Sustentabilidade
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Ex-Ante Impact Assessment of water policy reform in Southeastern of Tunisia: A CGE Approach

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Received:11.06.2011
Accpeted: 03.11.2011

RESUMO

Palavras-chave: reforma na política da água, equilíbrio geral computacional, matriz de contabilidade social, zonas áridas.

Localizada no sudeste da Tunísia, o território Medenine é caracterizado por um clima árido. A escassez de água foi acentuada pela crescente demanda de diferentes setores econômicos. A competição inter-setorial pela água, principalmente entre o turismo e a agricultura, representa um grande problema. Esta área de interesse socioeconômico e geopolítico foi alvo de diversos programas de desenvolvimento, em particular várias reformas na política da água. Apesar da intervenção pública já nos anos 1980, a avaliação integrada ex-ante de impacto (IIA) da reforma da política da água necessita de mais atenção em regiões áridas da Tunísia. Usando um modelo de equilíbrio geral computacional foi avaliado o impacto em toda a economia, resultante da reforma das políticas de água, que consistem em fornecer maior quantidade de água para os diferentes setores econômicos. Os objetivos centrais foram delinear um procedimento de construção de uma *Social Accounting Matrix*(SAM), descrever as opções políticas e apresentar os resultados preliminares. Os resultados do modelo mostram que o fornecimento de água segundo práticas não-convencionais para setores do turismo e da agricultura tem um impacto positivo na economia regional. Os resultados devem ser analisados com cautela, dada as várias limitações do trabalho que devem ser superadas. Este trabalho foi realizado no âmbito do Projeto Políticas de Uso da Terra e Desenvolvimento Sustentável em Países em Desenvolvimento (Lupis) (Reidsma et al., 2011).

ABSTRACT

Key word: water policy reform, computable general equilibrium, social accounting matrix, arid zones.

Located in the South-East of Tunisia, the Medenine governorate is characterised by an arid climate. The water scarcity was accentuated by the growing demand from different economic sectors. Thereby the inter-sectorial competition for water, mainly between tourism and agriculture, presents a major problem. This area of socio-economic and geopolitical interest has profited from various programmes of development; in particular, multiple water policy reforms. Despite of the early public intervention, since 80s, the ex-ante integrated impact assessment (IIA) of water policies reform needs more investigation in Tunisian arid regions. Using a Computable general equilibrium model we have assessed the economy-wide impact of water policies reform that consists of providing higher quantity water to the different economic sectors. The central aims are to outline the Social Accounting Matrix (SAM) building procedure, describe the policy options and present the preliminary results. Model results show that providing more non-conventional water to tourism and agriculture sectors has positive impacts on regional economy. Meanwhile, the results should be analysed with caution given the various limitations of the work that should be enhanced. This work was carried out in the framework of Land Use Policies and Sustainable Development on developing countries (LUPIS) project (Reidsma et al., 2011).

Introduction

"Sustainability Impact Assessment (SIA) of economic, environmental, and social effects triggered by governmental policies has become a central requirement for policy design. The three dimensions of SIA are inherently intertwined and subject to trade-offs. Quantification of trade-offs for policy decision support requires numerical models in order to assess systematically the interference of complex interacting forces that affect economic performance, environmental quality, and social conditions." (Böhringer & Loschel, 2006).

Computable General equilibrium models (CGE) seek to capture the direct and indirect implications of economic shocks and policy changes. Walarasien general equilibrium prevails when supply and demand are equalized across all of the interconnected markets in the economy. "CGE models are simulations that combine the abstract general equilibrium structure formalized by Arrow and Debreu with realistic economic data to solve numerically for the levels of supply, demand and price that support equilibrium across a specified set of markets." (Sue Wing, 2004).

The circular flow is represented as comprehensively as possible within the model with domestic consumption and production and factor markets as well as the government sector, trade and savings/investments (Chant et *al.*, 2011). With their ability to represent the complexity of the different economic interactions and their influence on the economic agents' behaviour, CGE models are extremely powerful tools for assessing land use policy impacts on sustainable development with their different intertwined dimensions.

