STRATEGIC POLICY OPTIONS TO IMPROVE IRRIGATION WATER ALLOCATION EFFICIENCY: ANALYSIS ON EGYPT AND MOROCCO

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Abstract

For a number of reasons government the world over have been unwilling to use water pricing to achieve water use efficiency. This research addresses questions of what policy alternatives to water pricing might improve irrigation water allocation efficiency. An empirical framework is provided to compare irrigation policies for allocating scarce water to agricultural production in Egypt and Morocco. Partial equilibrium agricultural sector models specific to Egypt and Morocco were employed for policy tests. Positive Mathematical Programming (PMP) was used to calibrate the models. Water pricing policy, water complementary input factor tax policy, and output tax policy are tested. Results suggest that effective policy depends on the social, economic, and environmental contexts of specific regions. The results for both countries demonstrate that some of the alternative irrigation policies can work towards directing cropping decisions to less water intensive crops and also generating revenues for governments in situations where governments choose not to price water.

Key Words: alternative policy, agriculture, cropping pattern, input tax, output tax, positive mathematical programming, water pricing, implementation.

Introduction

“In all economic activities, water demands depend on two factors, what is being produced, and the efficiency with which it is produced” (Gleick). This is especially true in the agricultural sector when we look for drivers to promote technology diffusion and lead wise use of irrigation water. The drivers should aim to increase productivity per drop through irrigation technology innovation and investment (water application efficiency) and allocate water among crops to achieve the most profitable outcomes (water allocation efficiency). There are a wide range of irrigation technologies available for irrigation. Using techniques available today, farmers could cut their water demands by 10-50% (Postel). However, both technology diffusion and water allocation efficiency improvement have not been easy without appropriate policy and economic instruments.

In seeking policy and economic instruments regarding the scarcity of water, competing views held by economists and policy makers from different countries and regions. Many stakeholders believe that access to water is an inalienable human right, a social necessity, and that water is critical for maintaining a stable, healthy social and economic environment for many regions. However, others tend to view water as a private good: one that should be allocated through competitive market prices. The notion that water should be considered as an economic good gained prominence at the Dublin conference on Water and the Environment in 1992 (ICWE, 1992). This idea was a compromise between those who tend to treat water as private good and those who view water access as a basic human right (Perry, Seckler, and Rock).

Briscoe; Perry, Seckler, and Rock; and Hellegers further clarified the confusion about treating water as an "economic good" as distinguished from valuing and charging for water. They recognized that treating water as an economic good is not about setting the appropriate price for water, but rather about making right choices for allocating water (Hellegers). If the choice is made based on a socio-economic trade-off, then economic efficiency is only one of the basic criteria in helping make good decisions about the optimal use and allocation of water among potential users (Hellegers). This argues that a multidisciplinary approach should be taken to address the issue.

However, invention and implementation of such approaches and policy options for allocating water to more productive uses remains a challenge in both developed and developing countries. Despite a fame of vicious, the economic efficiency criterion is attractive to most economists. Much of the literature has focused on the belief that resource allocation efficiency is achieved by equating cross sector marginal benefits (Dinar, Rosegrant, and Meinzen-Dick). The literature has covered the following water pricing methods (Tsur and Dinar, 1995): volumetric pricing, output pricing, area pricing, tiered pricing, two-part tariff pricing, and market pricing. Tsur and Dinar (1995, 1997) and Johansson examined in great detail the various pricing options available, and the contributions of these options to the goal of achieving economic efficiency of water use. Water pricing method in this paper, however, refers to volumetric pricing mechanisms that charge for irrigation water based on consumed quantities.

Some district analyses have demonstrated that similar pricing policies may have very different impacts under different conditions (Tsur et al.), as reflected in the shape (elasticity) of the derived demand curves. Farms with steep (inelastic) demand curves will be less responsive to price increases. However, when policy makers or project designers do not have a clear understanding or information of the shape of demand and supply curves, it will be difficult to find the most sensible price that will optimize water use. Tsur and Dinar (1995) found that water use is most efficient when pricing, such as Marginal Cost Pricing (MCP), affects water demand. However, the main drawback of MCP is the difficulty of including all marginal costs and benefits when determining the correct price to charge. Furthermore, as Perry (2001) indicates, a high marginal cost for water can reduce demand effectively, but is unlikely to be accepted within the politically feasible range. The limited acceptable range of pricing has weakened water pricing effectiveness as a policy option. As a result, most pricing reforms have only produced suboptimal solutions instead of first-best solutions (Dinar).

However, even with the sufficient information and known about the marginal value of water, the implementation of water pricing policy at or close to its marginal value is difficult in most of developing and developed countries. The obstacle is mainly from the lagged effect of historical water pricing policies. In many countries where irrigated agriculture plays an important role, farmers believe low or zero charges are justified. This belief is usually reflected in their political systems (Abu-Zeid). Some countries may also lack the tradition, experience, and appropriate institutions to price irrigation water. Many water scarce countries have adopted macroeconomic policies that have negative effects on agriculture in general and water in particular (Diao, Roe, and Doukkali). Most developing countries provide irrigation and domestic water supply systems at subsidized rates. By doing so they can secure water and food supplies, protect public health, and avoid opposition from farmers and urban poor to raising water prices (Abu-Zeid).

Molle (2002) summarized the reasons why water charges have been generally low for agriculture: (1) political sensitivity to increases in food prices; (2) competitiveness in international markets; (3) the depressed level of most staple food prices as well as their fluctuating nature; and (4) the political risks associated with a significant increase in water charges. Numerous studies suggest that maintaining low water tariffs will make this policy instrument ineffective in improving water allocation efficiency and increasing agricultural productivity (Molle, 2001; De Fraiture and Perry; Perry, 1996; Ogg and Gollehon). Ray looked at the social and economic impact of increasing water price in western India. She concluded that “significant price increases are politically infeasible, and feasible price increases are economically insignificant.” Perry (1996) also found that volumetric charges in Egypt were an unrealistic means of encouraging significant reductions in fresh-water demand because the price changes needed to generate a 15% fall in demand would have reduced farm income by 25%.

Sensitive physical, social, institutional, political and economic contexts of many regions and countries have left water pricing a contestable policy option. When transaction costs are high, it is difficult to move toward market pricing policy (Coase). Johansson et al., (2002) concluded that transaction costs make the implementation of water pricing methods difficult. In response to high transaction costs, political economy concepts and new institutional approaches have been introduced into the analysis of water pricing reforms (Dinar). Sampath; Rosegrant and Binswanger; Tsur and Dinar (1997); and Saleth and Dinar pointed out that water pricing may have a better chance of succeeding with minimal costs and less political opposition only when the institutional changes within the water sector can rapidly promote decentralization and privatization. However, the problem is that different countries and regions have different situations with respect to economic development, demographic growth and technical progress. Countries also differ in their levels of economic and political reforms, international commitments, social values and ethos changes, and natural calamities, which serve to motivate and speed up these institutional changes.

In summary, limited acceptable ranges of pricing have weakened the effectiveness of water pricing policy. High transaction costs embodied in implementation have resulted in slow institutional change in most developing countries that depend on irrigation water. This has deferred opportunities for saving water resources with water pricing policies within a reasonable time frame in these countries. There is a need to circumvent existing water pricing policy difficulties by examining other strategic policy options, which is also the major objective of this paper with a focus on Egypt and Morocco.

Egypt and Morocco differ in many aspects of agriculture and climate conditions. Even though agriculture accounts for 80% of fresh-water use in Morocco, irrigated areas account for 16% of total cultivated area, compared with 98% in Egypt (FAO, 2004). The major crops in Morocco's irrigated areas are orchards, sugar beets, sugar cane, potato and wheat, whereas Egypt has even more irrigated crops including wheat, maize, rice, sorghum, cotton, and sugar cane.

