020
- Both above scenarios implemented simultaneously

In both baseline and alternative scenarios one financing variable clears the government budget, while three other remain fixed and are updated depending on a rule. For example, a percentage of GDP can be imposed exogenously on a year-on-year basis. Foreign transfers from abroad, the equivalent to grand aid, clear the government budget in the baseline scenario. This rule changed under the alternative scenarios when the financing mechanism alternatively is domestic borrowing, domestic taxation or foreign borrowing in which case one of these three becomes the clearing variable of the budget.

The subsidized water price has an impact on the amount of water used for irrigation, as arguably a low price does not encourage efficient use. Moreover, the subsidized water price has also affected the allocation of production factors first among agricultural activities and second between the agricultural sector and the rest of the economy. Accordingly, removing this type of subsidy is expected to affect the structure of water consumption in the economy in addition to a reduction in water consumption in both countries, which is directly due to an increase in water price. In Tunisia, the water pricing policies followed since the 1960s increased the domestic demand of water given the high price elasticity of demand in all sectors, mainly in the upper blocks of consumption. Removing the half of subsidy on all types of water consumption will affect all segments of the economy. The two first direct effects are those linked to expected saving in public expenditures while the second reflect the deterioration of the households' welfare. In addition to these two contradictory effects (positive and negative), efficiency gains resulting from a better use of water resources among the various types of demands will be also important. The overall impact on the Tunisian economy is expected to be positive with growth in GDP under all financing alternatives. Increasing public investments in the mobilization and distribution of water is also expected to enhance economic activities through higher production and exports. Finally, and as expected, the cumulative impact of the implementation of the two previous scenarios is also positive.

In Morocco, the cost recovery policy through the reduction of 50% of subsidies will negatively affect the overall economic activity through a reduction in the level of GDP. Two major factors explain this result. First, in Morocco the level of water subsidy is higher than Tunisia (around 45%). Second the contribution of the irrigated agricultural sector to the Moroccan economy is much higher than Tunisia (15% against 9% in 2012) in the overall economic activity given its higher multiplier effects on the rest of the economy. . For these reasons, the efficiency and public saving gains are found to be smaller than the direct costs related to the decrease in households' welfare and agricultural production. The results of both models show clearly that the Tunisian agricultural sector has more flexibility to positively adjust to higher water prices compared with Morocco where the level of substitution among activities is more difficult.

Usually water-intensive products are encouraged in countries or regions where the price of water is very low and where incomes from these products are higher than previous activities in the same country or regions. In both cases of Tunisia and Morocco, water subsidies distorted agricultural production as water intensive agricultural productions have been gradually introduced rather than more efficient activities that are much more appropriate to the effective costs of water. By reducing the subsidy, the production cost of water intensive crops will rise significantly in both countries, mostly in the most water scarce areas. This would potentially lead to a change in production patterns in both of them, likely affecting the import and export of agriculture products. However, caution is required since water in water scarce areas is typically used more efficiently and more productively. The value added of farming in these two types of areas is also high; the net margin between rainfed agriculture and irrigated agriculture for many activities is also an important element in the determination of the net effects of rising water prices. Until a very high water price is reached, the reduction of subsidies to water infrastructures and operations costs might not change farmers' decisions on crops (and hence water use), since the price of the input (i.e. the water cost for the producer) is a very small proportion of the total costs of production. Also, there is no alternative best crop that will generate at least the same benefits.

6. Summary, Conclusions and Policy Recommendations

In both countries, pricing policies need to be accompanied by educational efforts to raise awareness on water consumption levels if they are to play a role in water conservation and public spending efficiency. Agriculture sectors in both countries enjoyed high public support for water pricing which impacted the capacities of farmers to introduce other activities with lower consumption of water. Despite many previous attempts to remove water subsidies in both countries, progress has been mitigated given the key social role of the agricultural sector in term of reducing social pressures in urban areas. Thus, water pricing has usually been below full cost recovery (especially when investments and externality costs are taken into account) despite the successive reforms of water pricing policies toward a more effective pricing. However, the increasing pressures on public resources in both countries requires the adoption of water pricing policy taking into account the principle of recovery of the cost of water services. Given that irrigation water subsidies policies adopted since the 60thaffected the choice of crops, leading to the farming of more profitable crops with higher irrigation needs which in turn leads to a higher consumption of water in both countries. Subsidies reduce production costs, but at the same time induce the development of water-intensive activities- which can be more profitable for farmers, but lead to an over use of water resources often not on the basis of comparative advantage but rather on a reducing cost strategy basis. Furthermore, the subsidies remove or decrease the price signal related to water consumption and therefore do not provide sufficient signal to stimulate water efficiency, such as the introduction of water efficient technologies or the renew of old infrastructures, which currently are responsible of huge losses. Increase of water prices is expected to lead to more efficient irrigation practices. However, the adoption of those practices may require significant investment from farmers. The reform of water subsidies can take several forms. It can either be though an outright elimination or a phased elimination of the subsidy. In the case of *outrigh*t elimination, the substitution of cultures with less water intensive ones can be used as a flanking measure, if financial support and technical advice aimed at such substitution is provided by the authorities to farmers simultaneously with the removal of the subsidies. Alternatively, if a *phased* elimination is chosen, authorities can direct crop selection towards less water intensive cultures by providing financial support and technical advice without removing the subsidies immediately and wait for the impact the change is due to have on water consumption. This will involve slower progress in water efficiency than the scenario where substitution of cultures is accompanied by the removal of the subsidies, since imposed substitution of cultures might not be feasible. However, such approach involves a smaller threat to farmers' income. If water demand is relatively inelastic, small increases of water prices might have an important effect on the prices of agricultural products, the competitiveness and the income of farmers. The removal of the subsidy can lead to significant impact on farmers' income. The results of this study show that farm income will decrease by about 20 percent before water demand decreases significantly. A reduction in the number of crops available for farming can also lead to greater technical and economic vulnerability of the agricultural sector in both Tunisia and Morocco. Employment is likely to be effected also in both countries.