The water resources development, uses and managements become a crucial issue for decision makers. Several international studies using CGE modelling have attempted to assess economic impact of water policies reform. Berck et al (1991) assessed the water policy impact in the San Joaquin Valley. Goldin et al (1995) studied the relationship between water management policies and foreign trade in Morocco. More recently, Seung et al (1998) examined in a regional CGE framework the reallocation of water from agricultural to recreational uses in the Walker River Basin of Nevada and California. Decaluwé et al (1997) applied general equilibrium model in Morocco with special features that allows for comparative analysis of different pricing schemes to assess their impact on water consumption and household welfare. Briand (2005) developed a static CGE model to estimate the water price policy impacts on production and employment in Senegal.

For the Tunisia case study, Thabet (2003) used a static CGE model focused on agriculture and food processing sectors at the national level to compare in terms of efficiency and equity, the impact of three alternative pricing methods on agriculture and food trade balance and on water conservation. According to the literature review carried out for the Tunisia case study (Chant et al., 2009), the impact assessment of land use policies mainly water policies on sustainable development at the regional level has rarely been performed and requires more investigation.

Using a Computable General Equilibrium (CGE) Model, the study attempts to provide some economic indicators of water reform policies impact on sustainable development in the province of Medenine located in the South East of Tunisia. More precisely, we study the economic impact of increasing water supply for tourism and agriculture sectors in the region.

The first results of the CGE application presented in this paper should be analysed with caution given the various limitations of the work that should be enhanced.

1. Methodology

1.1. Case study presentation

Located in the south-east of Tunisia (figure1), the Medenine governorate is characterised by desertification and land degradation. The area of Medenine governorate covers 916,707 ha and includes an agriculture area of 834,800 ha, representing almost 91% of the total. Water balance deficit persists for all months of the year, and the vegetation cover is fragile, depending on climate variation. Due to increasing human needs and agricultural development, the pressure on natural resources, mainly water, is becoming very high. This causes land degradation, a significant decrease of agriculture yields.

Water resources in the Medenine governorate are characterized by scarcity and a pronounced irregularity. The actual deep groundwater resources availability is estimated at 74.69 Mm^3, the water exploitation is almost 33.58 Mm^3, the groundwater resources are 12.67 Mm^3 and the exploitation reaches 17.75 Mm^3. The rainfall in the Medenine governorate doesn't exceed 150 mm/year.

The drinking water demand in the Medenine governorate is mainly related to tourism water demand in Djerba, and is marked by increased volumes (consumption reached the peak of -53000 cubic metres per day during the summer of 2009). To alleviate the pressure on this resource, two desalination stations of salt water have been constructed. A station was established in 2000 in Zarzis, with an approximate production capacity of 15000 cubic meters per day. The second station was built in Djerba, producing about 20 000 cubic meters per day since 2001. A feasibility study of a new seawater desalination station with a capacity of 50000 cubic meters per day in Djerba was done in late 2009. The reallocation of water used by the tourism sector and urban to agriculture can be considered an important policy option to alleviate the pressure on deep water resources.

1.2. Scenarios description

Based on several studies (Yahyaoui et al, 2000; Abaab et al, 2004; Romagny et al, 2006) the water management policies have shown many insufficiencies in the Medenine governorate. The main problem is the water scarcity coupled with the high water consumption and the water allocation between the different sectors water users; in particular the competing demands of the agricultural, urban, tourism and industrial sectors and the associated socio-economic and environmental problems.

Following a several workshops with policymakers from the department of regional planning

Figure1: Location of Medenine Governorate

(SDO)[1] and regional stakeholders in the framework of LUPIS project (Sghaier *et al.,* 2011) the range of water policies implemented by the national government since 1995 and the different scenarios was refined for the impact analysis using the CGE model. More precisely, the impact on sustainable development of providing more non-conventional water to the different economic sectors was identified as an important question for the Medenine region.

For the assessment of the impacts of policies, we have considered a 'business as usual' scenario that simply reproduces the initial structure of the economy as described in the regional social accounting matrix. The goal is to show what would happen in the lack of a policy change. In addition to the 'business as usual' scenario, two policy scenarios have been chosen as a first exercise for this impact assessment. The details of the scenarios are given below.