Egypt provides a case where rainfall is scarce and the nation's farmlands are almost entirely dependent on irrigation from the River Nile. Egyptian farmers do not have to pay for their irrigation water, but are responsible for the maintenance of canals that are attached to their fields. The country faces water scarcity due to increasing irrigation and industrial demand, and the water administration is very centralized. In contrast, Morocco provides a case where water from large scale irrigation has a water tariff, but the rates are very low and do not meet the operation and management cost in most regions. Due to irregular rainfall patterns and increasing use of irrigation water, it also faces a water scarcity problem. Morocco's water administration is currently undergoing a structural transformation from a centralized political structure towards a decentralized system of governance.

In searching for factors that determine the behavior for irrigation water demand along with agricultural production choices, alternative policy options for these two countries are considered. The policy options under study are: (1) water pricing; (2) taxation on water complementary input factors; and (3) taxation on output based on water intensity and low profit crops.

The objectives of this research are to evaluate alternative policy options (input and output taxes) to see if and how well they can serve as a proxy of water pricing policy in irrigated agriculture dominated country (such as Egypt) and rain-fed agriculture dominated country (such as Morocco), and to analyze the potential impacts on cropping pattern, irrigation water demand, welfare, and water agency revenues for each alternative strategic policy.

Methodology and Data

Agricultural Sector Model of Egypt (ASME) (Siam) and Agricultural Sector Model of Morocco (ASMM) (Doukkali) are used to conduct parallel research on the subject. Both are static partial equilibrium (PE) models in which social welfare, in the form of consumer and producer surplus from agricultural based commodities, is maximized subject to various resource, technical, and policy constraints. In order to achieve the maximized welfare, equilibrium demand and supply is required, i.e. the demand and supply balance of the agricultural products will be the key equations to solve for activity levels.

Water is a limited input in both models. The supply of irrigation water is assumed to be fixed and does not be fluctuating over time. The reality, of course, is that there is some fluctuation from one year to another. We also realize that irrigation policy will affect not only welfare in the agricultural sector, but the economy as a whole. Water policy in agricultural sector also affects other sectors of the economy, such as commercial, industrial and municipal residential consumption, and protection of the ecosystem. The agricultural sector models used for this research only encompass that sector and thus ignore water related benefits and costs in other sectors.

The Positive Mathematical Programming Method (PMP) approach, as suggested by Howitt (1995), has been employed to calibrate the models. In conventional mathematical programming, arbitrary constraints are added to avoid too specialized solutions and calibrate the model to the observed situation. However, PMP allows calibration of any linear or non-linear program to observed levels of the endogenous variables. Such a model can yield smoother response to changes in prices and constraints.

The agricultural sector model of Egypt has also been used to derive shadow prices for irrigation water. Water shadow prices can be derived using limited information via mathematical programming models (Shunway; Howitt et al., 1980, Kulshreshtha and Tewari; Chakravorty and Roumasset; Bontemps and Couture). The scheme to obtain these prices is as: (a) For a given output price, estimate the quantity of water maximizing the profit of the agricultural sector; (b) vary the level of water quantities to deduce the shadow prices under different levels of water.

Optimal crop production is calculated under various resource constraints and prevailing input-output prices. The water shadow price (λ) constraint is the marginal value of irrigation water. Shadow prices for water are determined by solving sum of the producers' and consumers' maximization problem. The procedure can be compactly written as the following:

$$Max \ \sum_{i=1}^{n}\left[\left(\alpha_i + \frac{1}{2}\beta_i D_i\right) D_i - C_i\right] \tag{1}$$

$$s.t. \quad C_i = \sum_{j=1}^{m} D_i r_i z_{ij} + \frac{1}{2} D_{ii}^{2} Q_i \tag{2}$$

$$S_i = y_i L_i \tag{3}$$

$$D_i \le S_i \tag{4}$$

$$\sum_{i=1}^{m} L_i \le L \tag{5}$$

$$\sum_{i=1}^{m} L_i a_i \le W : [\lambda] \tag{6}$$

$$\sum_{i=1}^{n} b_{ij} L_i \le Z_j \tag{7}$$

$$L_j \ge 0 \tag{8}$$

Where α and β are the intercept and slope of the demand function for crop *i*; L_i is the land allocated to crop *i*; y_i is yield of crop *i*; a_i is coefficient between water and yield of crop *i*; z_{ij} is quantity of other inputs *j* required for crop *i* per unit land; b_{ij} is coefficient between other inputs *j* and yield of crop *i*; p_i is price for output crop *i*; r_j is price vector for input factor j ; Z_j is available input levels for input factor j ; Q_i is the PMP coefficient for crop *i*; D_i and S_i are the demand and supply of crop *i,* respectively. λ is the water shadow price.

Equation (1) is the objective function of the producers' and consumers' maximization problem. Equation (2) defines the cost function on crop *i*, and equation (3) is the demand and supply balance. Equation (4) is the available land constraint. Equation (5) is the constraint on available irrigation water. The levels of the constraint are varied between the interval [0, *W**], where *W** is the maximum water capacity. Each iteration yields a new water shadow price (λ). Equation (6) is a constraint for other input factors, and equation (7) is the non-negativity constraint on land.

Data sets covering production and market dimensions have been used in the research models to describe the characteristics of the Egyptian and Moroccan agricultural sector. Irrigation water cost recovery data, which will be used for the water pricing policy scenario, is from the existing literature.

The data set for Agricultural Sector Model of Egypt (ASME) covers 1999 national and regional levels of land, labor, water resource availability and requirement, yields and fodder byproducts. The production of 27 crop commodities and 5 animal commodities in 8 regions are included in the model. The ASME has updated prices and cropping patterns to 2001.

The Moroccan data from Agricultural Sector Model of Morocco (ASMM) covers national and regional levels. There are 50 crop and 7 animal commodities in the model along with 5 irrigation zones and 6 agricultural regions based on climate differences (the amount and variability of rainfall).

The GAMS modeling software and MINOS 5.0 solver is used to solve and implement the model.

The Case of Egypt

Characteristics and Policy Goals of the Egyptian Irrigation System

The Egyptian economy depends heavily on the agricultural sector as a source to support non-agricultural sector growth. The Nile River supplies about 55.5 billion cubic meters of water annually to Egypt, and 80% of the water is used in agriculture. Over 90% of Egyptian agricultural land lies within the Nile basin and delta. There are three cropping seasons in Egypt, winter (November-May), summer (April-October) and Nili (July-October). The main winter crops are wheat, berseem (Egyptian clover) and broad beans. Among the summer crops, maize, rice and cotton are dominant. Vegetable crops such as tomato, potato, and others are cultivated in all seasons.

Water scarcity is growing in Egypt because of the competition use among users. According to a report by FAO in 2000, to maintain the irrigation infrastructure and conserve water, water pricing at cost recovery level and other incentives are needed. However, low cost recovery to gravity irrigation supply and subsidized energy cost for pumping groundwater is the most common distortion in Egyptian agricultural sector. The price of water is low. A three-fold increase would have minimal effect on farmer's profitability. This report also indicated that water pricing may not be a good tool to influence water conservation, but it is needed to raise financial resources to develop and maintain huge water infrastructure. The policy challege for

Egypt will be to meet the financial need for irrigation system and to provide incentives for efficient use of water.

Scenario Design for Egypt

Three policy scenarios are simulated using the ASME model (Siam, 2001): (1) a water pricing policy; (2) an input tax policy; and (3) an output tax policy. Table 1 summarizes the scenarios. The water pricing scenario observes the effects under different water pricing levels (cost recovery Pw1, and two shadow price levels Pw2 and Pw3). Pw1 (0.011696 Le/M^3) is the cost recovery water pricing level calculated by Perry in 1996. Pw2 (0.036 Le/M^3) and Pw3 (0.083 Le/M^3) are shadow prices derived using ASME under 5% and 10% reduction of water capacity levels, respectively. Input factor tax scenario includes three sub-scenarios: Nitrogen fertilizer (N-fertilizer), pesticides, and energy. The output tax scenario taxes paddy rice and sugar cane production since these crops are irrigation water intensive and have lower profit levels among all other crops in Egypt. Because the agricultural sector model used here is an endogenous price model, commodity supply equals demand. Domestic demand and prices are endogenous. However, export quantities and export prices are exogenous. In order to observe the response on the supply side from policy shocks, upper bounds on the exported quantities for all commodities in the model are increased by 20% before testing policy scenarios. Therefore, changes in exports are given a minimum (base level) and maximum (20% more than base level) bound. This allows the model to have a better environment to obtain insights into Egyptian export opportunities combined with the policy under consideration.