Both social and economic negative impacts are expected to follow the reduction of water subsidies, especially in terms of reduced farmers' income, reduced level of employment and, in extreme cases, land abandonment. Negative impacts can be addressed either through (1) flanking measures that support the removal of water subsidies, reducing the negative impact this removal might have on farmers' income or (2) compensatory measures that make up for the farmers' income loss following the removal of water subsidies in sustainable ways. Measures that address negative economic impacts through production changes (e.g., adoption of new technologies and production processes, introduction of new cultures with crop replacement and crop diversification) that improve farmers' competitiveness and consequently support farmers' income should be preferred to the ones that address primarily farmers' income. The former tend to be transitory, enabling the individuals to recover or improve their initial income without further support in the medium term, whilst the latter tend to delay the adaptation to the new conditions.

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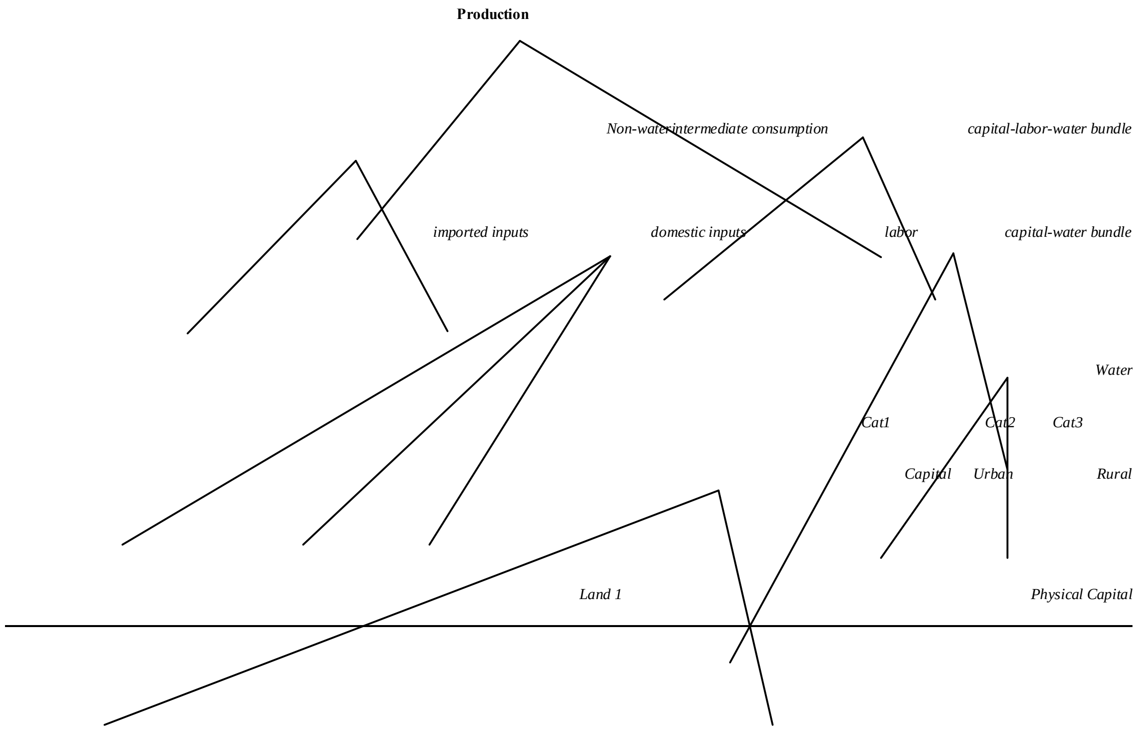
Figure 1: The Production Function



Notes: Each tree structure represents the choices facing producers in formulating factor demand. One or two substitution elasticities are associated with each decision level. These reflect the possibilities for adjustment of production factor demand in line with their relative pricing levels.