Business as usual scenario: The current situation concerning the water allocation plan is maintained.

Scenario 1: 50% increase in water availability

Scenario 2: 100% increase in water availability

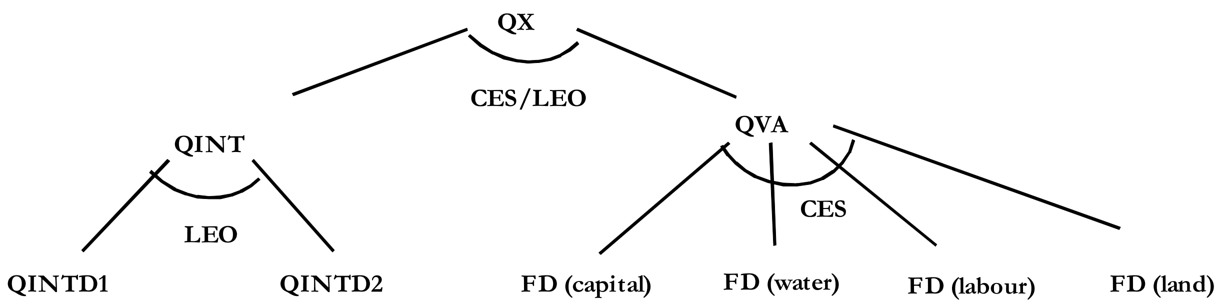
1.3. Model implementation

The regional CGE model reflects the specific conditions of the study region. We consider that the region is a "price-taker". In the model framework, according to the national input output table, we included 22 production sectors and 29 commodities. Four groups of factors of production have been taken into account: land, water, labour and capital. Water is used in the agricultural sector, tourism sector and by households, and land is used mainly by the agricultural sector. We consider three different types of land: grazing land, irrigated land, and non-irrigated land. Water is disaggregated into three types: groundwater, surface water and domestic water. The domestic water is used by households as consumption good. Water and land assumed to be freely mobile across sectors; one can convert them from one activity to another. Labour is disaggregated into four types: unskilled labour and farmers in the rural area, and unskilled labour and skilled labour in the urban area. There is one type of capital which is taken as sectorally fixed.

The behavioural relationships in the CGE model are represented by a mix of non-linear and linear relationships. According to micro-economic theory, households are assumed to maximise their utility subject to their income constraint. The utility function is a Stone-Geary function. Producers are assumed to maximise their profit under initial capital availability. The production function is a combination of constant elasticity of substitution (CES) function and Leontief function (Chant, 2008) as shown in Figure 2.

1.4. Social accounting matrix building procedure

The realistic economic data needed to solve numerically the CGE model are arranged in a accounting table known as a Social Accounting Matrix (SAM). "A Social Accounting Matrix (SAM) is a data set in the form of a square matrix in which each account has both a row and a column. The column entries record the expenditures/payments/outgoings for each account, while the incomes/receipts/incomings for each account are recorded as row entries. As such a SAM represents a form of double entry bookkeeping where each entry is a transaction, i.e., each entry has both price and quantity dimensions, which identifies both the source and destination of the transaction and the prices for each and



Where Leo indicates Leontief technologies, CES indicates a CES function, QX is the output of an activity, QINT is the aggregate intermediate input, QINTD1 and QINTD2 are representative intermediate inputs (Commodities inputs) and QVA is the aggregate quantity of value added. FD is factor demand and is shown for capital, labour (unskilled urban labourers, skilled urban labourers, unskilled rural labourers and farmers), land (agricultural land, non agricultural land, grazing land) and water (surface water, groundwater).

Figure 2. Production function structure

every entry in a row must be identical". (McDonald, 1997).

SAMs as a analysis tools were originally used mostly for national accounting purposes, but later a demand grew to apply them at regional and local levels. The SAMs can provide both a descriptive and prescriptive analysis of a regional economy (Fannin et al., 2000).