The results of the policy simulation are presented in four categories: 1) farmers' response modeled as cropping pattern change under different policy scenarios; 2) welfare change in terms of consumer and producer surplus change contrast with the change in water demand; 3) water demand elasticities; and 4) government revenue from each policy scenario.

Model Results for Egypt

Under water pricing scenario, the cropping area decreased for almost all major crops except citrus, most of all cotton and vegetables at the cost recovery water pricing level (Pw1) (Table 2). Cotton and vegetables have higher profitability than other crops in Egypt. With an increase in production cost (water cost), results favor production of higher valued crops than lower valued crops. The cropping area of onion and some cotton increased at the pw1 level. At a higher water pricing level such as Pw2 and Pw3, the model results show that cropping area of all crops decreased. Some crops, such as maize, paddy rice, sugar beet and sugar cane, dropped more than others (for example, vegetables). Land goes out of production at the cost recovery water pricing level, and at the water pricing levels Pw2 and Pw3. There are two reasons explaining this result: 1) increasing costs will cause activity levels to decrease until marginal revenue equals marginal cost. Land will go out of production if other activities can not be expanded profitably; 2) the PMP approach imparts a quadratic cost term which causes production costs to increase at an increasing rate as production deviates from the base. In other words, the PMP coefficients likely render the model too sensitive to cost and revenue changes.

For the water complementary input factor scenario, N-fertilizer and energy taxes results a similar cropping pattern change as with the water pricing scenario. However, a pesticide tax is not effective in decreasing the cropping area of water intensive low profit crops, such as sugar cane and paddy rice. This is because sugar cane does not use much pesticide and pesticide use is generally small for paddy rice in Middle Egypt and West Delta regions.

On the N-fertilizer tax scenario, we can see that the prominent decreases in cropping areas for major crops are from Nili maize, summer sorghum, sugar beet, and sugar cane. These crops are ranked comparatively high in N-fertilizer application rate. Cropping area for lentil, cotton, and onions increased at a lower N-fertilizer tax rate since their marginal profitability is higher than the other crops, although the N-fertilizer application rate are high for both summer and winter onions. However, as the N-fertilizer tax rate getting higher, the production of more crop types decreased including cotton and vegetables. Soybean cropping area also decreased as the N-fertilizer tax rate increased. This is because N-fertilizer has to be used in Egypt for soybean production because soils are nitrogen deficient and comprised mainly by sandy and clay soils that have low nitrogen use efficiency ratings. Soybean production in Egypt is low (about 13 thousand feddans in 2001). The reduction of irrigation water, however, is mainly from the decrease in paddy rice production along with sugar cane, wheat, maize, tomato and other vegetables.

Under energy tax policies, the model tends to shift more land to plant onions and cotton. The planting areas for some of the water intensive crops decreased including sugar cane, paddy rice, long berseem, and summer maize. These crops grow in specific regions require more pumping hours than other crops. Sugar cane in the west delta requires highest pumping hours among all crops. Paddy rice in the west delta requires much hours for pumping as well. Energy tax also affects the production of potato, tomato and other vegetables which also involve high pumping hours during the growing time.

Cropping area reduction mainly happens with sugar cane and paddy rice under output tax scenario. However, the production of profitable crops, such as lentil, increased up to 26% along with the increasing tax on sugar cane and paddy rice. A slight increase also happens with the cropping area of wheat, maize, bean, legume, and sugar beet. The main contributions to irrigation water reduction are from sugar cane and paddy rice. Although other crops demand more irrigation water as the output tax rate increases, their effects on demand for water is very small. More land moves out of production and can not be shifted to producing these crops due to the model constraint on export. Land will be allocated to producing more cotton and vegetables when the demand constraint is eliminated from the model.

Individual policy scenario analyses compare the scenario results with the base level. However, because the high sensitivity of the model to any cost and revenue change, the changes in irrigation water demand, welfare level, cropping pattern, and generated revenue provide good indicators of the direction of change, but not necessarily an accurate magnitude of change from the base level. Because the main purpose of this research is to look at some alternative policy options other than water pricing to identify the possible chances of adopting these policies which may achieve similar goals to water pricing policy, it is more constructive to compare the results of each policy with the water pricing results instead of the base level.

Figure 1 plots the percentage of welfare change in the agricultural sector caused by each policy scenario, contrasting with its percentage change of irrigation water demand. The pattern of welfare change and irrigation water decrease converges at the water cost recovery level and lower input or output tax shocks. The pattern of change on welfare and irrigation demand diverged when input or output taxes are high. Output tax appears to work better than water pricing policy. However, there are equity concerns related to farmers whose major crops are paddy rice or sugar cane. It will be hard for them to change the crop mix in the short run. Welfare measure change in agricultural sector is negative as it is shown in Figure 1. This is because the welfare measure in this study includes agricultural commodity consumers' and producers' surplus, while the remaining sectors of economy are not taken into account. However, if the economy were considered as a whole, reallocation of water from agriculture to other sectors would increase global welfare because water value is higher in other sectors.

Comparisons on the measure of water demand elasticity is depicted in Figure 2. It shows that none of the policy options are elastic. Comparatively, the output tax policy is relatively more elastic than others. Among the input tax policies, N-fertilizer tax above 50% elicits larger elasticities. Elasticities of N-fertilizer tax, energy tax, and output tax are comparable to elasticities with water pricing (Pw2 and Pw3).

Revenue generated cross all policy scenarios is calculated and presented in Figure 3. Except for the N-fertilizer tax rate of 10% (NF-10%), every policy scenario generated more revenues than the cost recovery water pricing policy at Pw1. However, none of the policy alternatives can generate as much revenue as the Pw3 water pricing level, which is the shadow price obtained when water availability is only 90% of the base level.

The Case of Morocco

Characteristics and Policy Goals of the Moroccan Irrigation System

Agriculture plays a very important role in the economic and social domains of Morocco as well. Moroccan agricultural production is characterized by rain-fed and irrigated farming. More than 84 percent of the total arable land is dry-land farming. Cereals and vegetables are the primary crops grown under dry-land agriculture. Irrigated farming has increased from 73,000 ha in 1953 to 1,471,797 ha in 1998. Irrigated land contributes about 45% of agricultural value-added, employs about 33% of rural labor, and comprises about 75% of agricultural exports (Yacoubi and Beghiti).

Agriculture also accounts for 80% of total fresh-water consumption in Morocco. Most fresh-water in Morocco comes from rainfall and melting snow collected by large dams. Water from these dams is delivered by canal systems. Some areas have ground water supply to supplement surface water (Tsur and Dinar, 1995). Surface water is regulated by nine regional agricultural development authorities. Water scarcity is also faced by Morocco because of irregular rainfall patterns and increasing use in agriculture (USAID).

Farmers are charged a fee by regional authorities that is generally lower than the water's real values (Diao, Roe and Doukkali). Benabderazik described the interaction between institutions and decision-makers in Morocco. He found that institutional change influences options available for water pricing and water allocation policies. Nevertheless, water administration in Morocco has demonstrated a tendency towards decentralization and functional specialization, even though it has a centralized political structure (Saleth and Dinar). Economy-wide gains from decentralized water allocation have been investigated by Diao, Roe and Doukkali. They concluded that macro-economic variables and water market reform together influence water reallocation among crops and farmers.

The present research classifies Moroccan agricultural land into Large Scale Irrigation (LSI) Land, Private and Other Irrigation (PRI) Land, and Rain-fed Land (Doukkali). Table 3 shows that cereals are the main crops grown in each category. Industrial crops, including sugar beet, sugar cane, sunflower, and peanuts, are planted on LSI land and rain-fed land. No industrial crops are produced on PRI land. Most vegetables and fruits are cultivated on PRI land. In the policy analysis that follows, this cropping pattern serves as a starting point for land allocation among crops under the different irrigation land classifications. Welfare levels for the agricultural sector including both irrigated and rain-fed area are reported. Irrigation water demand changes in regions using LSI and PRI irrigation systems and government revenue from each scenario in these regions are presented.