Table 1: Recent Evolution of Agricultural Sector Investment at Current Prices (MTD)

	2009	2010	2011	2012
Public	420.4	410.2	484.2	627.9
	(43%)	(40%)	(46%)	(48%)
Private	556.8	624.4	574.7	669.4
	(57%)	(60%)	(54%)	(52%)
Total	977.2	1034.6	1058.9	1297.3

Sources: Authors calculations based on statistics of Ministry of Agriculture (2013)

Table 2: Actual versus Potential Water Resources in Tunisia (values in Mm^3)

	Potential (10^6 m^3)	Mobilized resources (10^6 m^3)				
		1990	2000	2005	2010	2015 (Projection)
Surface water (56%)	2700	1179	1876	2200	2400	2500
Large dams		1170	1688	1927	2080	2170
Hill dams		5	125	160	190	195
Artificial lakes		4	63	113	130	135
Groundwater (44%)	2140	1576	1818	1860	1900	1940
Shallow aquifers		740	740	740	740	740
Deep aquifers		836	1078	1120	1160	1200
Total resources	4840	2755	3694	4060	4300	4440
Mobilization ratio (%)	**-**	**59**	**80**	**88**	**93**	**96**

Source: Al Atiri (2007).

Table 3: Tunisia and Morocco: Selected Macroeconomic and Government Indicators for the Baseline Scenario, 2005-2020 (% of GDP)

	2005		2010		2020	
	Tunisia	Morocco	Tunisia	Morocco	Tunisia	Morocco
National accounts						
Consumption- private	63.4	56.4	69.3	55.8	72.6	55.6
Consumption-Government	15.7	19.9	16.6	21.5	17.3	22.1
Investment-Private	12.9	23.9	12.9	26.8	13.9	28.2
Investment-Government	9.6	4.5	10.0	4.3	10.2	4.1
Exports	50.0	32.2	39.8	29.8	38.6	23.3
Imports	47.6	38.3	48.2	36.8	49.2	35.7
Government						
Foreign debt	53.9	13.4	39.0	15.3	47.8	15.7
Domestic debt	2.8	51.5	1.7	50.6	2.4	49.4

Source: authors' estimates based on application of Water-CGE model for Tunisia and Morocco

Table 4: Tunisia and Morocco: Additional Annual Public Spending Required to Keep the Domestic Price of Water at its Level in 2005 (deviation from baseline scenario, % of GDP) (Closure: additional public spending will be financed through an increase in taxes)

	Tunisia	Morocco
	0.8	1.1
Current	0.2	0.4
Capital	0.6	0.7

Source: authors' estimations based on application of the Water-CGE model for Tunisia and Morocco

Table 5: Cutting Subsidies on Water by 50% (SCENRIO 1), Doubling Public Investment in Water Mobilization by 50% (scenario 2), 2+1 (scenario 3)

	Scenario 1			Scenario 2			Scenario 3		
	tax	Fb	Db	Tax	Fb	Db	Tax	Fb	Db
Absorption	0.1	0.3	0.3	0.4	0.5	0.3	0.2	0.4	0.2
Consumption – private	0.2	0.2	0.3	0.3	0.5	0.2	0.3	0.4	0.2
Consumption – government	0.1	0.1	0.1	1.2	1.2	1.2	0.7	0.7	0.7
Fixed investment – private	-0.4	-0.4	-0.2	0.2	0.4	-0.1	-0.1	0.1	-0.2
Fixed investment - government	0.6	0.6	0.6	0.9	0.9	0.9	0.7	0.8	0.8
Exports	-1.4	-1.4	-1.2	1.5	1.7	1.4	0.2	0.4	0.3
Imports	0.6	0.6	0.5	-0.3	-0.4	-0.3	-0.1	0.2	0.2
GDP at market prices	0.2	0.2	0.2	0.4	0.5	0.3	0.3	0.4	0.3

Source: Authors' estimations based on application of Water-CGE model for Tunisia.

Table 6: Cutting Subsidies on Water by 50% (SCENRIO 1), Doubling Public Investment in Water Mobilization by 50% (scenario 2), 2+1 (scenario 3)

	Scenario 1			Scenario 2			Scenario 3		
	Tax	Fb	Db	Tax	Fb	Db	tax	Fb	Db
Absorption	0.1	0.0	0.0	0.4	0.6	0.6	0.2	0.3	0.3
Consumption – private	0.2	-0.1	-0.2	0.4	0.6	0.6	0.3	0.3	0.2
Consumption – government	0.1	0.1	0.1	1.2	1.2	1.2	0.7	0.7	0.6
Fixed investment – private	-0.3	-0.6	-0.6	1.2	1.9	1.9	0.4	0.6	0.7
Fixed investment - government	0.1	0.1	0.1	0.9	0.9	0.9	0.5	0.5	0.6
Exports	-1.4	-3.4	-3.2	1.3	1.7	1.6	-0.1	-0.8	-0.7
Imports	1.6	1.7	1.5	0.6	0.7	0.6	1.0	1.3	1.1
GDP at market prices	-0.1	-0.4	-0.4	0.3	0.5	0.4	0.1	0.1	0.1

Source: Authors' estimations based on application of Water-CGE model for Tunisia.