The SAM is read from column to row, so each entry in the matrix comes from its column heading, going to the row heading. Finally columns and rows are added up, to ensure accounting consistency, and the total of each column must equal the total of the corresponding row.

Following the aims of the study, the economic situation of the study area and the data availability, a typical structure for a regional Accounting Matrix is used .The SAM includes accounts for production (activities), commodities, factors of production, and various actors (institutions) and the rest of world. By developing the regional SAM we used an hybrid procedures, if the data is available at the regional level it is integrated directly into the SAM, if not we use the top down procedure by regionalizing the national data.

The regionalization of Supply and Use matrix for the Tunisia case study consists of three steps: the regionalization of the supply and use matrix, the regionalization of the final demand and the regionalization of the trade flow. The number of employees at the regional level was used in the regionalization procedure.

The activities accounts are disaggregated into agricultural, industry, and tourism activities. The agricultural activities receive special attention and are disaggregated into livestock, fishing, irrigated agriculture activity and dry agriculture activity. A one product for one activity assumption was made for the non-agriculture activities, while the irrigated agriculture and the dry agriculture activities produce several commodities.

Special accounts that describe national and provincial taxes were integrated in the SAM. The institutional accounts are the households, enterprises, and the national and provincial government.

1.5. Production Factors

The factors of production included in the SAM are labour, capital, and natural resources (land and water resources). The different production factors are subdivided into 10 subfactors (table 1). The remuneration of factors used by agricultural activities was estimated from data given by regional statistics (Specific survey on livestock and animal production system and Surveys of farm structure at the regional level (CRDA[1] of Medenine, 2006)) concerning agricultural production including factor of production use (land, water, labour and capital). Labour incomes were divided between farmer, unskilled and skilled urban, and unskilled rural labourers according to the number of employees. Some assumptions were made, for example that skilled rural labourers don't work for agriculture activities. The remuneration of factors of production by non-agriculture activities are given by the regionalized input output table.

The groundwater and surface water was allocated to the irrigated activities and evaluated according to the water pricing system. Rainfall water is allocated to dry agriculture and breeding activities according to the dry land and grazing land and evaluated according to the opportunity cost. Dry and irrigated agricultural land, and grazing land, is evaluated according to the rental value whereas the costs of non-agriculture land are estimated according to their commercial value. Specific calculations were made, for example, the value of the industrial zone area is shared between all activities using statistics given by the Office of South Development except for value of land used by building and public work and tourism activities which have a specific calculation. The capital remuneration is calculated as a residual and therefore equals value added less the remuneration of all other factors.

2. Model results and discussion

The model is comparative static in nature, so the 'business as usual' baseline scenario is simply the initial structure of the economy as described in the regional social accounting matrix. The two counter-factual scenarios are introduced via an exogenous increase in water supply of 50% in scenario 1 and an increase of 100% in scenario 2. The results of the two policy scenarios are considered by comparing their impact to the 'business as usual' scenario.

A priori, we expect that increasing the supply of water will lead agriculture and tourism to increase production as groundwater is used as production factor in their technology structure. Furthermore, increasing agriculture and tourism production will indirectly influence intermediate consump-

Table 1: Production factors

Aggregated factor	Factors	Definition
water	fGWATR	Ground water
	fSWATER	Surface water
Land	fGRAZLAND	Graze land
	fALAND	Arable Land
	fNALAND	Non agricultural land
Labour	fFARMER	farmers labourers
	fRUNSK	rural unskilled labourers
	fURBANSK	urban skilled labourers
	fURBANUNSK	urban unskilled labourers
Capital	fCAPT	capital

Table 2. Impact of water reform on macroeconomic indicators

Scenarios Indicators	Scenario 1 (%)	Scenario 2 (%)
Gross Domestic Product GDP	0.09	0.16
Total investment expenditure	0.16	0.29
Consumer Price Index (CPI)	-0.08	-0.14

tion of all economic activities and final consumption of institutions, as well as the overall output (Gross Domestic Product GDP) of the region.