The irrigation policy goals of Morocco are 1) to allocate irrigation water from low profit crop production to more profitable crops, such as fruits and vegetables, and 2) to collect revenue in order to meet the M&O costs and investment needed for supplying more irrigation water to balance increasing demand.

Scenario design for Morocco

Three policy scenarios for Morocco were simulated using the Moroccan Agricultural Sector Model (MASM) (Doukkali): 1) a water pricing scenario, 2) a tax on energy use for pumping; and 3) an output tax on cereals and industrial crops. Table 4 describes the policy scenarios for Morocco.

The water pricing scenario increases the base water tariff to its cost recovery level for regions using water from large scale irrigation systems (Table 5). Historically, improvement of the recovery rate of the water fee has had positive aspects with respect to the objectives of financial viability, economic effectiveness, and equity. From the institutional perspective, this scenario approximates Morocco’s anticipated future water tariff system.

An energy tax for pumping lies in the category of taxes on water complementary input factors. Taxes on N-fertilizer and pesticide are not tested for the Morocco case because these inputs are used both on irrigated land and in rain-fed production. There is no realistic way to tax these inputs only for irrigation production.

Output taxes are equivalent to a price reduction on certain crops. Output taxes are levied on cereal crops and industrial crops grown in LSI land. Among all the crops cultivated on LSI land, durum wheat uses about 8.3% of total water demand, while bread wheat uses about 16.5%

of total irrigation water (Table 6). The main industrial crops under LSI are sugar beet, sugar cane and peanuts. Sugar beet production consumes 7.9%, sugar cane production consumes 7.9% and peanut production consumes 6.8% of the total irrigation water served by the LSI system. Wheat and industrial crops receive producer price subsidies (Diao, Roe, and Somwaru). More specifically, wheat and sugar have border protection while sunflower receives a deficiency payment. Wheat and sugar beets are not among the most water intensive crops. However, they use a significant amount of land. This causes water demand for wheat and sugar beet to be high. Sugar cane, peanuts, and sunflowers use water more intensively compared to most of the other crops. Output taxes could serve as a mechanism to reallocate water use from producing cereal crops and industrial crops to producing vegetables and fruits which are the major export goods in Morocco.

Unlike the ASME model for Egypt, imports in the ASMM are endogenous instead of exogenous. However, exports are exogenous in the ASMM as well. In order to capture the export opportunities and responses from the policy scenarios tested, an export bound is also assumed in the policy simulation: the lower bound of exports is the base level and an upper bound is set to 20% higher than the base level.

Model Results for Morocco

Water pricing at the cost recovery level affects cropping patterns in both irrigated and rain-fed land (Table 7). Changes occur on LSI as land used for cereals decreased. There is only a small change on PRI for cereal production. The corresponding changes for cereal crops in rain-fed area are barley and corn. However, imports for durum wheat, bread wheat, and barley increased. Land for producing beans decreased 6% and other pulses decreased by 66% compared to the base level while imports for beans increased. Industrial crops decreased as well, especially sugar cane and sunflower. Land for peanut falls, which leaves room for rain-fed land to use more land than base scenario for peanut production. Land for producing greenhouse tomato, vegetables for processing and olives also increased on LSI.

Land allocation changes on PRI mainly with forage crops and vegetables. Forage crop increased. Except for early potato, land for vegetable production increased. This compensates for the decrease on land used to produce vegetables on LSI. Land allocated to oranges decreased on LSI, but increased on PRI.

Tables 8 to Table 10 show cropping pattern changes under different land classifications. Table 11 gives the import changes under corresponding scenarios. Cultivation of vegetables and fruits increased under all policy scenarios on LSI land (Table 8). Except for grape, it decreased slightly under water pricing and energy tax. Cereals and industrial crop decreased as well under all policy scenarios, although not in the same magnitude. Land for sunflower increased due to the decrease in import of raw sunflower oil (Table 11).

Table 9 provides changes in irrigated land (PRI) under energy tax and output tax scenarios. There are small decreases in land allocated to cereal and clover due to an increasing energy tax rate. More tomato, strawberry, melon, other vegetables, and olive, are planted on PRI with an energy tax. Increase on PRI land for some vegetables and olive production can also be observed in the model results.

In the rain-fed region (Table 10), land allocated to produce barley, forage, peanuts, sunflowers, and grapes increased to compensate the decrease of these crop productions on LSI and PRI at the corresponding energy tax rate. More durum wheat, bread wheat, and barley are imported into the country as the energy tax increases. The increase of energy tax rate enhanced the total land area cultivation on rain-fed land. Both durum wheat and bread wheat decreased;

however, imports of durum wheat and bread wheat balanced the domestic demand (Table 11). The total land for cultivation decreased on LSI and PRI while the land for cultivation increased on rain-fed area.

Contrast of the effects on agricultural sector welfare and irrigation water demand under different policy scenarios is shown in Figure 4. Unlike the model results for Egypt, welfare increases in the Morocco case. Welfare gains in Morocco are derived from the other two sub-sectors, rain-fed and PRI land, as the cost and revenue shocks are on LSI land. More rain-fed land is cultivated and more vegetables and fruits are produced on both PRI and rain-fed land. Compared with the water pricing scenario, an output tax at a 10% rate (OUTP-10%) could reach the same welfare level and reduce more irrigation water demand. On the other hand, an energy tax at a 200% rate (ENG-200%) reduced irrigation water demand as much as water pricing policy did.

Figure 5 plots the comparison of water demand elasticity under different policy scenarios. Water demand elasticities of energy remain the same with low and high tax rates; however, the output tax can be more elastic as the tax rate increased. Comparing with the elasticity of water pricing at cost recovery level, output tax is relatively more elastic.

Figure 6 illustrates the rank of revenue generated from each policy scenario under analysis. Energy tax and output tax at a higher level can also generate a comparable amount of revenue compared with the extra revenue generated from water pricing at cost recovery level. However, if output tax is just a lower price on the products, it is consumers, not the government, who receive the benefit. High energy tax policy can also be another attractive alternative in terms of collecting revenues; however the tax rate (200%) may be too high to be implemented.

Conclusions and Policy Implication

This research intended to provide a better understanding of alternative irrigation policies compared to water pricing by examining irrigation policy options for Egypt and Morocco. The profiles of the countries used in this analysis are considerably different. Egypt is a country characterized by irrigated agriculture for most of its land. Morocco is representative of countries who use mainly rain-fed land for agriculture with a tendency of increasing irrigated land. The analysis confirmed the effectiveness of alternative irrigation policy options in Egypt. For the purpose of reducing irrigation water demand, conserving water, and meeting the financial scarcity of irrigation development and promotion of water saving technology, using high water shadow pricing should not be an automatic policy response. Rather, it may be appropriate to find alternative ways: 1) output tax on rice and sugar cane could be used to reduce irrigation water demand on these two crops. This would promote cultivation of less water-intensive but more profitable crops such as sugar beet and other vegetables; 2) a very high tax on N-fertilizer and energy may not be possible at the present time. However, these policies demonstrated positive impacts and potential in directing the cropping pattern towards more profitable ones, such as lentils and vegetables. In the long run, increasing of N-fertilizer and energy taxes could be considered as a supplementary policy for Egypt for adjusting irrigation water application; 3) alternative policies could also be effective in terms of generating revenue for government or irrigation administration. If cost recovery water pricing or higher price levels can not be implemented in Egypt, lower levels on water complementary input factors taxes and output tax policy can meet this goal as well. However, output taxes may not be able to work on this purpose if it takes the form of reducing subsidies on sugar cane and paddy rice.

For the Morocco case, cropping patterns changed appreciably for all three policies on LSI irrigated land. Based on the model results, vegetable and fruit cultivation were significantly affected because most of the vegetable and fruits are profitable exports in Morocco. More land could be allocated to vegetable and fruit production if export of fruits and vegetables increased. Cropping pattern changes were also observed on the PRI land on vegetable and fruits, and rain-fed area on crops such as cereals, forages, and other industrial crops. Comparison on water demand elasticity results in a relatively constant elasticity under different energy tax levels, and the higher the output tax rate, the more elastic the output tax policy. Water pricing at the cost recovery level was effective in limiting irrigation water demand in LSI irrigated land. The change of overall welfare in the agricultural sector was positive under this policy. There was not a strong response from the energy tax policy in welfare and irrigation water demand. On the other hand, output tax on wheat and industrial crops on LSI irrigated land worked well in decreasing irrigation water use while increasing welfare level.

Increased water prices, energy taxes, and output taxes generated extra revenue for the Moroccan water agency and government. Water pricing at the cost recovery level increased revenue by 50%. This level can be reached by an output tax as well at the 10% level. The energy tax policy was not effective for generating revenue compared to water pricing and output tax policies.

The major conclusions regarding to policy implications for Morocco are as follows: 1) low level of energy taxation should not be used if the policy goal is to limit irrigation water and generate government revenue; 2) the output taxation policy could be an alternative policy to water pricing at the cost recovery level; 3) a higher energy tax or an output tax can also meet the financial goals in terms of generating revenue for government or irrigation administration.

This study also shows that the effective policy depends on the social, economics, and environmental contexts of specific regions. For countries like Egypt where most of land is irrigated, N-fertilizer tax, energy tax, and output tax on water-intensive and low profit crop production may be more effective than others. Morocco has both irrigated land and rain-fed land. Water pricing and output tax policies are better suited and effective for Morocco than water complementary input factor taxation. For example, energy tax policy is a comparatively less effective policy in Morocco, although it works well in Egypt. Findings from Morocco might be generalized to other countries with similar irrigation characteristics.

The Morocco case may be more compelling because of its diversity in irrigated (public and private) and rain-fed land. Taxation on crop inputs and outputs not only affect water use in the public irrigation sector, but private irrigation sector and rain-fed as a whole. There was an increase of welfare in the agricultural sector in Morocco from the model results. The irrigation policy on public irrigation system can improve the land allocation and hence increase welfare gains in rain-fed areas.

Limitation and Further Research

The research undertaken here is very important given the lack of information on irrigation policy with respect to water complementary input factors and high water-intensive low profit crops. The results demonstrated that it is a beneficial area of research for these two countries and should receive more attention. However, policy makers should consider that taxation policies on input and output factors are intervention tools that affect not only production, but the agricultural sector and the rest of economy as a whole. In the long run, prices, market conditions, and production technologies will all change and adjust over time. Future research should address these concerns.

Further research is needed to confirm the magnitude of the effects from each policy in the respective countries. The usage and distribution of water and other inputs can change when cost or revenue shocks are large. The assumed limited technology option and fixed yield might not be able to reflect the actual response in a precise manner. The links between irrigation policy practice and impacts on water saving technology adoption, substitution effects among inputs, and the rest of economy should also be considered.

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Table 1 Description of policy scenarios for Egypt Case.

Scenarios	Pw1	Pw2	Pw3	N-Fertilizer	Pesticides	Energy	Paddy Rice	Sugar Cane
Water Pricing	√	√	√					
Input Factor Tax				√	√	√		
Output Tax							√	√

Pw1: Using cost recovery price level calculated by Perry (1996)

Pw2: Using shadow price at the 5% reduction of irrigation water

Pw3: Using shadow price at the 10% reduction of irrigation water

Table 2 Egypt: Policy Effects on Cropping Area.

policy shocks Crop Items	Base Scenario	Water Pricing Scenario			N-fertilizer Tax Scenario			Pesticide Tax Scenario			Energy Tax Scenario			Output Tax Scenario		
	Base	Pw1	Pw2	Pw3	10%	50%	100%	50%	100%	200%	50%	100%	200%	10%	25%	50%
	000 fed	*% Change from Base*			*% Change from Base*			*% Change from Base*			*% Change from Base*			*% Change from Base*		
Barley	74.4	-2	-3	-4	-	-1	-1	-	-1	-1	-2	-2	-2	-1	-	-
Nili Maize	304.8	-2	-9	-15	-1	-8	-15	-2	-4	-7	-6	-12	-24	-	1	1
Summer Maize	1773.5	-1	-3	-8	-	-2	-5	-	-	-1	-2	-3	-7	-	-	-
Wheat	2341.8	-1	-2	-5	-	-2	-4	-	-1	-2	-1	-2	-5	1	1	1
Nili Sorghum	11.7	-5	-24	-46	-5	-19	-41	-5	-8	-17	-	-2	5	-	-	-
Summer Sorghum	314.1	-1	-4	-9	-	-2	-4	-	-	-	-2	-4	-8	-	-	-
Paddy Rice	1340.3	-1	-4	-10	-	-1	-2	-	-1	-2	-2	-4	-8	-8	-21	-43
Fava bean	333.7	-3	-6	-13	-	-1	-1	-3	-7	-14	-4	-8	-16	2	3	3
Soy bean	12.7	-4	-13	-30	-	-5	-9	-	-	-3	-7	-14	-28	-	-	-
Other Legume	42.4	-2	-3	-8	-	-1	-	-	-	-	-1	-1	-	1	3	3
Long Berseem	1939.5	-1	-2	-4	-	-	-	-	-	-	-1	-2	-3	-	-	-
Short Berseem	561.6	-1	-2	-5	-	-	-	-	-	-	-1	-2	-4	-	-	-
Ground Nut	149.9	-1	-1	-5	-	-1	-2	-	-1	-1	-1	-2	-4	-	-	-
Lentil	5.4	-	1	-5	1	3	7	-	-1	-2	-	2	2	11	26	26
Sesame	64.6	-2	-5	-11	-	-2	-3	-	-	-	-2	-3	-6	-	-	-
Flax	18.2	-	-	-1	-	-	-1	-	-	-	-	-	-1	1	-	-
Cotton (G45)	0.1	1	-2	-4	4	-1	-2	2	-1	-2	4	4	4	4	4	4
Cotton (G70)	72.0	4	2	-2	4	3	2	4	3	2	5	5	5	5	5	5
Cotton (G88)	10.6	-	-2	-6	-	-1	-2	-	-1	-2	1	1	1	1	1	1
Cotton (G80)	80.8	-1	-5	-13	-	-2	-6	-	-1	-4	1	1	1	1	1	1
Cotton (G83)	31.9	-2	-5	-11	-	-3	-6	-1	-2	-4	-	-	-	-	-	-
Cotton (G85)	80.9	-	-3	-8	1	-1	-2	-	-1	-3	1	1	1	1	1	1
Cotton (G86)	113.9	1	-2	-5	2	-	-2	1	-	-2	3	3	3	3	3	3
Cotton (G89)	128.1	-	-2	-7	1	-	-1	-	-	-2	1	2	1	2	1	1
Sugar Beet	142.6	-6	-19	-43	-5	-26	-51	-24	-47	-93	-13	-26	-52	1	-	-
Sugar Cane	306.4	-3	-10	-25	-1	-6	-13	-	-	-1	-4	-8	-16	-16	-40	-85
Citrus*	907.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Summer Onion	13.9	1	-	-2	2	-	-1	1	-1	-4	2	1	-	2	2	2
Winter Onion	54.0	1	-	-3	2	-	-2	1	-	-3	2	1	-	2	2	2
Nili Potato	47.3	-	-1	-1	-	-2	-4	-1	-1	-3	-1	-1	-2	-	-	-
Summer Potato	62.5	-	-1	-3	-	-1	-3	-2	-3	-6	-	-1	-2	-	-	-
Nili Tomato	67.1	-	-1	-1	-	-1	-2	-1	-3	-6	-1	-2	-3	-	-	-
Summer Tomato	200.9	-1	-2	-6	-	-2	-5	-2	-5	-10	-1	-3	-6	-	-	-
Winter Tomato	157.8	-	-	1	-	-2	-4	-2	-3	-7	-1	-1	-2	-	1	1
Nili Vegetable	153.7	-	-1	-1	-	-1	-2	-1	-2	-5	-1	-2	-4	-	-	-
Summer Vegetable	463.1	-	-1	-3	-	-1	-2	-1	-2	-4	-1	-1	-2	-	-	-
Winter Vegetable	427.9	-	-	-	-	-	-	-	-1	-2	-	-	-	-	-	-
Total Land of Cultivation	12810.9	-1	-3	-7	-0.1	-2	-3	-0.6	-1.4	-3.0	-1.4	-2.8	-5.8	-0.8	-2.7	-6.0

* Citrus cultivation is fixed in the model because most of the Egyptian fruit trees are perennials.