The results of the CGE analysis show an increase in GDP in the region by 0.09% in scenario 1, and 0.16% in scenario 2. Total investment expenditure increases by 0.16% for scenario 1 and 0.29% for scenario 2 (table 2) .The productions of domestic irrigated agriculture increases by 0.37% and 0.65% in scenarios 1 and 2 respectively. Other changes in domestic production can be observed including an increase in the production of legumes of 0.35% (scenario 1) and 0.63% (scenario 2) and arboriculture production of 0.7% (scenario 1) and 0.13% (scenario 2) respectively. These increases can be explained by the fact that some produced commodities use more water consumer than others. Furthermore, as the supply of water increases, the average price of water decreases significantly (28.7% and 43.8% respectively).

The prices of other production factors show a significant increase in scenarios 1 and 2. The more important price increases include agricultural land (0.12%, 0.22%), rural unskilled labour (0.35%, 0.65%), farmer labour (0.5%, 0.85%) and the price of capital (0.96%, 1.68%). These changes can be explained by the fact that more water availability leads to agriculture activity enhancement "all things being equal" the production factors demand will increase and the factors prices increases.

Impact of the change in the supply of groundwater on value added by activity is reported in table 3. The quantity of aggregated value added is influenced by groundwater increase for example the irrigated agriculture value added increase by almost 2% in scenario 1 and 3.26% in scenario 2. The tourism sector as a user of groundwater showed an increase in value added by 0.61% and 1.08% for the two scenarios respectively. The

Table 3. Impact of water reform on activities value added

Scenarios Activities value added	Scenario 1 (%)	Scenario 2 (%)
Irrigate agriculture	1.86	3.26
Dry agriculture	0.035	0.058
Livestock	0.07	0.12
Fishing	-0.067	-0.12
Food processing	0.075	0.13
Tourism	0.61	1.08

impact on groundwater increase in the other industrial and services activities is not significant, because there is no link between these sectors and water availability. The small changes recorded on some activities like food processing can be explained by the intermediate consumption variation.

Compared to the initial situation, the factor demand by agriculture activities in scenarios 1 and 2 show some changes (figure3). The use of groundwater by irrigated agriculture increase by 47% and 94% for the scenario 1 and 2 respectively. The groundwater uses by the tourism sector also showed an important increase by almost 50 % and 100 % for the scenario 1 and 2 respectively. Non significant decrease of agriculture land (-2.9%), farmers labourers (-3%) and capital (-3%) production factors have been shown for the agriculture sectors.

Table 4 shows the water policy reform impacts on factor and institutional incomes. The results predict non significant changes for all factors income except for groundwater. In fact, for scenario 1 groundwater income increase by 7%, while it increase by 12% for scenario2.

Table 4 illustrates also the water policy impacts on institution incomes. The total households' income (Urban and Rural) increases about 0.09 % for scenario 1 and 0.16% for scenario2. This small increase is due mainly to the additional income generated from owned land and labours factors. Other the enterprise income grew slightly by 0.12% and 0.21% respectively for scenrio1 and 2.

Conclusion

This study develops and uses a regional CGE model to assess policy water reform at the regional level. To calculate the economy-wide water increase, two scenarios are considered i) increase the groundwater availability by 50 % ii) increase the groundwater availability by 100 %. The results of the regional CGE model show that 50% and 100% increase of groundwater supply lead to 0.09% and 0.16% increases in GDP respectively.