Table 3 Morocco: Crop Set and Base Cropping Patterns (1998).

Crop Set	Base Cropping Area (000ha)		
	LSI	*PRI*	*Rain-fed*
Cereals	228.6	257.4	4514.6
Legumes	2.7	3.3	371.1
Forages	8.4	11.9	42.6
Industrial Crops	94.8	-	98.3
Vegetables	58.7	184.6	45.3
Fruits	59.3	241.3	47.3
Fallow	-	-	592.8

Source: MASM (Doukkali, 2002).

Table 4 Description of Policy Scenarios for Morocco Case.

Scenarios	Water (LSI)	Energy	Cereals[a]	Industrial Crops[b]
Water Pricing	√			
Input Factor Tax		√		
Output Tax[c]			√	√

a: Cereals: Durum wheat, Bread wheat, Barley, and Corn.
b: Industrial Crops: Sugar Beet, Sugar Cane, Sunflower, and Peanuts.
c: Output tax is on crops produced on LSI.

Table 5 Actual Volumetric Cost in Different Agricultural Zone in Morocco.

Agricultural Zone	Actual Cost (Dh/M^3)
Favorable Zone	0.681
Intermediate Zone	0.347
Unfavorable Zone East	0.642
Mountainous Zone*	0.17
Unfavorable Southern Zone	1.026
Sahara (Desert) Zone	0.753

Source: Ait Kadi.
* Mountain Area (mainly TADLA (Beni Amir))'s actual cost only includes O&M cost (Dh/M3)

Table 6 Morocco: Water Demand by Crops in LSI Land at Base Level.

Irrigated Crops	Water Demand	Percentage of Total Demand
	(million M^3)	*(%)*
Durum Wheat	158.0	8.3
Bread Wheat	315.2	16.5
Barley	79.9	4.2
Corn	49.2	2.6
Beans	3.6	0.2
Other Pulses	1.2	0.1
Clover	12.4	0.7
Forages (Irrigated)	7.8	0.4
Sugar Beets	150.0	7.9
Sugar Cane	149.9	7.9
Sunflower	69.9	3.7
Peanuts	129.7	6.8
Tomato (Under Greenhouse)	29.1	1.5
Tomato (Seasonal)	22.4	1.2
Potato (Seasonal)	24.5	1.3
Melon (Under Greenhouse)	6.4	0.3
Melon (Field)	15.4	0.8
Other Vegetables (Seasonal)	145.0	7.6
Vegetables (For Processing)	27.0	1.4
Orange	351.3	18.4
Apricot	9.1	0.5
Apple	18.8	1.0
Grape	78.7	4.1
Olive	53.5	2.8
Total	1907.9	100

Source: MASM (Doukkali, 2002).

Table 7 Morocco: Effects of Water Pricing on Cropping Area in LSI, PRI and Rain-fed Land. (Percentage Change from Base)

	LSI		PRI		Rain-fed	
Crop Items	*Base(000Ha)*	*% Change*	*Base (000 Ha)*	*% Change*	*Base (000Ha)*	*% Change*
Cereal						
Durum Wheat	66.04	-8	36.30	-1	1010.16	-
Bread Wheat	125.49	-13	114.47	-	1379.79	-
Barley	28.77	-10	92.14	-5	1797.19	1.1
Corn	8.26	-42	14.53	-1	327.52	-0.1
Legumes						
Beans	2.16	-6	2.60	-	151.38	-
Other Pulses	0.51	-66	0.70	-	219.76	-
Forages						
Alfafa	-	-	10.96	-	-	-
Clover	4.13	-	0.01	0	-	-
Forages (Irrigated)	4.25	-	0.91		-	-
Forages (Rain-fed)	-	-	-	-	42.62	0.1
Industrial Crop						
Sugar Beets	48.96	-2	-	-	7.74	-
Sugar Cane	14.30	-15	-	-	-	-
Sunflower	12.79	-34	-	-	88.29	0.1
Peanuts	18.70	-10	-	-	2.24	8.6
Vegetable						
Tomato (Under Greenhouse)	1.59	6	2.36	6	-	-
Tomato (Field)	-	-	1.75	7	-	-
Tomato (Seasonal)	4.59	-1	9.05	-	-	-
Potato (Early)	-	-	10.50	-1	-	-
Potato (Seasonal)	6.90	-2	43.11	-	-	-
Strawberry	-	-	2.42	-	-	-
Melon (Under Greenhouse)	0.35	0	0.63	1	-	-
Melon (Field)	4.50	-1	17.17	-	-	-
Other Vegetables (Under Greenhouse)	-	-	0.95	7	-	-
Other Vegetables (Field)	-	-	2.30	4	-	-
Other Vegetables (Seasonal)	35.59	-1	86.28	-	-	-
Vegetables (Dry-land)	-	-	-	-	45.28	-
Vegetables (For Processing)	5.21	17	8.14	12	-	-
Fruits						
Orange	37.80	-1	35.30	1	-	-
Apricot	1.24	0	12.68	-2	-	-
Apple	2.74	-1	25.03	-1	-	-
Grape	13.46	-1	25.71	-1	10.79	0.5
Olive	4.06	1	80.79	1	-	-
Other tree crop	-	-	61.81	-	36.53	-
Fallow (Dry-land Only)	-	-	-	-	592.79	0.4
Total Cultivation of Land	452.38	-8	698.57	-0.50	5712.08	0.4

Table 8 Morocco: Effects of Energy Tax and Output Tax on Cropping Area in LSI Land. (Percentage Change from Base)

policy shocks Crop Items	Energy Tax Scenario			Output Tax Scenario		
	50%	100%	200%	2%	5%	10%
Cereals						
Durum Wheat	-4	-9	-18	-8	-21	-43
Bread Wheat	-5	-6	-7	-4	-11	-19
Barley	-2	-2	-2	-	2	-100
Corn	-25	-29	-29	-26	-44	-74
Legumes						
Beans	27	55	-6	40	100	198
Other Pulses	-4	-9	-18	-	-	-
Forages						
Clovers	-20	-46	-81	-	-	1
Other Forages Irrigated	-	-	-	-	-	-
Industrial Crops						
Sugar Beet	-1	-2	-3	-2	-4	-8
Sugar Cane	-3	-5	-9	-1	-3	-7
Sunflower	-10	-19	-39	3	-8	-17
Peanuts	-3	-7	-13	-8	-20	-41
Vegetables						
Tomatoes under Greenhouses	6	6	5	7	7	7
Seasonal Tomato	-	-1	-1	-	-	-
Potatoes in Season	-	-1	-1	-	-	-
Melon under Greenhouse	2	1	-2	3	3	3
Field Melons	-	-	-1	-	-	-
Other vegetables in season	-	-1	-2	-	-	-
Vegetables for Processing	18	18	18	46	80	109
Fruits						
Orange	4	4	4	5	5	5
Apricots	2	2	2	2	2	2
Apple	-	-	-	-	-	-
Grape	-3	-7	-16	1	1	1
Olive	1	1	1	3	4	5
Total Cultivation of Land	-3	-5	-8	-2	-6	-20

Table 9 Morocco: Effects of Energy Tax and Output Tax on Cropping Area in PRI Land. (Percentage Change from Base)

policy shocks	Energy Tax			Output Tax		
Crop Items	*50%*	*100%*	*200%*	*2%*	*5%*	*10%*
Cereals						
Durum Wheat	-1	-1	-1	-1	-1	-
Bread Wheat	-	-	-	-	-	-
Barley	-4	-4	-5	-6	-4	-4
Corn	-1	-1	-2	-2	-2	-2
Legumes						
Beans	-	-	-	-	-	-
Other Pulses	-	-	-	-	-	-
Forages						
Alfalfa	-	-	-	-	-	-
Clover	-	-1	-	-	-1	-1
Other Forages Irrigated	-	-	-	-	-	-
Vegetables						
Tomatoes under greenhouses	6	6	6	6	6	6
Field Tomato	7	7	7	6	6	6
Seasonal Tomato	-	-	-	-	-	-
Early Potato	-1	-1	-1	5	5	5
Potatoes in Season	-	-	-	-	-	-
Strawberry	1	-	-	-	-	-
Melon under Greenhouse	1	2	2	-	-	-
Field Melon	-	-	-	-	-	-
Other Vegetables in Greenhouse	7	7	7	7	7	7
Other Vegetables Grown in Field	4	4	4	4	4	4
Other vegetables in season	-	-	-	-	-	-
vegetables for processing	11	11	11	1	-7	-8
Fruits						
Orange	-	-	-	-	-	-
Apricot	-2	-2	-2	-2	-2	-2
Apple	-1	-1	-1	-1	-1	-1
Grape	-1	-	-	-1	-1	-1
Olive	1	1	-	1	2	2
Other tree crops	-	-	-	-	-	-
Total Cultivation of Land	-0.5	-0.5	-0.5	-0.7	-0.6	-0.6

Table 10 Morocco: Effects of Energy Tax and Output Tax on Cropping Area in Rain-fed Land. (Percentage Change from Base)

policy shocks	Energy Tax Scenario			Output Tax Scenario		
Crop Items	*50%*	*100%*	*200%*	*2%*	*5%*	*10%*
Cereals						
Durum Wheat	-	-	-	-0.03	-0.03	-0.02
Bread Wheat	-	-	-	-0.01	-0.01	-0.01
Barley	1	2.5	1	1.61	2.68	6.2
Corn	-	-0.2	-0.4	0.05	0.01	-0.05
Legumes						
Beans	-	-	-	-	-	-
Other Pulses	-	-	-	-	-	-
Forages						
Rain fed forage	4	9	15.8	-	-	-
Industrial Crops						
Sugar Beet	-	-	-	-	-	-
Sunflower	-	0.1	0.1	-	0.1	0.1
Peanuts	2.8	5.6	11.3	6.9	17.2	34.4
Vegetables						
Vegetables in Dry-land	-	-	-	-	-	-
Fruits						
Grape	0.6	1	1.8	0.3	0.2	0.2
Other Tree Crops	-	-	-	-	-	-
Fallow	-	-0.2	0.1	-	0.1	0.3
Total Cultivation of Land	0.3	0.8	0.4	0.5	0.9	2

Table 11 Morocco: Import Change from Base (%)

policy shocks	Water Pricing Scenario	Energy Tax Scenario			Output Tax Scenario		
Crop Items	*Cost Recovery Level*	*50%*	*100%*	*200%*	*2%*	*5%*	*10%*
Durum wheat	3	2	4	7	3.3	7.8	15.9
Bread wheat	2	1	1	1	0.7	1.6	2.9
Barley	4	2	-	4	-	-	-
Corn	-	-	-	-	-	-	-
Beans	1	-2	-4	1	-2.9	-7.4	-14.7
Other Pulses	-	-	-	-	-	-	-
Raw Sugar	5	1	2	4	1.4	3.5	7.1
Sunflower	-	-	-	-	-	-	-
Raw Sunflower Oil	3	1	2	3	-0.1	0.7	1.5