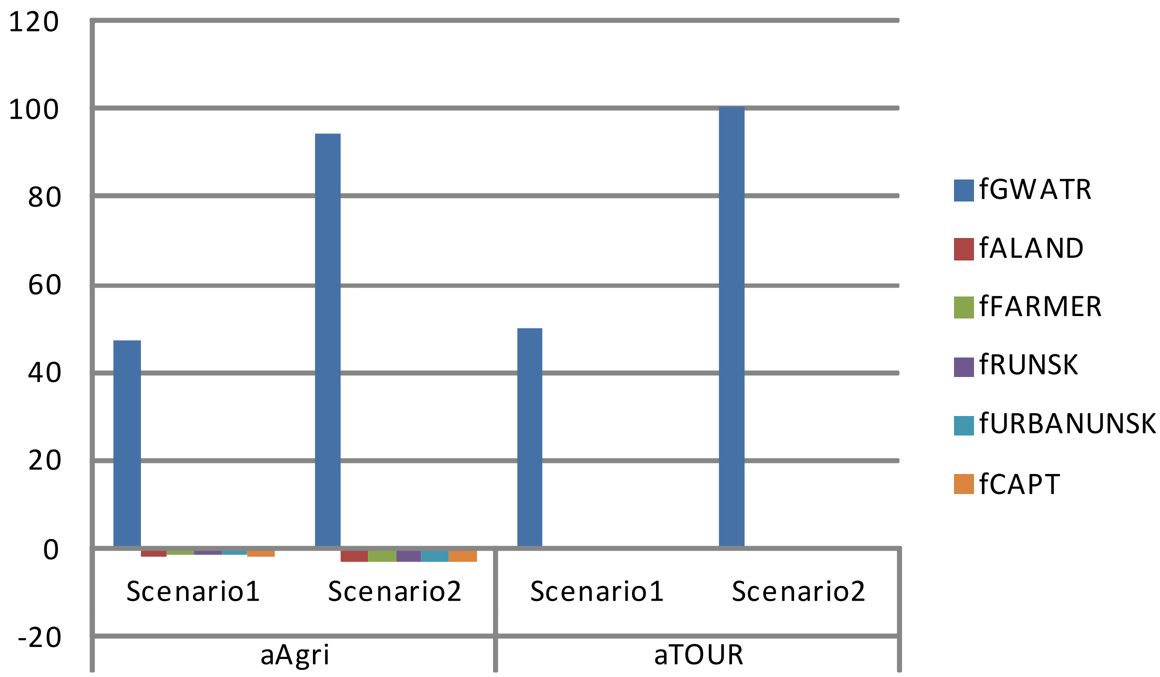


Figure 3. Factor use by activity (percentage changes from scenario)

Table 4. Impacts of water reform on factors and households incomes

		Scenario 1 (%)	Scenario 2 (%)
Factors income	fGWATR	7,02	12,30
	fSWATER	0,15	0,26
	fGRAZLAND	0,15	0,27
	fALAND	0,13	0,22
	fNALAND	0,16	0,27
	fFARMER	0,05	0,08
	fRUNSK	0,03	0,06
	fURBANSK	0,03	0,06
	fURBANUNSK	0,03	0,06
	fCAPT	0,10	0,17
Households income (urban and rural)		0,09	0,16
Households income		0.12	0.21

Thus providing more non-conventional water resources for agriculture and tourism sectors will be beneficial for the economy.

Indeed the integrated ex-ante policy impact assessment cross-sectors lead to reach and diverse picture of impact. Thus the study carried out serve as *Dashboard of sustainability* to the regional stakeholders and policy-makers useful for policy-orientation and decision taking. Meanwhile, the results should be analysed with caution given a range of limitations of the work that should be enhanced.

Firstly, the CGE model cannot fully capture the effects of water availability increase and water reallocation policy. To capture this effect the model should be extended and some changes on model structure should be taken to capture the productivity of water in the different economic sectors, and investigate the impact of covering the tourism sector water need by non-conventional resources.

Secondly, due the data availability and technical constraints, the foreign agent is aggregated into a consolidated account showing imports, exports and income transactions of the regional economy with abroad. In fact, in order to address the water policy reform impact outside the region and to take into account the optimal allocation of the groundwater between sectors and regions an interregional CGE model is required.

Thirdly, addressing the complex issues of sustainability and sustainable development and giving support to policy-makers at the regional level required the use of integrated assessment and modelling approaches. In this way to obtain the operational results, the regional CGE model should be linked to a bio-physical model. The goal is to use biophysical modelling results to inform changes in technical coefficients into the SAM (productivity change of different types of agriculture under effects of surface water harvesting and effect of climate change). The expected results would be integration tentative for policy-oriented approach.

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Endnotes

[1] SDO: South development office.

[2] Regional Commissariat of Agriculture Development.