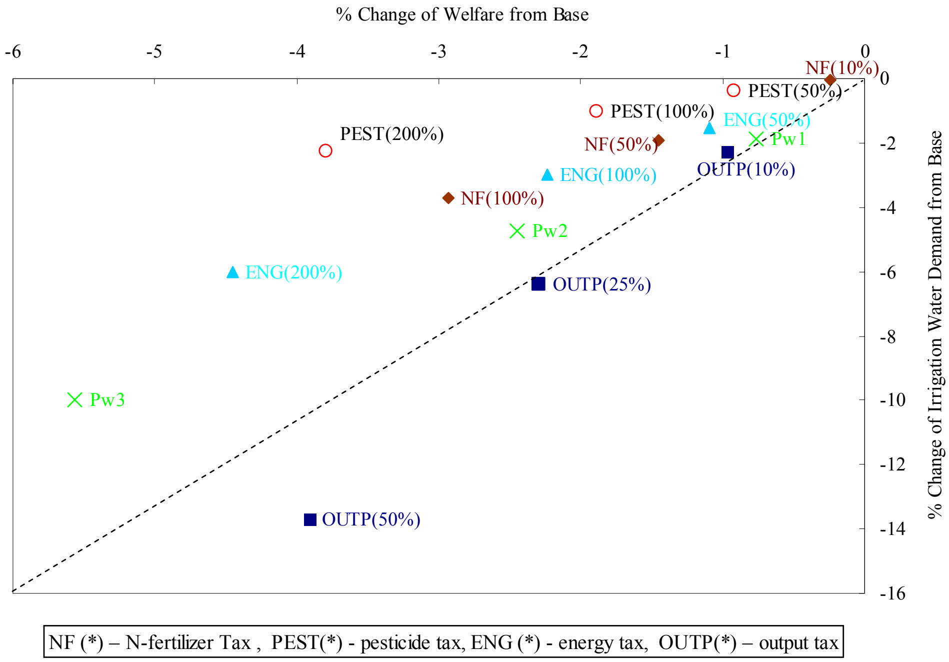

Figure 1 Egypt: Welfare and Irrigation Water Demand Changes

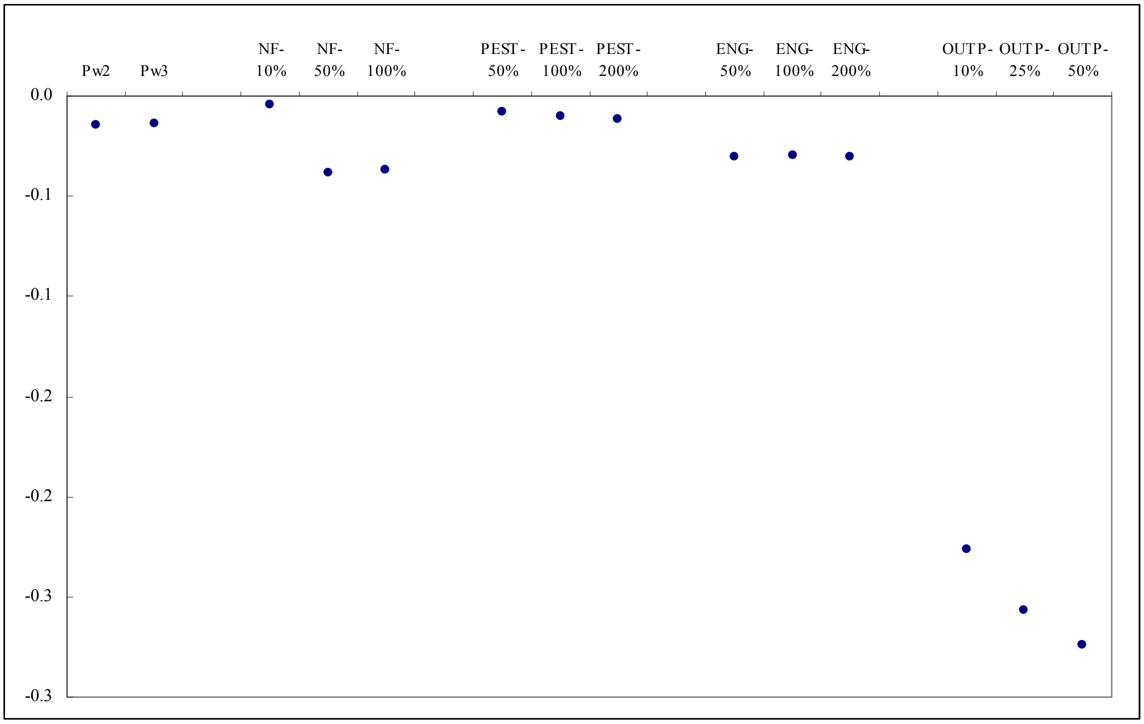

Figure 2 Egypt: Comparisons on Water Demand Elasticity

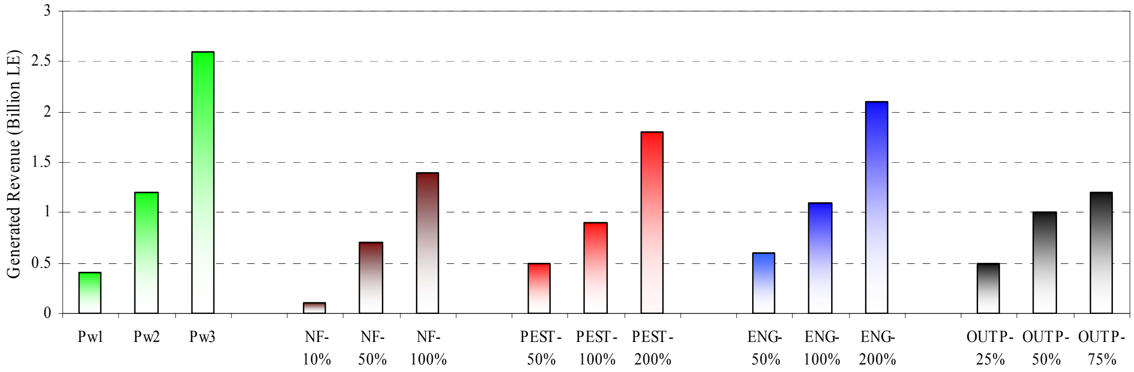

Figure 3 Egypt: Generated Revenue from each Policy Scenario (Billion LE)

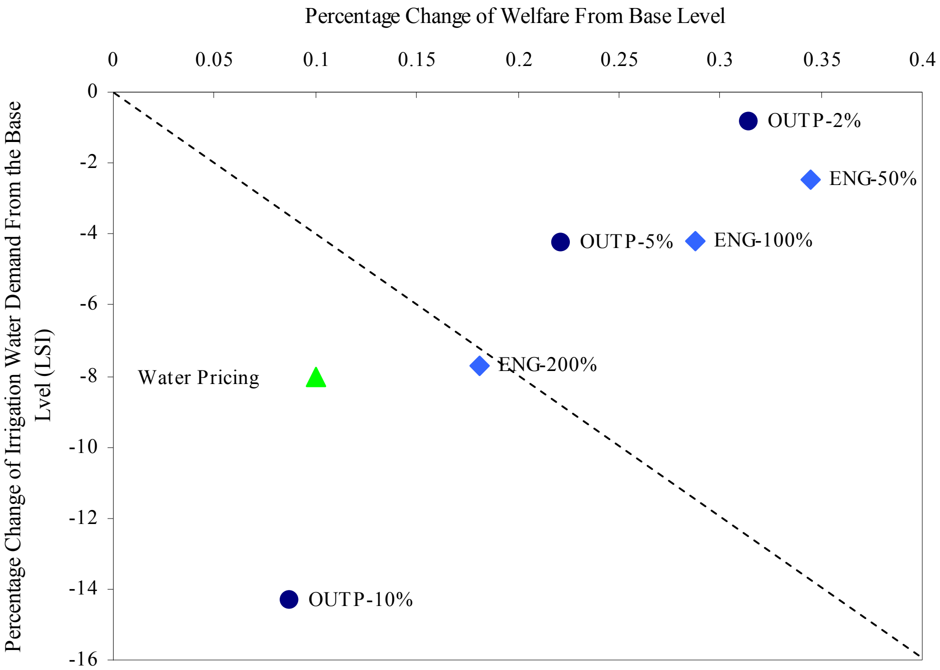

Figure 4 Morocco: Welfare and Irrigation Water Demand Changes (%)

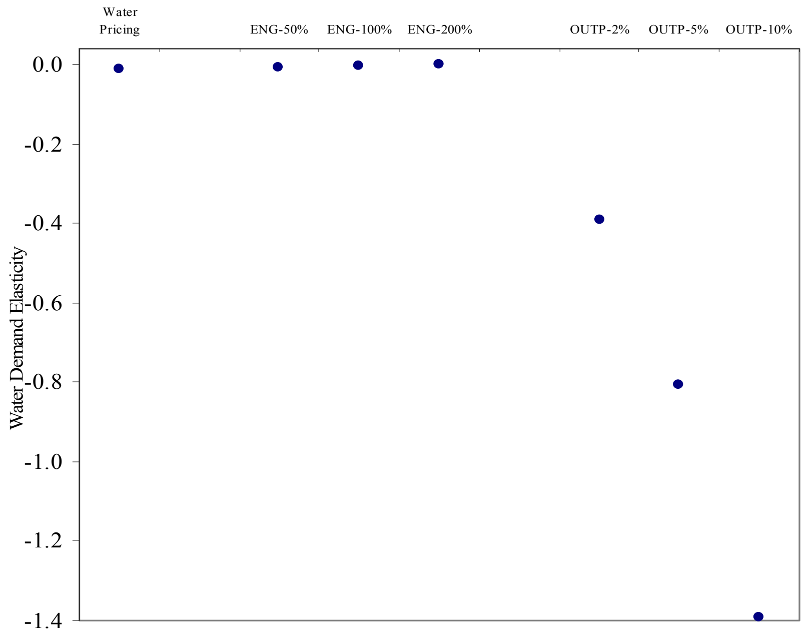

Figure 5 Morocco: Comparison on Water Demand Elasticity

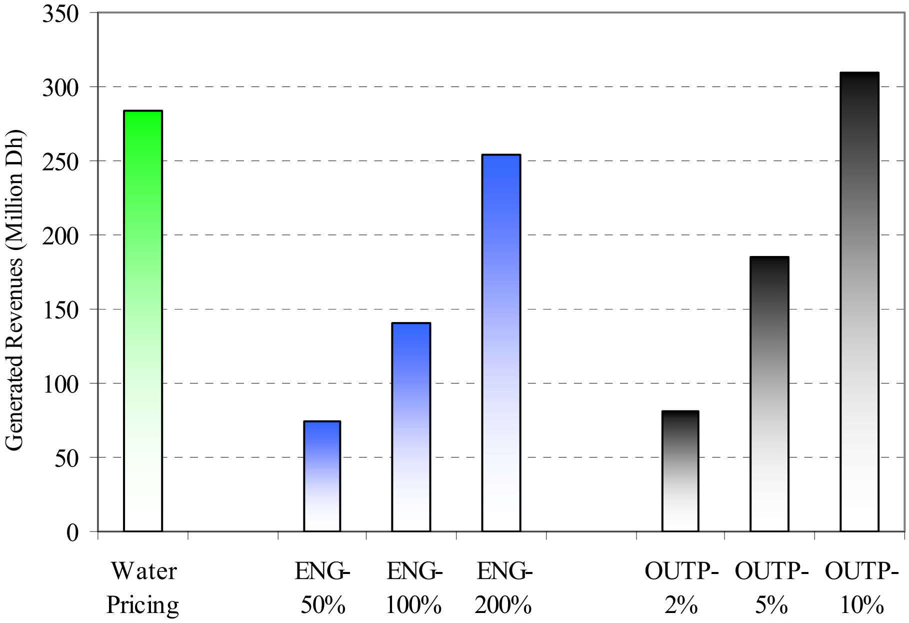

Figure 6 Morocco: Revenue Generated from Each Policy Scenario (*million Dh*).